A Brief Emphasis on Bio-Gasification Through Case Studies

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Abstract*— Amongst many environmental hazards torturing the communities of the world today, solid waste is most hazardous for the environment. It is the haphazard disposal of solid waste that causes pollution while its proper management assures healthy conditions. The major objectives of Solid waste management (SWM) are the maintenance of clean and hygienic conditions and reduction in the quantity of solid waste. Solid waste management (SWM) is one of the basic services organized and administered by the municipal authorities in the country to improve the cleanliness of the local surroundings of the country. Poor management of solid waste leads to cluttering and in this way unsanitary living conditions. There are traditional as well as new methods of waste disposal have been practiced to manage solid waste including dumping, landfilling, incineration, recycling, composting and bio-gasification. The article has described the bio-gasification technique, its procedure and benefits through site visited case studies. The article mentioned around three case studies viz., domestic bio gas plant at Karad, Karad Municipal Corporation's biogas plant and biogas plant at Council hall, Pune. The reported case studies revealed that bio-gasification technology can be beneficial to the environment, economy, waste as resource of energy and best approach towards SWM.

Index Terms- Bio-Gasification, Solid Waste, Biowaste, Energy, Disposal

I. INTRODUCTION

In every Country in the world face the problem of waste disposal and it is increasing day by day. Actually, every community that generates solid waste has to fight the problem of its disposal. Due to progress of civilization, quantity of waste increases which in itself reflects the progress of the country and on other hand avenues for the proper disposal of waste, are being reduced.[1]

Solid waste management is one of the environmental hazards crippling the world today, India is developing country, the growth of population and industrialization is at a rapid rate due to which the solid waste generation is also increasing every year due to this effectively management of solid waste is important. Whether they are semi-solid waste from municipal and industrial treatment plants, domestic garbage, or other materials that are no longer useful to society, disposal is the final destination for all solid wastes. The appropriate disposal of an item that has been discarded in compliance with local environmental regulations. [2]

Worldwide garbage disposal practices differ depending on a nation's economic standing. A number of factors, including insufficient municipal capacity, a lack of political will, a lack of funding, inadequate technical guidance, a lack of accountability on the part of individuals and organization, and SWM laws and regulations that are in place in a nation, limit safe disposal. Recycling, incineration, chemical, physical, and biological treatment, landfilling, open burning, sea dumping, composting, and bio-gasification are some of the several processes used worldwide. [1, 2]

This review paper in detailed emphasizes on the bio-gasification, its procedures economic benefits. To achieve this, three case studies have been studied on bio-gasification at various places that covers small and large processing plants which have been described well.

Global Scenario

The average amount of solid waste is generated in India is between 0.5 and 0.99kg per person per day, while the average for low-income nations worldwide is between 0.1 and 0.49 kg per person per day. Developed countries produces greater than 1.5 kg of waste per person per day, which is far greater than India. The comparison of daily waste generation worldwide per person is shown in chart 1.1 in kilograms.

However due to shifting lifestyles, increased use of packaging, etc. waste production is steadily rising, particularly in larger cities. The population of cities is growing at a rate of 2.7% to 3.5% per year, which will lead to a rise in solid waste creation of more than 5%. [3]

Solid Waste Management: The Indian Scenario
In the last few decades, the issue of managing municipal solid waste in India has grown alarmingly. Prior to this, waste management was not regarded as a serious worry because it could be disposed of in an environmentally friendly way. But over time, as a result of people's shifting lifestyles, unforeseen development projects, urbanization, and industrialization, waste qualities and quantity have changed, making solid waste management difficult. [4]

Due to the alarming scenario the Government of India (Ministry Of Environment and Forest) came up with set of rules to manage municipal solid waste throughout India. These rules were known to be the Municipal Solid Wastes (Management and Handling) Rules, 2000. These rules were applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid wastes.

Bio-Gasification
When biodegradable organic matter breaks down in the absence of oxygen, created gas it is known as biogas. Another name for this procedure is "anaerobic fermentation of bio-degradable materials." Because methane and carbon dioxide make up the majority of biogas, it is also known as bio methane. Hydrogen sulphide is present in trace amounts in biogas in addition to carbon dioxide and methane. Biogas can be used as an alternative fuel for cooking and can also be transformed into electricity and heat in anaerobic digesters through the release of energy during combustion of these components. Moreover, biogas can be compressed to create "biofuel," which is used to run automobiles. [5]

In essence, the demand for a backup energy source, like biogas, has never been greater than it is right now. Due to a lack of proper waste management facilities and the rapid growth of the population, mechanization, and urbanization, a significant amount of waste is generated daily and ends up in the environment. Meanwhile, the demand for energy and the amount of waste discharged are also rising daily. The only way out of the energy dilemma is through alternate energy sources. The process of turning waste into energy has several advantages. It is best suited for environmentally friendly waste disposal. [3, 4]

Two urgent problems are addressed in the case of biogas: the demand for alternative energy sources and the handling of organic waste.

Raw Material: This method can be used to treat any easily degradable material, such as, fruits and vegetables waste, fish and meat waste, waste water including bio waste components. With the use of specific pre-digesters made for the job, this method can also be used to handle slowly degradable materials like vegetables and green or moist plant parts.

Procedure for Producing Biogas: Biomethanization, the process of producing biogas, is anaerobic in nature and occurs in two stages:
Phase 1: Acid Production At this point, organic acids are produced from the waste as a result of acid-forming bacteria acting on it.
Phase Two: Production of Methane is produced by methanogen bacteria reacting with organic acids. These bacteria cannot function well in the presence of oxygen or light because they are oxygen- and photosensitive.

The fundamental idea behind a biogas-generating digester's operation is: Anaerobic digesters can be used to produce biogas. The process of filling digesters with cow dung and a microbial culture to cultivate the bacteria within begins the digester/reactor's operation. Without additional feeding from cow dung or bacterial culture, the microorganisms in the digester proliferate after the first meal and efficiently break down the bio waste. Microbes that have been cultivated in the plant will develop, proliferate, and stay in the treatment plant. Energy crops like maize silage or biodegradable wastes like sewage sludge and food waste can be fed to these plants. Methane is produced throughout the process, which converts biomass waste into an airtight tank. This sustainable energy can be used for a variety of purposes, including heating and electricity

production. The weight of the material deposited from above covers and compresses the trash mechanically. Because this substance shields anaerobic microorganisms from oxygen, they can grow and thrive. This gas can be collected as biogas as it accumulates and is gradually discharged into the landfill's atmosphere. [6]

Pre-Digester: Scum formation is a possibility in typical model digesters because of the buildup of non-treated, partially treated, slowly degradable, and light weight waste materials in the top surface of the digester. As a result, the digester's moving elements will have less freedom to move, which would eventually lower the plant's efficiency. Specialized scum breakers/agitators are installed inside the digester of large-scale waste-to-energy plants, and they operate continuously to avoid the accumulation of scum. In order to produce biogas, the leachate from the pre-digesters is collected using filters that are specifically made for the purpose and directed towards the digesters. The pre-digesters can yield processed bio waste, which can then be collected and used as bio manure. [5, 6]

Benefits for Society and Economy

Biogas has developed into an innovative and reliable way to handle organic waste at the source by using a variety of environmentally friendly treatment techniques. Numerous benefits are evidently obtained from this procedure.

i. A widely used and tested method for producing bioenergy from biowaste is Biomethanization.
ii. It requires no ongoing costs and is very easy to use.
iii. Any degradable waste can be processed through the use of Biomethanization technology, which involves the use of various anaerobic bacteria and microorganisms in a hidden chamber or digester.
iv. It can be a useful tool in addressing the energy crisis because it is a renewable energy source.
v. It helps with decentralized waste management since it is made from organic waste or Municipal Solid Waste (MSW). Since the wastes are treated at the source, there is no need for waste collection, transportation, or segregation.
vi. High-quality organic manure and liquid fertilizer are produced in order to replace and supplement chemical fertilizer use. Can be burned to create energy, which can then be utilised as cooking fuel. By preserving the firewood, this improves the surrounding ecosystem and maintains the protection of the forest cover.
vii. It can be used in anaerobic digesters to produce heat and power.
viii. It can be crushed to create biofuels that are suitable for driving automobiles.
ix. Efficient management and disposal of trash ensures control of the air pollution problem and creates a hygienic atmosphere.
x. Methane can be captured by the process of Biomethanization, which can help manage or reduce greenhouse gas emissions and climate change.
xi. The digester produces liquid or semi-liquid biowaste products after they have been processed. For all kinds of plants, this fertilizer is excellent. This can be sprayed straight to plants or combined with an equivalent or greater amount of water.
xii. In addition to homes, biogas plants can be found in a variety of public and private establishments, including markets, slaughterhouses, colleges, schools, hospitals, hostels, and canteens for employees. [7]

Primary Data

Primary data of case study is collected from the field visit carried out in case of bio gas plant, personal interview with Mr. Jadhav's who operates the plant for his own resident. And Mr. Bhaldar who is in charge of SWM plant of karad Municipal Corporation and also Mr. Shankar who operates biogas plant installed at Council Hall. Pune

The personal interview with Mr. Jadhav's helped me to understand the operation of bio gas plant which generates methane gas for his household consisting of seven member. The personal interview with Mr. Bhaldar helped me to understand the waste generated per day, collected by karad Municipal Corporation for scientific disposal of the same through bio gasification.

Criteria for selection of case studies

The case studies were selected to explore both small and large scale bio-gasification. [9] The case studies considered by keeping in mind the following aspects,

a) Public place where solid waste is generated
b) Where solid waste is generated in bulk quantity

c) Where effective SWM is in practice
d) Where new disposal techniques of solid waste are in practice
e) Where solid waste can be considered as resource instead of waste
f) Where ideal SWM practices are carried out in the organisation [10]

Case Studies

1. Case Study 1 - Site visit at Domestic Bio Gas Plant

A site visit was done at Mr. Sagar Jadhav's home. There, he has installed a bio gas plant of 30 kgs capacity for treating household food waste. The plant has been installed 9 years ago and it provides necessary Methane gas for his household consisting of 7 member's family every day.

The details regarding its installation and operation are as follows:

- The plant setup was done 9 years ago for a minimum costing of RS: 50,000/-.
- Initial slurry of 100kgs of cow dung and 200 liters of water was mixed for generation of micro-organisms, useful for fermentation of slurry (which would be fed later till the life of the plant). This needs to be kept for initial 15 days till the process of gas generation is started.
- Post the initial 15 days, stage of plant installation, daily 20-30 kgs of crushed degradable materials including cooked and raw food waste, fruits and vegetable waste, fish and meat waste mixed with water to form slurry is fed into the digester (1kg of waste mixed with 1.5 liters of water) is the standard feeding proportion in this case. Peels of Onion, Garlic, Egg shells and Sour Content is excluded from feeding into digester.
- Methane Gas is generated from the slurry is 20Kgs/day Waste X 31 Days = 620Kgs of Input per month. Which generates gas capacity of approximately 31 Kgs per month which would turn out to be 1 kg per day.
- The daily manure output generated from the process would be 3 to 4 kgs which is directly used in farm cultivation.

Fig. 1 Mr. Jadhav explaining about The working mechanism of household Bio gas plant

The family uses its own solid waste as well as waste from other households from the Society for generation of Bio gas. The family does not hand over the waste collected to Municipal Corporation but uses it for self-consumption for generation of Bio gas. There is no procurement of LPG cylinder for the household's uses, whatever the gas generated is self-consumed for cooking purpose. There is no foul smell from the process carried out in generation of Bio gas. The manure extracted from the Bio gas plant is used by them into the garden as well as excess manure is sold into the market.

2. Case Study 2 - A Field Visit to Karad Municipal Corporation's Solid Waste Management Plant

Considering the research undertaken, a planned visit was made to a solid waste management plant located on the outskirts of Karad. The population of Karad Municipal Corporation stands to be 85,000 as per 2017 census. The collection process is carried out by 18 vehicles, the collection process is carried out in morning 7 to 11. All vehicles have various compartments for segregation of waste in the form of Bio-degradable waste and Non-Bio-degradable waste. The area covered for this plant measures approximately 15 Acres which includes Bio-degradable waste, Non-Bio-degradable waste, Bio-medical waste, sanitary land fill and plastic recycling process.

Taking into consideration scope of study the main focus was only on the process carried out on Bio-degradable waste and Non-Bio-degradable waste at the plant. The plant controller Mr. Bhaldar guided us about the processes carried out at various plants in the premises. Daily collection of wet waste is 9 to 10 tonnes /day mostly collected from households, hotels, restaurants, canteens and small snack centers in the

city of Karad. Out of the wet waste collected 2 tonnes /day is used for generation of Bio gas and the remaining is used for windrow composting. The detailed processes carried out on the same are as mentioned here under.

Bio Gas Plant

- Wet waste is first grinded into a thick paste and moved into a tank having capacity of approximately 91,000 liters. Through compressed air pressure grinded waste along with equal quantity of water now known as slurry is then transferred to a digester.
- The capacity of digester is 5 tonnes the fermentation process is carried out continuously by the bacteria's present in the process unit. The gas generation occurs on continuous basis, quantification of gas generated could not be known as the pressure gauge equipment was not available with the authorities. Currently the gas is collected in the setup, made up of rubber balloon.
- The gas generated is utilized for generation of 20kw electricity which powers the whole plant during day time as well as night. Grinding machines, compressors, hydraulic pressing machines, screening machine, street lights, water pumps, and administrative office lights are operated through the gas generated from the plant.

The quantity of slurry which is fed into the digester on daily basis, manure of 17% to 20% of input quantity is generated and pumped out of the digester. The manure is sold in market and is directly utilized for agricultural purposes.

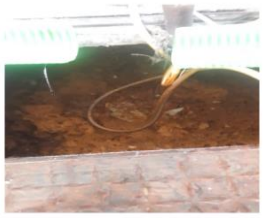

Fig.2 - Wet waste grinded and transferred to tank

Fig.3 - Tank from which the thick paste is transferred to digester through compressed air pressure

Fig .4 - Inflated polymer balloon after complete fermentation.

Fig .5 - Manure collection unit post new slurry is transferred into the digester

Fig.6 Digester into which Slurry is transferred

At collection point there is a segregation of Bio-degradable waste and Non-Bio-degradable waste through small vehicles, which is more cost effective on the basis of reach and collection of wet waste quantity. The process carried on wet waste is as per norms set for the plant. Electricity is generated through biogas plant is used for self-consumption but the operations of biogas plant is not carried out to the optimal level, the gas generated is never quantified also the gas generated should have been further segregated into Methane, Hydrogen and Sulphur compressed and stored. [11]

3. Case Study 3 - A Field Visit to Biogas Plant at Council Hall, Pune

- A planned visit was made to a biogas plant at council hall, Pune. Where the plant set up is done for canteen which is in its premises. Biogas plant installed is for treating canteen wet waste. [12]
- The capacity of plant is 100 kgs. There are total 10 units installed, the single unit's capacity is of 10 kgs. These containers are kept on platform made with the fencing open to sky besides canteen kitchen. The requirement of space for wet waste processing of a single unit is approximately 30 to 35 sq.mt admeasuring 5ft x 5ft, with a height of 1.8 mt.

- All procedures are done by two workers daily for 1 hour. 70 to 100 kgs of wet waste is generated at canteen every day, the same is fed in to the digester tank. In its initial setup cow dung is required for generation of biogas.
- After period of 35 days, biogas is generated in its full capacity. Generated biogas is collected in a balloon which is installed at rear side of the kitchen through pipes. These pipes are directly connected to the gas grill for cooking purpose.
- Approximately 150 numbers of commercial cylinders of 19 kgs are generated per year through this biogas. This can be calculated on the basis of Flow Meter setup at the plant.
- Apart from Bio Gas another component known as Slurry which is in the form of liquid called 'leachate' is generated through biogas plant which is extracted from each unit which is used as manure for plants and crops. Approximately 200 litres of leachate is generated per week, which turn out to 9,800 litres per year.
- The PH value is to be checked daily by workers, the standard norm set is less than 6 for balance wet waste and for odour control. This leachate is directly used for gardening purpose and in farms, as it has good nutritional value being organic in nature. Excess leachate generated is sold out for Rs 10/litre.


Fig.7 -Ten units of Biogas plant installed at Canteen of Council Hall, pune

Fig.8 -Mr. Shankar explaining about the plant setup


Fig.9 - Good quality of leachate is generated

Fig.10- Wet waste is generated at canteen through this process

70 to 100 kgs of wet waste is generated per day and 250 to 300 no of people consume food in canteen per day. Total 10 units are installed, each having 10 kgs of capacity for generation of biogas. Approximately 150 numbers of commercial cylinders of 19 kgs are generated per year through this biogas plant and approximately 9,800 liters of leachate per year. Generated methane gas through this plant is directly used as cooking fuel at canteen. Quality of slurry generated through it is of a good quality. Process of bio gasification is being effectively carried out at the plant. The operation of this system is simple, it's clean and has sustainable process, and it takes up less space. [13]

CONCLUSION

Solid waste management is one of the environmental hazards crippling the world today. To reach upon a successful SWM system there should be proper segregation, collection, transportation and disposal. There should be focus on reduce, reuse, recycle and recovery of solid waste. There should be a well-planned shift from traditional SWM Programme to systematic SWM Programme. The reported case studies reflect bio-gasification as a significant technique with maximum benefits. In bio gasification process, methane gas can be generated which can be directly used in the kitchen as cooking fuel, saving the cost of LPG. Manure extracted from bio gas can be directly used in garden, and it will save cost of fertilizer and improve soil fertility. Through this consumption of fossil fuel could be reduced as much as possible and also environmental hazards relating to waste disposal could be minimized.

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