

Characterization of Biogas Production from Anaerobic Digestion of Animal & Plant Wastes

Ezema E.E¹, Ani S.E², Onyia P³

¹Electrical/Electronic Engineering Dept, Enugu State University of Science & Technology

^{2,3}Electrical/Electronic Engineering Dept, School of Post Graduate Studies, Enugu State University of Science & Technology

Abstract— The negative impact of the increased use of fossil fuels for energy generation and consumption has reached a global dimension and can no longer be over looked. All efforts are now being geared towards an alternative source of energy, renewable in nature and more environmental friendly in use. This study investigates the production of biogas – a renewable energy from the anaerobic digestion of three different types of biodegradable wastes (Cassava peelings and poultry droppings, Beans waste and poultry droppings, Cassava peelings and beans wastes) as an alternative to fossil fuels for energy consumption. The study was carried out using a 0.1m³ capacity biogas digester constructed to investigate the anaerobic digestion in generating biogas. The experiment was batch operated and daily gas yield from the plant was monitored for 24 days. During this period, many operation factors were monitored to determine the effect each of them has on the biogas generation. These factors monitored are temperature changes, Pressure changes, pH changes, changes in alkalinity, Cassava peelings and poultry dropping generated the highest maximum biogas of 0.035m²/kg/day at a PH value of 7.35 on the 19th day. This was followed by poultry droppings and beans mixture. Cassava peelings and beans waste had the least volume of biogas. This treatise assets that biogas is not only a renewable energy source but has a dual function of waste management in the course of its production.

Keywords— Biogas, Renewable energy, Anaerobic Digestion, Waste, Fossil.

I. INTRODUCTION

Three major challenges to any nation and the world in general today are rise in energy need of the citizens, waste management and problems arising from environmental degradation such as green house effect, deforestation, desertification, flooding, global warming etc. These aforementioned problems are directly or indirectly linked to the use of energy sourced from fossils. The singular solution to these problems is seeking alternative sources of renewable and environmental friendly energy like biogas.

Biogas is a mixture of colourless, flammable gas obtained by the anaerobic digestion of plant based organic waste material [1]. Biogas is typically composed of 50-70% Methane, 30-40% carbon dioxide and traces of other gases [2]. In Nigeria, there are abundant of wastes arising from the domestic and agricultural sources of which the potential has not been tapped [3,4]. A look around every city in Nigeria shows enormous dumps every here and there of wastes lining up everywhere and polluting the environment. These could be re-cycled and used in biogas production.

Anaerobic biodegradation of cellulose materials is a biological process, the end product of which are a methane-rich gas called biogas and spent slurry of fertilizer vale. It is a process by which organic materials such as straw, weeds, human or animal excrements, garbage, sludge, domestic sewage and organic liquid wastes from factories etc are degraded by huge amount of various microbes of different functions under anaerobic conditions to yield methane in the end [5]. Biogas technology has advantages which include amongst others; treated digested sludge mixed with molasses and grains is said to have high nutritional value equivalent to cowpea meal with which birds can be fed [6]. It is a process having the potential for sterilization which can reduce public health hazards from faecal pathogens and if applied to agricultural residues, a reduction in the transfer of fungal and plant pathogens from one year's crop to the next [7]. The earlier problems mentioned infesting nations could be easily solved by the adoption and implementation of biogas technology. This has been the goal of this research work.

II. MATERIALS AND METHODS

2.1 Sample collection

The wastes used in the testing of the digester were poultry droppings mixed with Cassava peelings, poultry droppings mixed with beans waste (these included the beans coats removed during the preparation of 'akara', infested beans removed during picking, etc). Thirdly, cassava peelings mixed with beans waste. The poultry droppings were procured from poultry farmers

along Ugwogo-Nike road. They were dried and bagged dry. The cassava peelings was procured from local garri producers at Ugbo Odogwu while the beans waste was procured from 'moimoi' and 'akara' producers at eke Obinagu market. These three groupings of wastes were used in feeding the digester in the experimental anaerobic batch digestion runs.

2.2 B: Slurry Preparation

In the setup, an expected biogas production per day was fixed at 100litres. Batch operation was selected which entailed one of the procured waste mixtures at each run time. Different analysis were carried out on the feedstock to determine Carbon-Nitrogen ratio, moisture content, Carbon content, Nitrogen content, total solids, volatile solids etc. It is also pertinent to mention here that the water to waste ratio used was 2:1.

2.3 C: Digester charging

After measuring and mixing of the wastes, the digester was charged with wastes, the inoculums and then the calculated volume of water. Part of the waste mixture goes in first, followed by about half of the inoculums and the remaining wastes. The entire content was vigorously shaken to allow for homogeneity. The inlet pipe which has been hitherto open was closed and locked. The digester content is then allowed to undergo digestion for a retention period of 30 days with daily measurement of gas yield.

III. RESULTS AND DISCUSSIONS

The digester performance evaluation was carried out using the following operational parameters.

- Daily gas production measurement by downward displacement of water in the gas collector.
- Temperature changes during biogas production

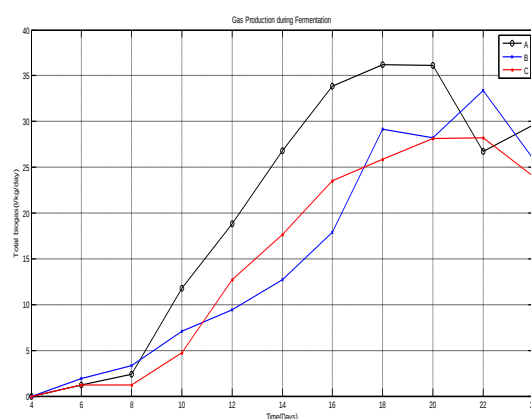


FIGURE 1: Gas generation during fermentation: A-Poultry Droppings + Cassava Peelings +Water, B-Poultry Droppings+Beans waste + water, C-Cassava Peelings + Beans waste +water

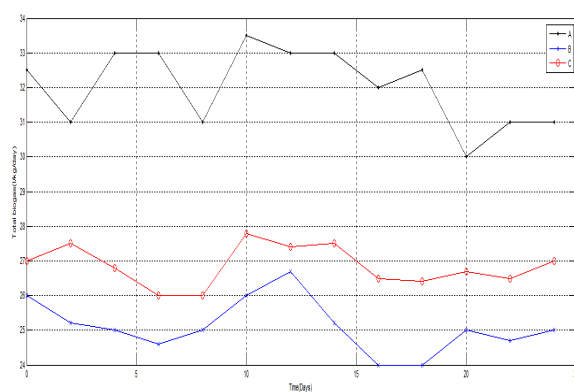


FIGURE 2: Temperature changes during Fermentation, A-Poultry Droppings + Cassava Peelings +Water, B-Poultry Droppings +Beans waste + water, C-Cassava Peelings + Beans waste +water

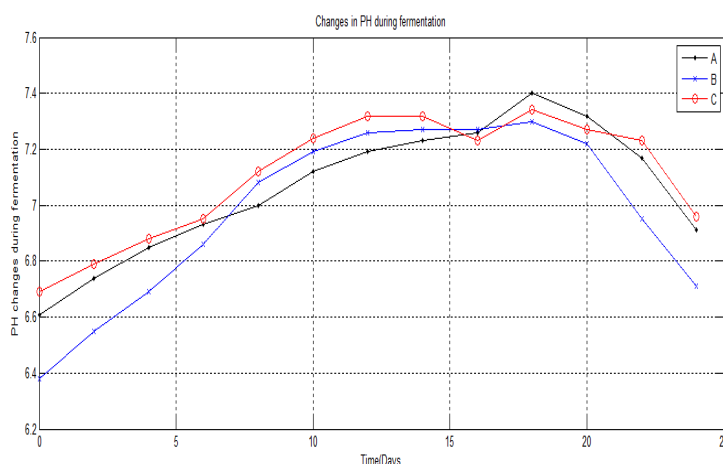


FIGURE 3: PH changes during Fermentation, A-Poultry Droppings + Cassava Peelings +Water, B-Poultry Droppings +Beans waste + water, C-Cassava Peelings + Beans waste +water.

3.1 A: Volume of biogas produced by each waste.

Figure1 above shows the volume of biogas produced by each of the constituents of A(poultry droppings and cassava peelings), B(poultry droppings and beans waste) and C(cassava peelings and beans waste) within the retention period of 24 days. It could be seen that there was no biogas production in the first 5 days. This is because biogas production rate in batch condition is a function of methanogenic bacteria [8]. Maximum production of biogas was 35.2l/kg/day on the 18th day of biodegradation in the poultry and cassava mixture. The temperature at which this maximum gas yield was attained is 32.4°C as seen in figure 2. In beans waste and poultry mixture, a maximum of 33l/kg/day was attained while that of the mixture of cassava peelings and beans wastes yielded 28.4l/kg/day during the same period of time.

3.2 Effect of Temperature on gas yield by wastes

Temperature has been observed by most biogas researchers to be quite critical for anaerobic digester since methane producing bacteria operate most effectively at temperature of 30°C -40°C or 50°C -60°C [9]. In this study, a temperature range of 26 – 32.5 was operated. The effect of temperature on the gas yield is shown in figure 2. Generally, a temperature run of 25°C-45°C is regarded as the mesophilic fermentation temperature while that of 45°C – 50°C is regarded as thermophilic. From the gas yield of the three different constituents' mixtures, it could be seen that the quality and quantity of biogas production using farm or agricultural materials are function of nature and composition of the digester feedstock. This is similar to the report of [9].

3.3 Effect of PH changes on gas yield by wastes.

PH changes in the course of this experiment are shown in figure 3. The PH of any medium affects microbial population and action. In the fermentation process, it affects the rate of biogas production. From figure 3, it is seen that the PH was low at the first 6 days, dropping to below 7.0. This is sequel to the breaking down of organic matter and production of volatile fatty acids by acid forming bacteria. After the first 8 days, the acid forming bacteria were possibly dislodged by the methane forming bacteria. This informed the breaking down of acids by the methanogens to methane and the gradual rise of the PH. From figure 3, beans waste and cassava gave a maximum PH of 7.4, followed by poultry droppings and beans waste with 7.37 and lastly,

7.32 by poultry droppings and cassava. It could also be observed that between the 18th and 20th days of the fermentation, maximum PH was obtained. After this, a gradual drop in PH is seen till the end indicating once again that the methane producing bacteria has dislodged the acid forming bacteria thus inhibiting gas production.

The changes in PH are probably due to temperature variation or pressure of toxicants or inhibitors or both. From the result shown, biogas production continued even at PH of 6.7 in conformity with reports of earlier researchers. Biogas production proceeds quite well as long as the PH is maintained between 7.0 and 7.4 [10] At PH values below 6.2 and above 7.6, toxicity is acute and can impair gas production [11]. Also, PH of less than 6.0 or greater than 8.0 rapidly inhibits methanogenesis under most operating conditions [12].

It is important to maintain the PH of an anaerobic digester between 6 and 8, otherwise, methanogenesis growth would be seriously inhibited[13].

IV. CONCLUSIONS

The study on the production of biogas from the digestion of mixtures of poultry droppings and cassava peelings, poultry droppings and beans waste, cassava peelings and beans waste has shown that biogas can be produced from these wastes through anaerobic digestion for biogas generation.

These wastes are readily available in our environment and can be used as source of fuel if managed well. The biogas generated contains up to 65% methane which supports combustion. It was found out that temperature fluctuations and PH are among the factors that affect biogas production and temperature ranges of 25°C–45°C also purvey mesophile thermal stage for biogas production. It has also been shown that for maximum gas generation, experimentation with various mixes is very important. Results show that mixing of nitrogen rich and carbon rich wastes at a presumed ratio produce more gas than nitrogen – nitrogen or carbon – carbon rich wastes.

Finally, embarking on anaerobic biodegradation process on environmental pollutants for biogas production will not only lead to clean and safer environment but also reduce the use and much dependence on fossil fuels whose by-products are deforestation, desertification, erosion, global warming and flooding.

REFERENCES

- [1] Abubakar MM (1990) Biogas generation from animal wastes. *Nigerian J Renewable Energy* 5: 69-79.
- [2] Cheremisinoff NP (1980) Biomass Application. In: *Technology and Production*. Marcel Dekkar Inc, USA.
- [3] Igoni AH, Ayotamuno MJ, Ogaji SOT, Robert SD(2007) Municipal Solid waste in Port Harcourt Nigeria. *Applied Energy* 84:664-670.
- [4] Olounnisola A(2007) Production of Fuel Briquette from waste paper and coconut husk Admixture. *Agricultural Engineering International: CIGR E-Journal*.
- [5] Eze J.I, Garba, B and Atiku, A(1998). The Application of biogas slurry(Biofertilizer)in crop production. *Nigerian journal of Renewable Energy*, Vol.1 and 2, 1997, p.22-44.
- [6] Stout, B.A(1983). Biomas Energy Profile. *Agricultural service Bulletin*, 54, Food and Agric. Organisation, Rome.
- [7] Bitrus R (2001) Design of An Anaerobic Bio-Reactor for the production of methane from Solid waste Organic Matter, Dept of Agricultural and Environmental Science River State.
- [8] Nopharatana A., Pullammanappallil P.C. and Clarke W.P. (2007) Kinetic and dynamic modelling of batch anaerobic digestion of municipal solid waste in a stirred reactor. *Waste management*. 27: 595-603.
- [9] Ilori O.M., Adebuseye A.S., Lawal A.K., Awotiwon A.O., (2007) Production of Biogas from Banana and Plantain Peels. *Adv. Environ. Biol.* 1 (1):33-38.
- [10] McCarty, P.L. and Mckinney, R.E.(1961). Volatile acid toxicity in anaerobic digestion. *J.WPCF* 33:223.
- [11] Hills, D.T; Bolte, J.P and W.D(1979). Methane Gas production from dairy manure and field crop residues. *Proc. 4th Int'l conf. Livestock Waste*. ASAE Publ. No,2-81. Am. Soc. Agric. Eng. Michigan. U.S.A.
- [12] Blanchard, J.G.(1987). Methane production by continous digestion of wastes. In:D.1. Wise(ed.). *Global Bioconversion*. Vol.1 CRC Press Inc. Florida.
- [13] Gerardi, M. H. (2003) Toxicity, in *The Microbiology of Anaerobic Digesters*, John Wiley & Sons, Inc., Hoboken, NJ, USA. doi: 10.1002/0471468967.ch17.