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Full Length Research Paper

Effect of cow dung variety on biogas production

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Biogas is a renewable, alternative and sustainable form of energy from the action of bacteria when waste vegetable matter, organic waste and some industrial waste are fermented in the absence of oxygen. This study was conducted to find the effect of cow dung variety on biogas generation. Some samples of fresh cow dung (2 Kg for each breed of cow) of cows which were not exposed to treatment with anti-biotics for some weeks, were collected from Sobere Farms and mixed with water in ratio of 1:1 volume and the mixture was loaded into a bio-reactor to ferment. The Hydraulic Retention Time (HRT) was 9 to 14 days. The reduction in retention time was achieved by adding human excreta and urine into the digester to increase micro-organism and pathogenic activities. The biogas obtained after 11 days was gathered and analyzed in a 250-Gas Chromatograph and Integrator. The results showed the percentages and calculated energies (calorific values) of biogas from the cow dung of four (4) selected varieties of cows, namely, Holstein Friesian, Simmental, White Fulani and Jersey, which were fed with concentrates in equal proportions and at the same time for some weeks. The Holstein cow has methane (CH_4), (84.916%) and 196.199 cal/m^3 of energy, Jersey cow (69.233%) and 159.963 cal/m^3 of energy, (60.459%) and 149.235 cal/m^3 of energy for Simmental cow and White Fulani cow has (85.331%) with 197.157 cal/m^3 of energy respectively. The results indicate that the White Fulani cow has the higher quantity of combustion energy than the other breeds of cows.

Key words: Effect, White Fulani, Holstein, Jersey, Simmental, biogas, percentages, cow dung.

INTRODUCTION

There is an ongoing life cycle as plants and animals die. Plants and animals die and are recycled to keep and sustain life on the planet. In the presence of oxygen, organic material "composts" (undergoes aerobic decomposition) and when decomposition occurs in the absence of oxygen (anaerobic conditions), methane gas is produced, and the liquid remaining is rich in nitrogen and other nutrients (Village Earth, 2010).

Biogas as an energy source can be converted to benefit Nigeria domestically and to power our industries and small scale enterprises. This is possible in Nigeria where agricultural, human, domestic and industrial wastes are in large supply. This research was carried out with the purpose of discovering which breed of cows is most effective for biogas generation, particularly in the West-African sub-region. Past research efforts were largely on the biogas content from cows, but this research is interested in knowing percentages from various and specific varieties of cows. This is to assist the government, individuals and the private sector to concentrate in farming the breed that has the highest content biogas and for meat and milk respectively. In addition, this research narrowed and concentrated on biogas (CH_4) that is available in the local White Fulani breed, which is the predominant breed of cow in Nigeria

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and the West-African sub-region. The work is intended to boost current research materials in biogas production area and widen academic interest. Proper use and application of the abundant wastes (cow dung) in Nigeria can be used to generate biogas for cooking, lighting and power generation by operating a dual fuel engine. This and other immeasurable uses and benefits developing countries stand to drive from biogas that makes it absolutely necessary to look into this subject.

Nigeria is tremendously blessed with a variety of energy resources (both conventional and non-conventional). The reserves for animal waste alone which is a viable source for biogas production as at 2005 was estimated to be 61.00 million tonnes/yr and crop residue was put at 83.00 million tonnes/yr. However, 50 and 400 MW of electricity is targeted to be generated from biomass by 2015 and 2025 respectively (Esan, 2008).

Biogas is a renewable, alternative and sustainable form of energy (Bio Applications Initiative, 2008). Not only does biogas technology help to produce an alternative energy source, but it also helps in maintaining the environment and improving health conditions.

The energy in plant vegetation, animals, industrial and domestic waste matter can be released in terms of a useful gas when fermented anaerobically, that is, in the absence of oxygen. The biogas formed after the decomposition of organic wastes is channeled or transported to homes for use for cooking, running engines, electrical power generation and heating, with virtually little or no pollution at all. This gas is now used in large scale in many countries.

Biogas production and use dates back to 2,000 years. It is a valuable fuel which in many countries is being produced in purpose-built digesters, filled with the feedstock like manure or sewage. There are indications that biogas has been in use for many years. However, anecdotal evidence indicates that biogas was used for heating bath water in Assyria during the 10th century BC and in Persia during the 16th century AD (History of Biogas, 2011).

Marco Polo mentioned the use of covered sewage tanks. It probably goes back to 2,000 to 3,000 years ago in ancient Chinese literature (Dekker and Lewis, 1983).

Biogas is a mixture of methane, cabon dioxide and traces of hydrogen sulphide (Nijaguna, 2002). It is generated from human excreta, animal dung, poultry droppings, and sewage sludge, among others.

If the fermentation is done in the absence of air, the gas produced may contain the concentration of methane (CH_4) as high as 70 to 75%; the remaining gas is mostly carbon dioxide ($C0_2$), hydrogen (H), Hydrogen Sulfide, and traces of nitrogen compounds such as Ammonia (NH_3). When animal, plant vegetation and domestic wastes are allowed time, they are acted upon by anaerobic bacterial to produce a gas which is commonly referred to as biogas. This natural gas or “marsh gas” can be used as a rich source of fuel and power generation (Biogas Plants, 2010).

MATERIALS AND METHODS

Samples of cow dung (2 kg) were obtained from the Jersey cows, Holstein Friesian cows, White Fulani cow and Simmental cows respectively. The cows were all fed in equal proportion and at the same time before the samples were collected, with di-calcium, premix, Soya meal, wheat offal, cotton seed, molasses and cotton husk. The cows were monitored for two weeks and ensured were in good health conditions and were not treated with antibiotics within the weeks prior to samples gathering. The reason is that the presence of antibiotics in the mixture can affect biogas generation and destroy micro-organism and pathogens that aid biogas production. The fresh cow dung was weighed and mixed with water to form slurry (water and cow dung) in a ratio of 1:1 by volume.

Fresh human excreta, grinded water hyacinth and urine were added to the mixture to hasten the generation of biogas and also served as starter. Also, the generation of biogas is enhanced by the presence of metal ions in the biomass (Geeta et al, 1990; Obayomi, 2008).

The 263-50 Gas Chromatograph, D2500 Chromato-Integrator and Gas Sampler were used for the collection and analysis of the biogas samples collected from the bio-reactor. Temperature of the substrate is a major factor in the production of biogas. With a mesophilic flora, digestion proceeds best at 30 to 40°C.

Retention period was reduced due to the application of the human waste or excreta as a starter to enhance quick production of biogas. Within 9 to 14 days the biogas generation commenced. The pH value of the slurry was kept at a favourable value of about 6.8. This was achieved after some sample of the dung was mixed with water and the pH taken by a pH meter.

The gas sample was introduced into the 263-50 Gas-Chromatograph which was connected to a D2500 Chromato-Integrator and charged for a period of 13 min. The results were plotted on graph by the D2500 Chromato-Integrator and summary given within 13 min by the Integrator. The results indicate the presence of Air (Oxygen and Nitrogen), CH_4, CO, N, CO_2 and traces of other gases.

The content of the gas was analyzed using the 263-50 Gas-Chromatograph with the results displayed by the aid of D2500 Gas Chromato-integrator.

RESULTS AND DISCUSSION

Tables 1 and 2 revealed the calorific values and percentages of biogas collected from Jersey, Simmental, Holstein Friesian and White Fulani respectively. The tables and the gas Chromatograph plots revealed 69.233, 60.459, 84.916 and 85.331% of CH_4 gas for Jersey, Simmental, Holstein and White Fulani cows respectively.

The researcher observed that even in terms of weights, breeds of cows differ from the other and that can be a contributing factor in the amount of biogas obtained from each of the breeds. Also, the variation in the results according to the researcher has to do with the nature of the cows, feeds and the environment. The White Fulani which is predominantly found in Nigeria and the West-African sub-region in large number feeds most often on green grasses and marine plants grown along river banks which are high density energy plants.

Table 1. Moles percentages and composition of biogas for Jersey, Simmental, Holstein and White Fulani cows.

Composition of biogas matter	Chemical formula	White Fulani (%)	Holstein (%)	Jersey (%)	Simmental (%)
Methane	CH_4	85.331	84.916	69.233	60.459
Carbon dioxide	CO_2	13.011	14.89	22.911	27.991
Nitrogen	N_2	1.596	0.177	7.800	11.484
Carbon monoxide	CO	0.13	0.001	0.001	0.021
Air	(N +O)	0.048	0.010	0.055	0.045
Total	-	100.00	100.00	100.00	100.00

Table 2. Calorific values of biogas obtained from Jersey, Simmental, Holstein and the white Fulani cows.

S/No.	Cow species	Percentage methane	Calorific value (Cal/m^3)
1	White Fulani	85.331	197.157
2	Holstein Friesian	84.916	196.199
3	Jersey	69.233	159.963
4	Simmental	60.459	149.235

Also, the percentages of carbon dioxide (CO_2) in the biogas are 22.911% for Jersey, 27.991% for Simmental, 14.896% for Holstein and White Fulani is 13.011% of CO_2. These values agreed with the 35 to 45% (Nijaguna, 2002).

Air was relatively low with a proportion of 0.055% for Jersey, 0.045% for Simmental, 0.010% for Holstein and 0.048% for White Fulani. With additional bleeding, the air can be totally removed out of the digester. Obichigha (2005) values for Nitrogen are in the same range with the 7.800% in Jersey, 11.484% in Simmental, 0.177% in Holstein and 1.596% in White Fulani.

The analysis showed the order of elution with White Fulani having 85.331% of CH_4 gas, 0.048% of air, 0.013% carbon monoxide, 1.596% nitrogen and carbon dioxide 13.011% respectively. This was followed by Holstein Friesian which has 84.916% of methane gas, 0.010% of air, 0.001% of carbon monoxide, 0.117% nitrogen which appeared to be the lowest and 14.896% carbon dioxide gas. Jersey has 69.233% of methane, 0.055% of air, which is the highest so far, 0.001% of carbon monoxide, 7.800% nitrogen and 22.911% of carbon dioxide which is the highest. The Simmental cow has 60.459% of CH_4 gas the lowest percentage in the four (4) cows analyzed, 0.045% of air, 0.021% of carbon monoxide, 11.484% of nitrogen and 27.484% of carbon dioxide which is the highest amongst the four cows analyzed.

The table revealed that hydrogen, hydrogen sulfide and other gases were not eluted. The researcher is convince that further research into the variations in composition of CH_4, CO_2, CO, air, Nitrogen and other gases, for the varieties of cows is necessary to ascertain the primary cause for the differences.

In Table 1, the percentages of CH_4, CO_2, N_2, CO and air (O + N) in each of the four cows were arranged as eluted by the D2500 Gas-Integrator.

In Figure 1, Series 1: Represents the White Fulani cow composition of biogas 85.331% CH_4, 13.011% CO_2, 1.596% N_2, 0.13% CO and 0.048% air. Series 2: Represents the Holstein Friesian cow percentages, 84.916% CH4, 14.89% CO_2, 0.177% N_2, 0.001% CO and 0.010 of air. Series 3: Represents the Jersey cow composition of methane (69.233%), Carbondioxide (22.911%), Nitrogen (7.800%), Carbon monoxide (0.001%) and air (0.055%). Series 4: Represents the biogas composition of Simmental cow (60.459% CH_4, 27.991% CO_2, 11.484% Nitrogen, 0.021% CO and 0.045% of air respectively.

Table 2 content the energy or calorific values of biogas. The White Fulani cow has 197.157 cal/m^3 of energy, Holstein Friesian has 196.199 cal/m^3, the Jersey cow has 159.963% cal/m^3 and Simmental (149.235 cal/m^3).

In Figure 2, the energy of 197.157 cal/m^3 (28%) represents the energy from the White Fulani cow with methane composition of 85.331%, 196.199 cal/m^3 (28%) is for the Holstein cow, 159.963 cal/m^3 (23%) represents the energy from the Jersey cow and 149.235 cal/m^3 (21%) is for Simmental.

From Tables 1 and 2, the research showed that White Fulani cows are the most effective in terms of production of biogas among the four (4) cows studied. This is probably attributed to the nature of the feed (mainly green grasses) the local White Fulani breed feeds on. Therefore, government and individuals interested in biogas generation need to harness and take this advantage to enhance biogas production.

Conclusion

The research looked into the effect of biogas production from variety of cows. The White Fulani, a predominant

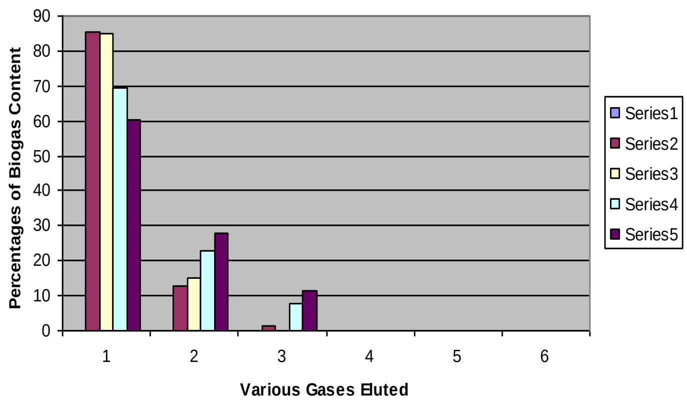

Figure 1. Analysis of cow dung produced from White Fulani, Holstein, Jersey and Simmental.

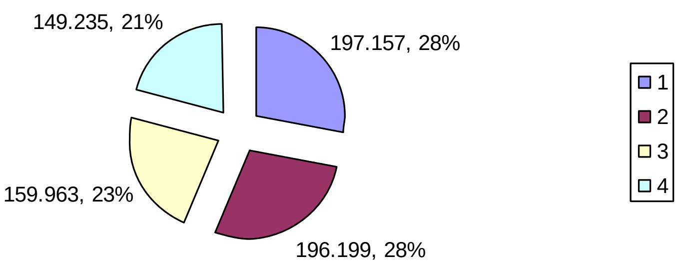

Figure 2. Energies generated from cow dung of White Fulani, Holstein, Jersey and Simmental.

variety in Nigeria and the West-African sub-region content the highest percentage of biogas. The methods and materials used prove that the white Fulani has the highest percentage of bio-energy as compare to other breeds studied. The shortage of energy for cooking, lighting and power generation, which is a problem in the developing nations of Africa, especially West-Africa, can be solved by the abundance of this local breed of cows. The methane from the White Fulani cows can be used to ameliorate the energy crisis, improve standard of living, generate employment and reduce incidences of deforestation in West-Africa. Therefore, Nigeria as a nation need to be really committed to energy production by utilizing the numerous sources of energy available to it and engage in production of bio-fuel which source is readily available. The government and private sector need to mobilize energy resources in cow dung, particularly the White Fulani and other wastes to ensure energy is provided to Nigerians. Also, the researcher believes that further research into the variation in the percentages of biogas production for each breed will go a long way in enriching energy production capacities of nations.

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