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UTILIZATION OF MUNICIPAL SOLID WASTE OF GWALIOR CITY FOR ENERGY GENERATION (A CASE STUDY)

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Abstract- *Gwalior is the large city of Madhya Pradesh region which is located 319 kilometers south of Delhi a capital city of India .The population of Gwalior is 1159032 as calculated by ICLEI in Aug 2015. The MSW generated in the city is around 380 tonnes and about 80 % of MSW is collected per day from the various collection points in the city. The uncontrolled and unscientific dumping of such waste has brought about a rising number of incidents of hazards to human health. Based on the Quantum and Quality of MSW generated in Gwalior, Various technological options to recover energy from solid waste are available like Incineration, Pyrolysis, Anaerobic digestion & Landfill gas recovery. The waste composition of Gwalior city mostly shows organic matter approx. 55 %. Wastes to Energy technologies are able to derive renewable energy from organic matter present in municipal solid waste. By using various WTE technology the energy can be recovered in the form of Electricity (i.e. power), Heat, Fuel, Biogas (Methane) ,and Syngas with additional byproducts such as fertilizer from digested sludge and the Ash content which is used for construction material.*

Key Words - Municipal solid waste (MSW), anaerobic digestion (AD), waste to energy (WTE), Landfill Gas Recovery(LFG), Integrated solid waste management (ISWM)

1. Introduction

The solid waste generation is increased due to rapid economic and population growths, changing pattern of life style .Broadly it is generated in urban, municipal and industrial sectors of the country, besides in rural areas. The solid form include human excreta (night soil), household waste (generally termed as garbage), city wastes (resulting from public utilities & sanitation services), commercial waste (resulting from institutional activities), industrial waste (resulting from industrial process/ production activity) etc. Improper management of municipal solid waste (MSW) and practice of dumping waste on land in hygienic way causes hazards to inhabitants. Municipal Solid Waste has to be managed by various technologies and methods that are able to keep our cities clean, protect the environment and minimize the cost at the same time through recovery of energy and resources. There is a need to reduce the waste generation and increase in material and energy recovery, which are considered as the essential steps for sustainable waste management system. Landfill is not the first option for disposal of waste as compare to other methods such as recycling, composting and Incineration, but it is the last step after all possible material and energy recovery in integrated solid waste management system.

The problems arising from solid waste can be solved by various waste to energy technology such as Anaerobic Digestion, Incineration, Pyrolysis and Gasification .Energy recovery from waste or Waste-to-Energy (WTE) has become an effective option for sustainable waste management solution. Waste to Energy (WTE) refers to the process of generating energy in the form of heat or electricity from municipal solid waste. The ISWM hierarchy indicates that recovery of energy from waste is preferable only after considering the potential for recovery of material. Valuable energy is sought to be recovered after ensuring that all possible reduce, recycle and recovery mechanisms have been adopted. Proven Waste to Energy technologies include Incineration of municipal solid waste with recovery of energy, either as heat or converted to electricity and production of high calorific value Refuse Derived Fuel (RDF) from municipal solid waste, which is fast gaining acceptance. Combustion technologies in India have to cope with the comparably high moisture and inert content, as is common in Indian waste.

2.Case study

Gwalior city is located at **(Latitude: 26° 13' 25 N, Longitude: 78° 10' 45 E)** on Indo-Gengetic plains in the state of Madhya Pradesh. As per the data provided by

ICLEI in 2015, The city has a population of about 11,59,032(as per census in 2011, the population was 1069276). Gwalior Municipal Corporation (GMC) is responsible for the management of the MSW generated in the city. The city is divided into 66 municipal wards(including newly added 6 wards). The city area around 423.35 km^2].

2.1 Present Scenario

The Gwalior city generates approximately 380 TPD of MSW daily. Municipal waste as collected was usually found in a mixed form, where bio-medical waste, house waste and animal waste were all mixed together and stored in the open. Waste are transported by open trucks and dumped in a natural state at a trenching ground of Sagartal and Sureshnagar . The crude dumping caused generation of obnoxious odors, various diseases in surrounding area. Burning of the waste at disposal site was very common, which used to generate hydrocarbons ,NO_x, SOx, and other environmental pollutant gases.

In present condition there is no treatment and processing of municipal solid waste takes place in Gwalior. The new landfill site situated in kedarpur has simply dumped the waste received from the city.

3. Methadology

Municipal solid wastes from Gwalior city were used in this study. The wastes were collected from different collecting centers within the city..The Gwalior city has 66 municipal wards; in our study we have selected only 5 wards of Gwalior city for survey work of MSW. We have collected the waste samples from these five wards no. 22, 28, 29,30,31 and analyzed the waste characteristics of these five wards. The MSW received from various wards contain mostly organic (putrescible matter).we have classified this waste into different categories such as paper, plastic, organic matter, inert material, metal, clothes etc and percentage of each fraction is find out by measuring machine. The moisture content is find out with the help of dry oven machine. After analyzing the quality of MSW the best method for waste to energy recovery is selected for maximum utilization of this waste.

3.1 Composition of Waste in Gwalior city

On an average 380 tonnes of garbage and solid waste are produced daily in Gwalior, including 20-25 tonnes of vegetable market waste. Out of this only 80% is removed by the GMC from various collecting points of the city. There are 66 municipal ward in Gwalior city .we have selected 5 wards namely 22,28,29,30,31 for our analysis.

Location: Ward 22 - Suresh nagar
Ward 28 - kumharpura
Ward 29 - Darpan Colony
Ward 30 - Govindpuri
Ward 31 - R.P. Colony

Fig:1 Sample collection for analysis

Average Physical Characteristics of MSW on the Basis of Data Collected From 5 Wards-

S.NO.	CHARACTERSTICS/ PARAMETER	AVERAGE PERCENTAGE BY MASS
1.	Organic matter	55.2 %
2.	Plastic	11.99 %
3.	paper	11.34 %
4.	Inert material	13.3 %
5.	Glass	2.28 %
6.	Clothes	1.12 %
7.	Biomedical	0.45 %
8.	Cardboard	1.06 %
9.	Metal	0.38 %
10.	Wood	2.54%
11.	Thermocol	0.06 %
12.	Leather	0.28 %

Fig:2 segregation of waste and its weight

3.2 Dermination Of Moisture Content-

The moisture content can be calculated with the help of dry oven machine on wet weight basis . The sample collected from the sampling point having weight (W_{wet}) . This sample is placed in dry oven for 24 hour and again weighed (W_{dry}). Then moisture content is:

$$M.C\ (\%) = \frac{W_{wet} - W_{dry}}{W_{wet}}$$

The moisture content is **51.04 %**

4. Techniques Of Energy Recovery-

4.1 Biomethanation

In Biomethanation, the biodegradable organic waste is placed in an enclosed space under controlled conditions of temperature and moisture etc. It is a human engineered decomposing system which is based on the waste characteristics .The waste mass undergoes decomposition thereby generating biogas comprising mainly of methane and carbon dioxide. Biomethanation could be considered as one of the most Production of biogas under controlled condition is often termed as biomethanation,also known as Anaerobic Digestion (AD)technically viable options for the Indian municipal solid waste due to the presence of high organic matter and moisture content.

Merits Of Biomethanation Process

- Energy generation
- Reduction in land requirement for MSW disposal
- Reduction of environmental impacts from landfilling by avoiding contamination of land and water sources from leachate.
- Biomethanation of biodegradable organic material would ultimately result in stabilized sludge which can be used as a soil conditioner.

4.2 Incineration

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

The potential for energy generation depends on the waste composition, moisture content, density and presence of inert in the waste. In practice, heat energy can be recovered from 65 to 80 % of energy content of the organic matter which can be used either for direct thermal applications, or via steam turbine generators for producing power.

This technology have the potential for energy use and it helps to reduce the landfill volumes. This option is suitable when other better options of processing of waste are not fesible and land for landfilling is scarce.

4.3 Pyrolysis

Pyrolysis involves an irreversible chemical change in an atmosphere devoid of oxygen brought about by the action of heat. Pyrolysis is also referred as thermal decomposition, destructive distillation and carbonisation. Pyrolysis, unlike incineration is an endothermic reaction in which heat must be applied to the waste to distil volatile components. Process of converting plastic to fuels through pyrolysis is possible, but yet to be proven to be a commercially viable venture.

In Pyrolysis, the temperature lies between 500 and 1000°C and produces three component streams such as Gas(CO, H_2, CH_4, CO_2), Liquids (light oil, tar, pitch, methanol, acetic acid) and Char (consists of inert materials and elemental carbon).

The gas, liquids and char are useful byproduct because of their high calorific value. The heat obtained by combustion of either char or gas is many time used as process heat for the endothermic pyrolysis reaction. It has been found that even after supplying the heat necessary for pyrolysis, certain amount of excess heat still remains which can be commercially exploited.

4.4 Gasification

Gasification is a partial combustion of organic or fossil based carbonaceous materials, plastics etc. into carbon monoxide, hydrogen, methane and carbon dioxide. It is carried out at high temperatures (1000°C and above), with a controlled amount of air/oxygen and/ or steam. The process is largely exothermic but some heat may be required to initialize and startup the gasification process. The main product received from Gasfication is syngas, which contains carbon monoxide, hydrogen and methane.

The gas produced from gasification will have a net calorific value of 4 - 10 MJ/Nm$_3$.The other main product received from gasification is a solid residue of non-combustible materials (ash) which contains a relatively low level of carbon

4.5 Bio reacter landfill

A Bio Reactor Landfill (BRL) is a municipal solid waste landfill that uses enhanced biochemical processes to transform the decomposed organic waste within a limited period of time of approximately 5 to 10 years as compared to longer time periods of 30 to 100 years taken by conventional landfills, also referred to as “dry-tomb” landfills. This process also increases the extent of organic decomposition, changeable rates and process effectiveness. Aerobic, anaerobic and semi-aerobic BRLs have been developed. However, in the Indian context the following issues have to be considered: As per the MSW (M&H) Rule, biodegradable material should not be disposed in a landfill; therefore any bio-reactor landfill with such small percentage of organics may not be very efficient. While a BRL may be regarded as a huge bio-methanation facility (with the potential for gas recovery due to enhanced degradation of MSW), it does not have the advantage of a bio-methanation facility, in that it is logistically impossible to evacuate it at the end of the design life. Therefore the BRL would remain as a stabilized landfill, albeit in a shorter time frame. Based on the above logic, a BRL does not appear to be a practical solution in the Indian context. The bioreactor landfill process are controlled and optimized, primarily through the mixture of leachate or other liquid amendments like sewage sludge, temperature control and nutrient supplementation. The bioreactor landfill operation may also involve addition of air. There are different kinds of bioreactor landfills operated viz., aerobic bioreactor, anaerobic bioreactor and aerobic-anaerobic (hybrid) bioreactors. Bioreactor landfills have not achieved application beyond research and test plants. Key problems are ambitious operations, challenging technology optimization and high costs.

4.6 Refuse Drived Fuel

Refuse Derived Fuel (RDF) is also known as high calorific, non-recyclable fraction of processed municipal solid waste which is utilized as a fuel in terms of steam/ electricity generation or as alternate fuel in industrial furnaces/boilers (co-processing/co-incineration of waste in cement and steel industry and for power generation). The composition of RDF mixture consists of a higher concentrations of combustible materials .

Production & combustion of RDF for energy recovery is not only an economically viable option for MSW management, but also greatly reduces the requirement for landfill space. The techno-economic feasibility of producing high calorific value RDF from mixed MSW has to be seen in the context of the framework conditions of a particular ULB.

RDF typically consists of dry fraction of MSW including paper, textile, rags, leather, rubber, non-recyclable plastic, jute, multi-layer packaging, and other compound packaging, cellophane, thermocol, melamine, coconut shells and other high calorific fractions of MSW. However from the ISWM hierarchy perspective, the city should give priority to separately recycle relevant components (e.g., paper, plastics, jute, metal, glass, multi-layer packaging used for liquid food items etc.). The composition and resultant energy content of RDF varies according to the origin of waste material and the sorting/separation/processing processes being adopted in the processing facility.

RDF quantity and composition is determined by the nature of the waste and extent of material recovery/recycling processes implemented by the city. The quantity of RDF that can be produced per tonne of MSW varies depending on the type of collection, preprocessing and composition of waste source.

RDF may be utilized in the following manner-

- co-processing in cement kilns;
- co-combustion in coal fired power plants38;
- on-site/off site in an appropriately designed waste incinerator for thermal recovery or power generation

The RDF production line consists of several unit operations in series which are given below:

- Sorting or mechanical separation (In case of effectively source segregated feed material, this process may not be required)
- Size reduction (shredding, chipping and milling)
- Drying (where required)
- Separation
- Screening
- Air density separation (for removing fine inert material)
- Blending
- Packaging and
- Storage

6. Benefits of Energy Recovery

Waste to energy technologies uses trash to generate electricity and its environmental benefits are many.

The various advantages of waste to energy conversion are listed as below:

- Production and use of energy
- Reduction of waste going to landfills
- Avoidance of disposal cost and landfill taxes
- Use of by- products as fertilizers
- Avoid methane emissions from landfills
- Reduction in carbon emitted
- Reduction of reliance on fossil fuel
- Domestic production of energy
- Employment creation in local community
- Stability in availability of energy and its price
- Reduction in greenhouse gas emission.
- Demand for land for landfilling is reduced.
- Net reduction in environmental pollution

7. Conclusion

With the fast development of national economy, the continued improvement of living standard and urbanization, the output of Municipal solid waste is constantly increasing. It causes environmental pollution and affects people's health, stopping the sustained development of city. The generation of large quantity of waste, pollutes water and air, and lead to serious environmental trouble. Therefore Proper waste disposal is an urgent and important task for further development of city.

The waste composition of Gwalior city shows that there is possibility of utilizing municipal solid waste for energy recovery**.** Energy crises are one of the burning issues of today's world. Energy recovery from waste or waste to energy has become an effective option for many countries as sustainable waste management solution. We have collected the waste from different wards of Gwalior city and analyzed the waste for various parameters and characteristics of the waste.

characterization of waste collected from five different wards in municipal circle Gwalior shows the average organic matter present in MSW is approx. 55 % , which can be utilized for energy generation by using various WTE technologies i.e. Anaerobic Digestion, Incineration & Gasification . This technology also proved to be environmentally friendly as compare to open dumping, which creats nuisance and unsanitary condition in the city and affects the aesthetic view of the city.

References

[1] A report on solid waste management at Gwalior, prepared by central pollution control board.

[2] B. L. Chavan, and N.S. Zambare, "Studies On Energy Recovery From Municipal Solid Waste; A Case Study At Solapur, Maharashtra, India," Case Studies Journal ISSN, 2014, v. 3, Issue 12.

[3] Data collected from Gwalior municipal cooperation and survey conducted by ICLEI in August 2015.

[4] H.Y.yap, and J.D.Nixon, "A multi-criteria analysis of options for energy recovery from municipal solid waste in India and the UK," waste management journal ,2015, pp. 265-277.

[5] Manual on solid waste management publish by CPHEEO New Delhi.

[6] Municipal solid waste (Management and handling) rule, 2000