GENERATION OF BIOGAS AS AN ALTERNATIVE ENERGY SOURCE FOR DOMESTIC PURPOSES

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Abstract

This work deals with the production of biogas from cow dung and fowl droppings (biomass). The model for our demonstration is a poly-plug flow digester. The biomass is fed into the digester in a slurry form. Under conducive conditions, anaerobic bacteria act upon the biomass and produce biogas, which is channeled to a gas reservoir through a piping system. A gas escape valve is fitted within the system to serve as a pressure relief valve.

The piping system continues after the reservoir and terminates at a burner fitted with a gas control valve. A flame test carried out on the system produced a smoke-free, sooth-free, blue flame. The digester efficiency- was determined to be 64%. After digestion of the biomass, the left over can be used as good manure for soil fertility, which is apparently free from harmful chemicals and serves to promote sustainable agricultural practices.

Introduction

The overall economic development of a country largely depends on the availability and consumption of energy. The categories of energy resources available can be classified into two: renewable and non-renewable. The non-renewable sources, also called fossil are readily in use in Nigeria and their energy deposits are continuously depleted by our withdrawals. However, the renewable sources of energy, which are being deposited everyday, are not fully in use. Bio-energy which is an alternative and cheap source of the renewable energy and which can be made available to both the rural and urban areas of the country spells a viable option.

Bio-energy is stored in biomass. Biomass materials include wood, grasses and other herbage, grain and sugar crops, crop residues, animal manure, food processing waste, kelp from ocean farms, oil bearing plants and other materials. Biomass can be converted to energy through direct combustion, thermo-chemical conversion processes, bio-photolysis and biological conversion processes. Biological conversion processes may either be by fermentation or by anaerobic digestion. The anaerobic bioconversion of biomass produces a mixture of carbon (iv) oxide, traces of other gases, and methane called biogas.

Apart from the problem of non-renewability of fossil fuels, they are also not domestically available when compared to biomass, which is always readily available and just laying around waiting to be harnessed. Also, the technological feasibility of obtaining fossil fuels is very low and economically demanding. In addition to the problem of environmental pollution caused by fossil fuels, even the methane resulting from the anaerobic digestion of un-harnessed biomass (e.g. cow dung) while composting escape to the atmosphere. This adds to the accumulative green house gases causing ozone layer depletion, but when burnt, it produces carbon (iv) oxide, which results in the abatement of climatic changes (Charles and Sanders, 1986),

In today’s energy conscious world, alternative forms of energy are becoming more and more important in deciding the future of the world’s energy needs. Anaerobic digestion is the most efficient process of capturing energy from biomass. Unlike fossil fuels, biomass is a natural by-product that is not hidden under the ground. It has no question of existence, do not require extraction from its source but is regularly deposited on daily basis and is economical. The purpose of this work is to promote anaerobic digestion as an environmentally friendly method of waste reduction and energy recovery. It also aims at providing an alternative energy supply for domestic purposes (cooking) such that families can easily turn away from the traditional fire place and have a biogas plant installed to provide energy for cooking and even lighting. This provides a smoke-free and ash-free kitchen meaning that women will no longer be prone to lung and throat infections and can look forward to a longer life expectancy. Waste will no longer be stored in the home but will be fed directly into the biogas plant along with toilet waste thus resulting to improvement in the standard of hygiene and sanitary conditions. Biogas is used to heat and light homes, to cook and even to fuel buses. It has been called swamp gas or sewer gas at different points in time (Onyi, P. N.. 2004)

Anaerobic digestion can be described as a two-stage process accomplished by several types of bacteria, which flourish in absence of oxygen. In the first stage (acidification stage), acid-forming bacteria called acidogens break complex organic waste down into simpler fatty acids. In the second stage (methane production stage), methanc-lbrming bacteria (metlianogens) consume the acids produced by the acidogens. generating biogas as a metabolic by-product.

Anaerobic processes can be managed in a '"digester" (an air tight vessel) or a covered lagoon (a pond used to store manure) for waste treatment. The primary benefits of anaerobic digestion are nutrient recycling, waste treatment and odour control. Biogas produced in anaerobic digesters consists of methane (50"<i-8()%), carbon (iv) oxide (20%-5()%) and traces levels of other gases such as hydrogen, carbon (ii) oxide, nitrogen and hydrogen sulphide. The relative percentage of these gases in biogas depends on the feed material and the management of the process. When burned 0.028cubic meters, (a cubic foot) of biogas yields about 2.52kcal (10 Btu) of heat energy per percentage of methane composition?

Materials and Methods

Much of the agricultural and biological wastes are good substrate for biogas production. Based on the availability and accessibility, coupled with the production levels of divers' wastes, we decided to produce biogas from a mixture of cow dung and poultry droppings. The first operation involved was the removal of the dirt, sand, stones, bricks, etc before loading the digester, which was suitably insulated to preserve the temperature of the process. The waste mixture was mixed with water to form slurry and then, was loaded into the digester (Biogas generator). The slurry comprised of carbohydrates. proteins and fats, which were worked upon by the consortium of bacteria to produce biogas. The biogas formed bubbles in the mixture, and collected at the top of the digester. It was piped to a lager balloon-like bag (or storage vessel) where it was stored until needed. The ambient range of i’ll required to prevail in the mixture is between 6.2 and 7.8.

As the rate of production of biogas in the digester began to slow up. the slurry was replaced with a fresh supply to start the process'again. The old material was unable to produce anymore biogas but still contained large amount of plant material and other organic matter. It was dried to form a rich black soil that could be spread on Helds as a fertilizer. Three digesters were set up and were subjected to varying conditions of temperature, alkalinity/PI I ranges and tests conducted to ascertain the optimum conditions for maximum biogas generation. The results are as recorded below.

Results

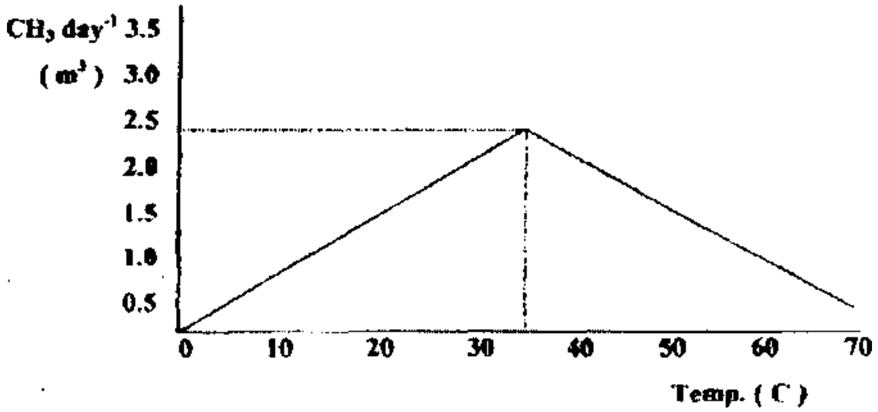
Factors that Influence/Affect the Rate of Biogas Production

The ultimate yield of biogas depended on the composition and biodegradability if the organic feedstock but its production rate was dependent on the population of microorganisms, their growth condition, fermentation temperature and dilution with water.

1. Temperature

The anaerobic digestion process is carried out by a delicately balanced population of various bacteria that can be very sensitive to changes in the environment. The temperature is a prime example. It was determined that .15 degree Celsius (95 degree fahrenheit) is an ideal temperature for anaerobic digestion. As the temperature fell, bacteria activities decreased and consequently biogas production also decreased. As the temperature increased, some began to die and once again biogas production decreased.

Generation of Biogas as an Alternative Energy Source for Domestic Purposes **Fig. 1: Methane Production Per Day at Vary ing Temperature**



2. Alkalinity and PH

Alkalinity is a measure of the amount of carbonate in the solution. The PH indicates acidity or basicity of a solution. A PH greater than 7 indicates a basic solution and a PH less than 7 indicates an acidic solution. Alkalinity is important because as acid is added to the solution, carbonates will contribute to the hydroxide ion, which tend to neutralize the acid. This is known as the buffering effect of alkalinity. As the acid-forming bacteria produced acid, the methane - forming bacteria utilized the acid and maintain a neutral PH. Since the reaction rate involving the acid forming bacteria proceeded much faster than the reaction involving methanogens, a larger population of methanogens were nurtured and maintained. In order to allow methanogens population to grow, the digester was initially fed in very small amounts and was often buffered by raising the alkalinity. This was achieved by adding baking soda, which raised the PH to approximately 7.5.

3. Volatile Solids (VS)

VS are a measure of the amount of organic material in the waste. If too much organic matter is added, the acid-forming bacteria can convert the organic matter to acids before the methanogens can use the acids. The resulting acid accumulation will cause the digester to fail because the methanogen bacteria cannot survive in highly acidic condition. A safe loading rate for the digester was found to be 1kg VS/(m'day). Optimum VS loading rates usually vary between 1 and 4.

4. Hydraulic Retention Time (HRT)

HRT is the measure of the amount of time the digester liquid remains in the digester. A good way of considering HRT is that if a 200 litres digester is horizontal with the input on the left, output on the right, and not mixed, it will take 20 days for that which is put on the left to come out on the right if 10 litres is added and removed each day. HRT is crucial because if the feed does not stay in the digester long enough for the entire digestion process to take place, biogas will not be produced.

5. Carbon-Nitrogen Ratio

Just as a balanced diet contributes to a healthy person, a balance diet helps maintain a stable healthy bacteria .population. Anaerobic⁻ bacteria commonly use carbon .as energy source for growth anti nitrogen to build cell structure. It was discovered that the bacteria required 25-30 times more carbon than nitrogen. The bacteria most ellieienlly utili/cd feeds, which bate a carbon-nitrogen ratio of 30:1.

Operational Time Duration

The initial setting up of the digester took about eight hours. The digester was monitored and fed once every two days and half an hour was spent each time on this activity. A reasonable quantity of gas was generated within the first twenty-eight days, hence a total of seven hours was spent in feeding and monitoring the digester. During flame test, the gas was burnt for ten minutes. Thus, a total fifteen hours, then minutes was spent on the entire processes.

The table below shows, for the digester set up under optimum conditions. the several activities and the lime taken to earn them out from the initial setting up to

Table 1: Activity / Time Duration for Optimum Performance

Activity	**Duration (hrs)**
Initial design, fabrication and	8
feeding and monitoring the	7
Flame test	1/6
Total	15 1/6

when a reasonable quantity of'gas was generated.

Efficiency of the Digester

In calculating the efficiency of the digester, the volume of the volatile solid. VS of the biomass was used as the major parameter.

I Inis, the digester efficiency =

$$\frac{\text{Volume of } VS_{in} - \text{Volume of } VS_{out}}{\text{Volume of } VS_{in}} \times \frac{100}{1}$$

$$\frac{(14 - 5)\text{ litres}}{14 \text{ litres}} \times \frac{100}{1}$$

$$= \quad {}^{9}/_{14} \times 100 = 64.29\%$$

$$\therefore \quad \text{Efficiency of the digester} = 64.29\%.$$

Discussion

1. Temperature control is an important consideration in designing digesters. Anaerobic digestion will occur even at room temperature, however, any method of maintaining digester temperature constant near 35C will improve digester performance. Any novel means of maintaining the temperature are encouraged.
2. The bacteria population responsible for methane -production nourishes under anaerobic conditions, over a relatively narrow temperature range and over a narrow PI I range of 6.2 to 7.8. Digester starting is an especially critical time. On feeding the digester initially, acid-forming bacteria quickly produce acid, The methanogens may not be sufficient to consume the acid produced and maintain a neutral PI I. If the PI I drops below 6.2. the methanogen population begins to die thus making the bacteria population further unbalanced. The digester acidifies and consequently produces no biogas.

Conclusion

1. Biodegradable wastes can be harnessed and used as an alternative energy source for several domestic purposes, specifically cooking. This will reduce the present state of over-dependence on the non-renewable energy sources like the fossil fuels. It will also curb the menace of wood felling and the attendant problems of environmental degradation like ozone depletion and green house effect.
2. The use of this cheap source of energy is recommended for communities, institutions and the nation at large.

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