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Production of Methane Gas from Cow's Residue: Biogas as Alternative Energy in Transportation and Electricity

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Abstract: Biogas is known by many names such as swamp gas, marsh gas, gobar gas etc. It contains about 50 to 60 % methane in it. It is the primary constituent of natural gas. Biogas is also produced naturally from the degradation of plants in such situations as rice paddies, ponds, or marshes. Ancient Chinese experimented with burning the gas given off vegetables and manures were left to rot in a closed vessel. Recently Volto, Beachans, and Pasteur worked with biogas-producing organisms. At the turn of the 20th century, communities in England and Bombay, India, disposed of wastes in closed containers and collected the resulting gas for cooking and lighting. Germany, the United States, Australia, Algeria, France, and other nations constructed such methane digesters to supplement dwindling energy supplies during the two world wars.

Keywords: Biogas.

INTRODUCTION

Biogas is known by many names such as swamp gas, marsh gas, gobar gas etc. It contains about 50 to 60 % methane in it. It is the primary constituent of natural gas. Biogas is also produced naturally from the degradation of plants in such situations as rice paddies, ponds, or marshes. Ancient Chinese experimented with burning the gas given off vegetables and manures were left to rot in a closed vessel. Recently Volto, Beachans, and Pasteur worked with biogas-producing organisms. At the turn of the 20th century, communities in England and Bombay, India, disposed of wastes in closed containers and collected the resulting gas for cooking and lighting. Germany, the United States, Australia, Algeria, France, and other nations constructed such methane digesters to supplement dwindling energy supplies during the two world wars.

Innovation is indispensable in energy sector whereby several researches are done to improve the supply of it. The energy / gas produced from biological beings is called as Biogas. Biogas also refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas is generally produced from raw materials such as agricultural waste, cow's manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is a renewable energy source (J. B. Farrell, C. Gene Haugh, 2011). In this regard a biogas plant is the name often given to a place where the gas is been produced. This requires anaerobic digester that treats farm wastes or energy crops. It can be produced using anaerobic digesters (air-tight tanks with different configurations). See Figure 1.1 – Domestic Anaerobic digester. These plants can be fed with energy crops such as maize silage or biodegradable wastes including sewage sludge and food waste. During the process, the microorganisms transform biomass waste into biogas (mainly methane and carbon dioxide) and digester. The biogas is a renewable energy that can be used for heating, electricity, and many other operations such as internal combustion engine and gas turbines which are suitable for the conversion of biogas into both electricity and heat. High levels of methane gas can be produced when manure is stored under anaerobic conditions. During storage and when manure has been applied to the land, nitrous oxide is also produced as a by-product of the denitrification process.

By converting cow manure into methane biogas via anaerobic digestion, the millions of cattle in Malaysia would be able to produce thousands of tonnes of methane gas and 100 billion kilowatt hours of electricity, enough to power millions of homes across Malaysia. In fact, one cow can produce enough

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manure in one day to generate 10 kg (2.5 BTU –British thermal unit) of gas; only 2.4 kilowatt hours of electricity are needed to power a single 100-watt light bulb for one day. Furthermore, by converting cattle manure into methane biogas instead of letting it decompose, global warming gases could be reduced by 99 million metric tons or 4% (Daniel Ingold, 2012)

Biogas generators or digesters yield two products: The biogas itself and a semi-solid by-product called effluent or sludge. Biogas systems are most popular for their ability to produce fuel from products that might otherwise be wasted--crop residues, manures, etc. The fuel is a flammable gas suitable for cooking, lighting, and fuelling combustion engines. The digested waste sludge is a high quality fertilizer. The digestion process converts the nitrogen in the organic materials to ammonium, a form that becomes more stable when ploughed into the soil. Ammonium is readily "fixed" (bonded) in soil so that it can be absorbed by plants. In contrast, raw manure has its nitrogen oxidized into nitrates and nitrites, which do not *fix" well in soil and are readily washed away.

Moreover, biogas systems offer a means to sanitize wastes. Simply put, these systems are capable of destroying most bacteria parasitic eggs in human and animal wastes, and enabling the digested sludge to be applied safely to crops. Tests have shown that Biogas systems can kill as much as 90 to 100 % of hookworm eggs, 35 to 90 % of ascarid (i.e., roundworms and pinworms), and 90 to 100 % of blood flukes (i.e., schistosome flukes, which are found in water, snails that commonly live in paddy fields and ponds). Biogas systems are also capable of digesting municipal sewage, which is a major source of pollution. Using biogas systems in this way substantially reduces the potential for environmental pollution. Finally, agricultural and animal wastes, the major raw materials for biogas production, are usually plentiful in rural areas. People living in rural communities, who are often, subjected the price and supply fluctuations of conventional fuels to fertilizers, can benefit directly from biogas systems. And It should be noted that, while this paper focuses on the production of biogas for fuel, in some applications the gas is considered to be the by-product of the process. Some digesters in China, for example, are used primarily for treating sewage producing fertilizer, and only secondarily for producing fuel.

PRODUCTION PROCESS

Cow dung which was considered as a waste, or product with little or no value in the past, is now gaining value with the recent research which shows that cow dung can produce methane gas in large quantity. Methane gas can be used for domestic cooking, transportation fuel and to generate electricity. Bio-gas methane is highly flammable. Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as cow dung (manure), sewage, municipal waste, green waste, plant material, and crops. This paper shall focus on the production of biogas using cow waste. The following is the step-by-step on how to produce methane gas from cow's waste. To produce biogas the following materials would be needed.

- Anaerobic Digester
- Collector
- Cow dung
- Water

Materials

The materials proposed to be used for this project were cow's dung, waste paper, and water hyacinth. Pre-treatment operations involved weighing about 500g of freshly harvested water hyacinth and allowing it to sun dry for a period of 30 days, after which they were dried in an oven at 600C for 5hours. The cow's dung was sun dried for a period of 20 days to preserve its microbial population and then crushed mechanically using a mortar and pestle. The dry weights of these biomasses were weighed with a weighing balance (Mettler P.No. 163) into digesters.

Step-By-Step Process

Digester

Anaerobic Bio-digester simply means biological action on bio-degradable material in the absent of oxygen, a digester needs to be in place. A typical 50kg will have two lids, so the bigger one will be used as slurry inlet, which is to pump methane gas to the collector.

Gas collector

While many methods can be used to collect gas generated from the digester, a floating gas-collector is suggested for this project whereby two drums are involved. One is 30 litters plastic and the other one is

20 litters metal drum. The 30 liters is for water and 20 litter drum is for gas. A gas lock is attached to the smaller lid which will extract gas from digester.

Gas Production

Once digester is ready, the proportion of cow's dung to be mixed with respective ratio of water and the same has to be poured along with slurry into digester via the slurry inlet. A gestation of 15 days is required for this chemical process and finally Methane Gas is ready, and flame test can be carried to check its content.

Calculation of Volume

There are several methods to calculate the amount of biogas that can be produced from a certain feed-stock/ substrate. Calculating on the basis of Total Solid (TS) content

- One tonne of TS can produce 200 ccm of biogas, thus 1 kg of TS will produce 0.2 m3 of Biogas.
- One Kg of dung contains about 20% TS.
- Now, 1 kg of dung which contains 20% TS will produce, 0.2*0.2 = o.04 m3 of biogas.
- 1 kg dung will produce 0.04 m3 of biogas.
- Hence, 1/0.04 = 25 kgs is required to produce 1 m3 of Biogas.
- Density of biogas is 1.15 kg/m3
- Mass (required here is 1 kg)
- Volume required to make 1 kg biogas = mass (1 kg)/ density (1.15 kg/m3) = 0.86 m3.

Therefore to produce 1 kg of biogas we may need approximately 22Kgs of cow's dung (0.86*25 = 21.7)

Please note the above calculation has been conducted without the addition of water. Generally a 1:1 ratio of feedstock is to water is taken. This will alter the calculations significantly. Similarly, biogas yield can be calculated on Volatile solid (VS) content, which is a percentage of TS content. Another way is to base your calculations on the Chemical oxygen demand (COD) of the substrate. Though COD methods are generally employed for waste water treatment

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