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Biogas Production From Household Biodegradable Solid Wastes (HBSW)

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Abstract- Household biodegradable solid waste (HBSW) was considered as a feedstock to produce biogas by anaerobic digestion. This work presents the measurement of produced biogas from HBSW which collected from the dormitory of Jessore University of Science and Technology of Bangladesh. This experiment was carried out in batch type home-made stirred tank reactors. Biogas emission data were taken with a portable analyzer for 12 weeks. The biogas production was greatly influenced by the temperature of the anaerobic digester process. Moreover, the qualitative and quantitative influence over the biogas production was determined by the organic matter content of the raw material subjected to the composition, pH, moisture content, total solids, volatile solids, biodegradability, ashes and time of confinement of solid wastes. It can be concluded from the investigation that by adopting active biogas collection procedure from landfills of the country, huge amount of electricity can be generated to meet the increasing demand of electricity as well as save the environment.

Key words: Household solid waste, Anaerobic Digestion, Bio-gas, Electricity.

1. INTRODUCTION

Biogas is one of the alternative energy sources in Bangladesh. For improving this sector a lot of works have been done worldwide and now it is a common phenomenon. This study will be carried out on biogas production from kitchen wastes. Jessore University of Science and Technology Teacher's Dormitory will be considered as study area. In this regard, conventional methods will be used for producing biogas in small scale. From this study an idea can be obtained to produce biogas in large scale to meet the fuel requirement of the dormitory kitchen. Some other benefits can also be achieved from the project outcome like, to reduce environmental pollution from wastes generated from the kitchen, right use of waste, decrease dependency on fossil fuel etc. Moreover it will increase awareness of waste producer about proper waste management. It will be a temporize work in regarding national energy reserve and environmental pollution. Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude. It means higher efficiency and size of reactor and cost of biogas production is reduced. Also in most of cities and places, kitchen waste is disposed in landfill or discarded which causes the public health hazards and diseases like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences. It not only leads to polluting surface and groundwater through leachate and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odor and methane which is a major greenhouse gas contributing to global warming.

Mankind can tackle this problem(threat) successfully with the help of methane, however till now we have not been benefited, because of ignorance of basic sciences – like output of work is dependent on energy available for doing that work. This fact can be seen in current practices of using low calorific inputs like cattle dung, distillery effluent, municipal solid waste (MSW) or sewerage in biogas plants making methane generation highly inefficient. We can make this system extremely efficient by using kitchen waste/food wastes.

2. LITERATURE REVIEW

Biogas is the gas produced by the biological breakdown of organic materials. Fermentation or anaerobic digestion is the most common process that breaks down the organic materials. The organic materials are then oxidized and create energy, which dates back to ancient Persians who observed that rotting vegetables produce flammable gas. Anaerobic digestion is a process that uses microorganisms to break down the organic material in the absence of oxygen which creates energy. An anaerobic digestion plant was built to process sewage in Bombay in 1859 and has been used in the United Kingdom since 1895.

The types of organic materials include biomass, landfill waste, sewage, manure, and plant material. The most common gases produced are methane and carbon dioxide. Other common gases that can be formed include hydrogen, nitrogen, and carbon monoxide, methane, hydrogen and carbon monoxide can be combusted to create heat and electricity. When biogas is created from existing waste streams, it reduces odors and methane emissions and creates two renewable resources. Sewage sludge and animal slurries usually end up as fertilizer, so it is better to obtain fuel from them first, while preventing runoff and methane emissions at the same time. Biogas is not a widely used renewable energy technology for most new construction or major renovation projects since most buildings do not have a large source of organic material. However, projects located near a landfill or contained animal feeding operation may want to consider this option since it can provide low-cost energy.

Due to scarcity of petroleum and coal it threatens supply of fuel throughout the world, also problem of their combustion leads to research in different corners to get access the new sources of energy, like renewable energy resources. Solar energy, wind energy, different thermal and hydro sources of energy, biogas are all renewable energy resources. In order to survive with the growing living standard of life that led huge energy. But crisis of energy needs more study in alternative sources of energy. Now-a-days waste is major problem that cannot be ignored, but everyday huge amount of waste generates from household kitchen. Wastes poses serious threats to environmental health and requires specific treatment and management prior to its final disposal (Hossain et al 2008)[3]. Dr. Anand Karve (ARTI) developed a compact biogas system that uses starchy or sugary feedstock (waste grain flour, spoilt grain, overripe or misshapen fruit, non-edible seeds, fruits and rhizomes, green leaves, kitchen waste , leftover food, etc). Just 2 kg of such feedstock produces about 500 g of methane, and the reaction is completed with 24 hours. The conventional biogas systems, using cattle dung, sewerage, etc. Use about 40 kg feedstock to produce the same quantity of methane, and require about 40 days to complete the reaction. Thus, from the point of view of conversion of feedstock into methane, the system developed by Dr. Anand Karve[1][4] is 20 times as efficient as the conventional system, and from the point of view of reaction time it is 40 times as efficient. Thus overall, the new system is 800 times as efficient as the conventional biogas system.

Hilkiah Igoni[2][5] (2008) studied the Effect of Total Solids Concentration of Municipal Solid Waste on the biogas Produced in an Anaerobic Continuous Digester. The total solids (TS) concentration of the waste influences the pH, temperature and effectiveness of the microorganisms in the decomposition process. They investigated various concentrations of the TS of MSW in an anaerobic continuously stirred tank reactor (CSTR) and the corresponding amounts of biogas produced in order to determine conditions for optimum gas production. The results show that when the percentage total solids (PTS) of municipal solid waste in an anaerobic continuous digestion process increases, there is a corresponding geometric increase for biogas produced. A statistical analysis of the relationship between the volume of biogas produced and the percentage total solids concentration established that the former is a power function of the latter, indicating that at some point in the increase of the TS, no further rise in the volume of the biogas would be obtained.

Shalini Singh[6] et al (2000) studied the increased biogas production using microbial stimulants. They studied the effect of microbial stimulant aquasan and teresan on biogas yield from cattle dung and combined residue of cattle dung and kitchen waste respectively. The result shows that dual addition of aquasan to cattle dung on day 1 and day 15 increased the gas production by 55% over unamended cattle dung and addition of teresan to cattle dung kitchen waste (1:1) mixed residue 15% increased gas production.

Jantsch and Mattiasson[7] (2004) discuss how anaerobic digestion is a suitable method for the treatment of wastewater and organic wastes, yielding biogas as a useful by-product. However, due to instabilities in start-up and operation it is often not considered. A common way of preventing instability problems and avoiding acidification in anaerobic digesters is to keep the organic load of the digester far below its maximum capacity.

There are a large number of factors which affect biogas production efficiency including environmental conditions such as pH, temperature, type and quality of substrate, mixing, high organic loading, formation of high volatile fatty acids and inadequate alkalinity and removal of H_2S from Biogas Produced by Food Waste using an aerobic Sludge Bio-filter for Steam Reforming Processing. They showed that a bio-filter containing immobilized aerobic sludge was successfully adapted for the removal of H_2S and CO_2 from the biogas produced using food waste. Taleghani and Kia [8] (2005) outlined the economic and social benefits of biogas production.

3. Methodology

3.1Anaerobic Process

Anaerobic digestion is a collection of processes by which microorganisms break down biodegradable material in the absence of oxygen.[9] Figure 1 shows the anaerobic process diagram for biogas production. The process is used for industrial or domestic purposes to manage waste or to produce fuels. Much of the fermentation used industrially to produce food and drink products as well as home fermentation uses anaerobic digestion. Anaerobic digestion (AD) is a well-established process for renewable energy production in which biomass (also referred to here as substrate or feedstock) is broken down and converted to biogas (a mixture of methane, carbon dioxide and traces of other gases) by micro- organisms. Commonly used substrates for biogas production include industrial waste such as dairy waste, agricultural waste such as fodder residue and manure, and energy crops such as maize (corn). The ability to make biogas out of many different substrates is one of the main advantages of anaerobic digestion over other processes like ethanol production. However, some substrates can be very slow to break down (so that biogas is produced) because-

- They contain chemical that inhibit the growth and activity of the microorganisms.
- They create physical problems like floating, foaming or clumping, and block impellers and pipes in biogas plants. Their molecular structure is poorly accessible to microorganisms and their enzymes (for instance because of their highly crystalline structure or low surface area).

Sometimes all these problems occur at once. Pretreatment can be used to overcome some of these problems. This brochure mainly focuses on substrates with poorly accessible molecular structures (i.e. lingo-cellulosic substrates) which include many agricultural residues such as maize leaves, some industrial residues such as brewers spent grains, and some energy crops such as switch grass. Some emerging biogas substrates also come under this category, such as oil palm empty fruit bunches (EFB). Pretreatment technologies that are used for other substrates such as sewage sludge, but not for lingo cellulose, are covered briefly in section. In biogas substrates, the main sources of methane are sugars and other small molecules. In plants (lingo cellulosic substrates) these small molecules come from the breakdown of starch, cellulose and hemi-cellulose. While starch (α-1-4 linked D-glucose) is relatively easy and quick to break down biologically, cellulose (β-1-4 linked D-glucose) and hemi-cellulose (a polymer of various sugars and uronic acids) are used to maintain the structure of the plant and are by necessity difficult and slow to break down. The breakdown of cellulose and hemi-cellulose is further complicated by the bonds between different cellulose chains (termed cellulose crystallinity) and by the presence of lignin, another polymer which slows down the breakdown process. It is generally believed that lignin cannot be degraded by anaerobic bacteria, although this has been challenged (DeAngelis et al 2011), and may even inhibit the degradation of other substances like cellulose. Pectin also affects breakdown, binding cellulose fibrils together and binding plant cells together (Carpita and Gibeaut 1993). Breaking down this lingo cellulose complex is the key to biogas production (Noike et al 1985).

4.Discussion

It was found that the dwellers of teachers' dormitory, Jessore University of Science and Technology (JUST) produce 133.33 kg household organic solid wastes daily. It can be assumed from the data profile 5.77m^3 biogas can be produced per day in large scale from the daily generated wastes of JUST teacher's dormitory. Yearly biogas production will be 2106.05 m^3; energy production will be 10.66 KWh every day. So, it can be said that annually 3890.9 KWh electricity can be produced from these wastes. Figure 2 shows the power generation process from biogas.

5. CONCLUSION

Biogas was produced quite successfully from household biodegradable solid waste (HBSW) by anaerobic digestion process. Production of biogas in large scale will also ensure the proper utilization of wastes as well as less environmental pollution. This project based on 12 weeks long data collection survey and it was found that

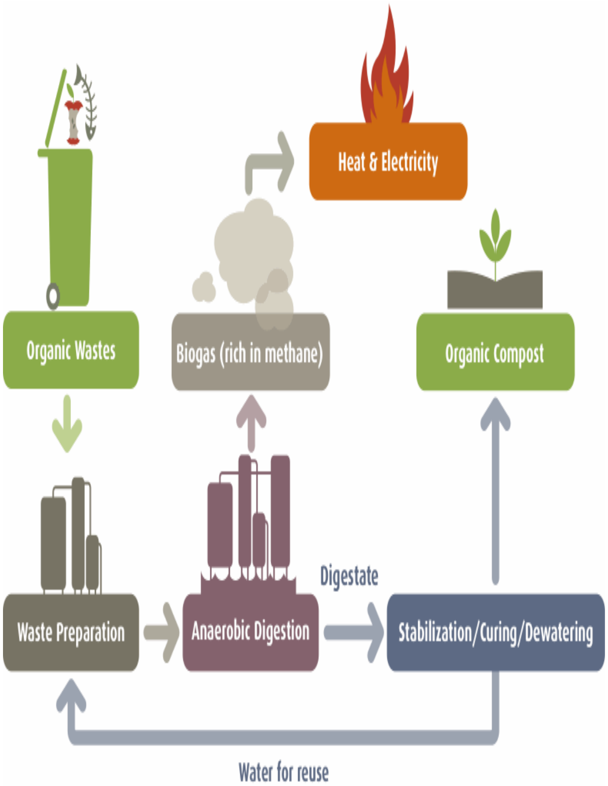

Fig.1: Anaerobic process diagram for biogas production

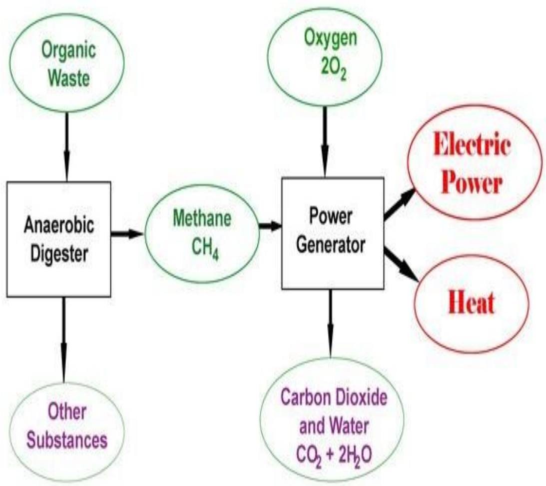

Fig.2: Flow chart of power generation from biogas.

the dwellers of teachers' dormitory of the Jessore University of Science and Technology produce about 133 kg household organic solid wastes daily. In lab scale gas production was 5.77 m^3 per day and annual biogas production will be 2106 m^3 that can support in cooking purposes as well as decreasing dependency on natural gas. Moreover, it can be said that annually 3890 KWh electric power can be produced from the wastes. If proper utilization of these wastes can be done then it can support partially to meet national fuel and energy demand. Government should take necessary steps to increase biogas production from wastes as well as to manage household waste for the betterment of our economy and environment.

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