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The Effect of Temperature, Pressure and PH on Volume of Biogas Production from Anaerobic Digestion of Plant & Animal Wastes

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***Abstract* - Many factors affect the volume of biogas production in the anaerobic digestion of plant and animal wastes. In this treatise the three major factors of temperature, pressure and PH are investigated. Here the biodegradable wastes used were Cassava peelings and cow dungs, Beans waste and cow dungs, Cassava peelings and beans wastes. For the purpose of this investigation, a 100 liters capacity steel biogas digester was constructed to investigate these factors. A batch operation method was used whereby a daily biogas generation was monitored for 24 consecutive days. It is pertinent to state here that other factors that could affect the volume of biogas production like alkalinity, acidity etc were ignored. Cassava peelings and cow dungs produced the highest biogas of 0.032m^2/kg/day at a pH value of 7.34, followed by beans waste and cow dungs mixture and lastly Cassava peelings and beans waste having the least volume. The respective effects of temperature, pressure and PH were monitored and plotted alongside these biogas productions to showcase their effects. From the plots, their respective effects on the respective volumes of biogas generated can easily be seen. It is important to note in the passing that biogas is a form of renewable energy.**

Keywords: Biogas, Temperature, Pressure, PH, Renewable energy, Anaerobic Digestion.

I. INTRODUCTION

Energy needs, environmental and waste management are the major problems confronting all countries of the world today. In the process of solving energy problem, environmental and waste management problems like environmental degradation in the form of greenhouse effect, deforestation, desertification, flooding, global warming and some unnamed ones arose. Energy sources from fossils which are predominantly used today for sources of energy gave rise to all these as byproducts. A permanent solution to all these is a deviation from current energy sources from fossil to a more energy friendly alternatives like solar energy, biogas, wind etc. Biogas is a mixture of colourless, flammable gas obtained by the anaerobic biodegradation of plant based organic waste materials [1].

Biogas is a mixture of gases at different proportions. Analysis of biogas gives a composition of 50-70% Methane, 30-40% carbon dioxide and traces of other gases [2]. Nigeria is purely an agricultural based country. Crop and animal production have left an unquantifiable volume of animal and plant wastes more often than not being part of the environmental hazards that is a problem on its own [3]. Biogas sources its energy from animal and plant wastes. These wastes if properly managed could be re-cycled and used in biogas generation [4].

Biogas production is a biological process of anaerobic biodegradation of cellulose materials in a biodigester tank of steel, fibre, plastic tanks etc with the end product being a gas rich in Methane and solid substance in the form of spent slurry which is an organic fertiliser that can easily be applied to crops. This process involves the use of organic materials such as seed husks, straws, animal dungs, weeds, garbage, sludges, domestic sewage and organic liquid wastes from factories, wastes from slaughter houses. These wastes are biodegraded or digested by large number of various microbes under anaerobic conditions to librate methane in the process[5].

Biogas production and its technology when appropriately implemented can take absolute care of environmental management issues and other hazards arising from weather pollution and green house effects. Animal feeds production is also achieved using treated sludges mixed with molasses and grains [6]. The process when utilized can eliminate public health hazards and pathogens. In plant production, it will result in the reduction of fungal and plant pathogens from being transferred from one year's crop to the following year [7]. An effort in identifying the factors that affect the production of this biogas and their extents is an effort in the right direction and that has been the goal of this work.

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II. MATERIALS AND METHODS

A) Collection of Sample

A 100-litre steel digester was designed for the process. Wastes procured from different sources and locations for the work are as follows: - Cassava peelings and cow dung, Beans waste and cow dungs, and finally, cassava peelings and beans waste. Beans waste included the husks removed from it and even chaffs. Each of the segment of the mixtures as enumerated were mixed well and fed the digester in the anaerobic batch of experimental digestion runs.

B) Slurry process

Since the digester volume is 100 litres that becomes the expected per day. Batch operation approach system was used since there was only one digester. This entails each selected mixture being ran in turn one after the other at each run time. Analysis were carried out on each groupings of the feedstock to find out the Carbon-Nitrogen ratio, moisture, Carbon and Nitrogen, contents of each mixture, total solids, volatile solids etc. Water to waste ratio was 2:1.

C) Digester charging

The appropriate measured quantities were charged into the digester. First the inoculums and thereafter the measured volume of water. Some quantities of the waste mixture were charged first, followed by water and later the remaining materials. After the entire contents were vigorously stirred with a stirrer to allow for homogeneity. The inlet pipe was closed and locked. The digester content was then allowed to undergo digestion for a retention period of 30 days with daily measurement of biogas yield.

III. RESULTS AND DISCUSSIONS

Performance evaluation of the gas production and factors influencing it was carried out using the following operational parameters.

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

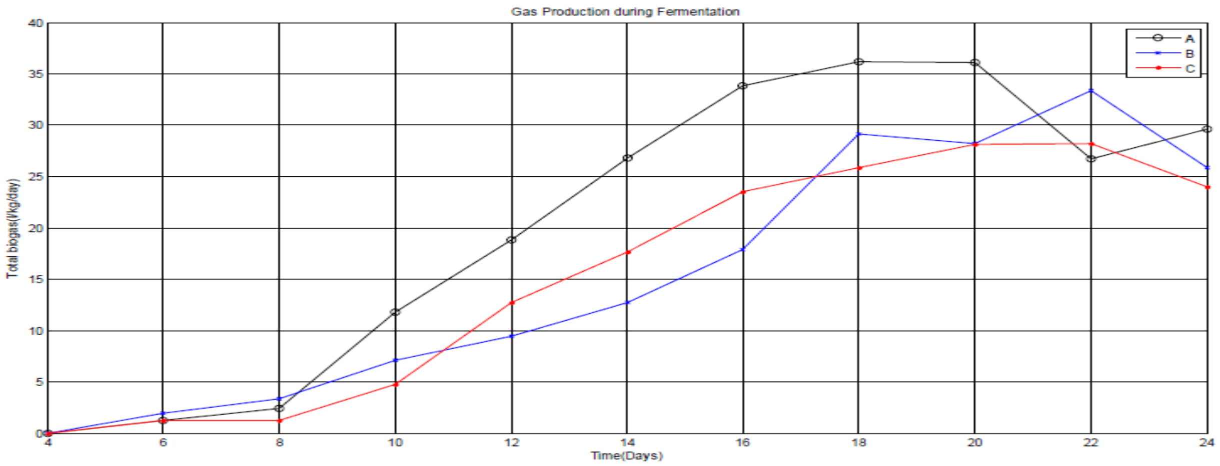

Figure 1: Gas generation during fermentation: A-Cassava peelings + Cow dungs +Water, B-Beans waste + Cow dungs +water, C-Cassava Peelings + Beans waste +water

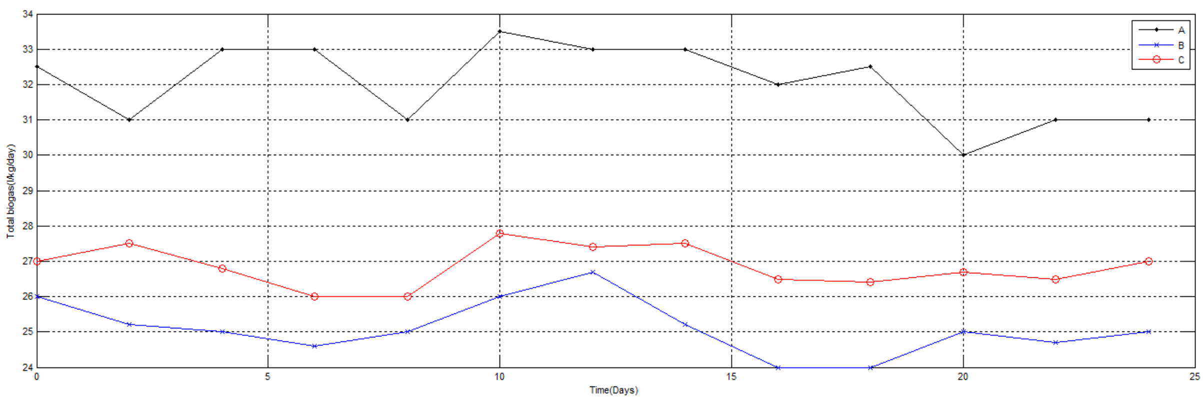

Figure 2: Temperature changes during Fermentation, A-Cassava peelings + Cow dungs +Water, B-Beans waste + Cow dungs +water, C-Cassava Peelings + Beans waste +water

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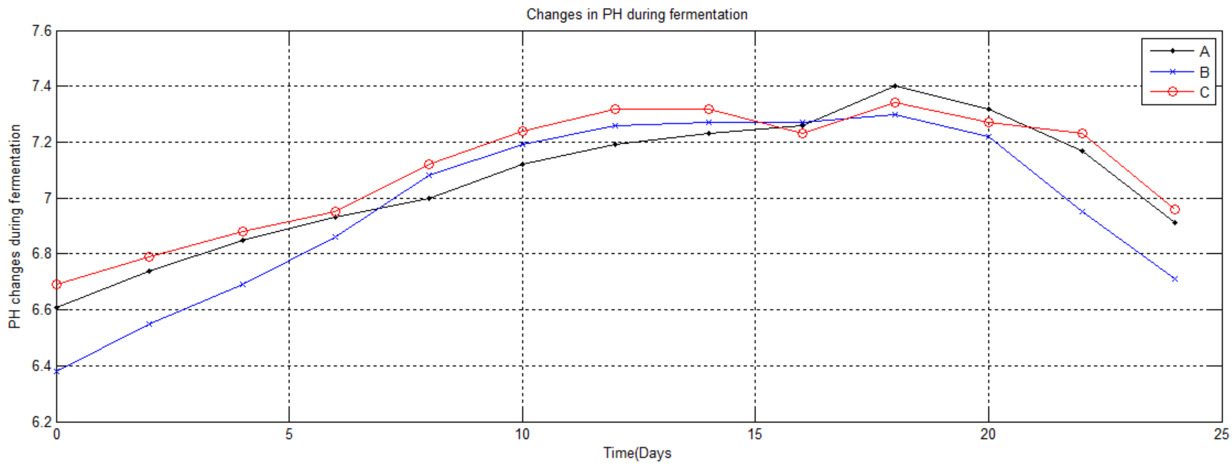

Figure 3: pH changes during Fermentation, A-Cassava peelings + Cow dungs +Water, B-Beans waste + Cow dungs +water, C-Cassava Peelings + Beans waste +water

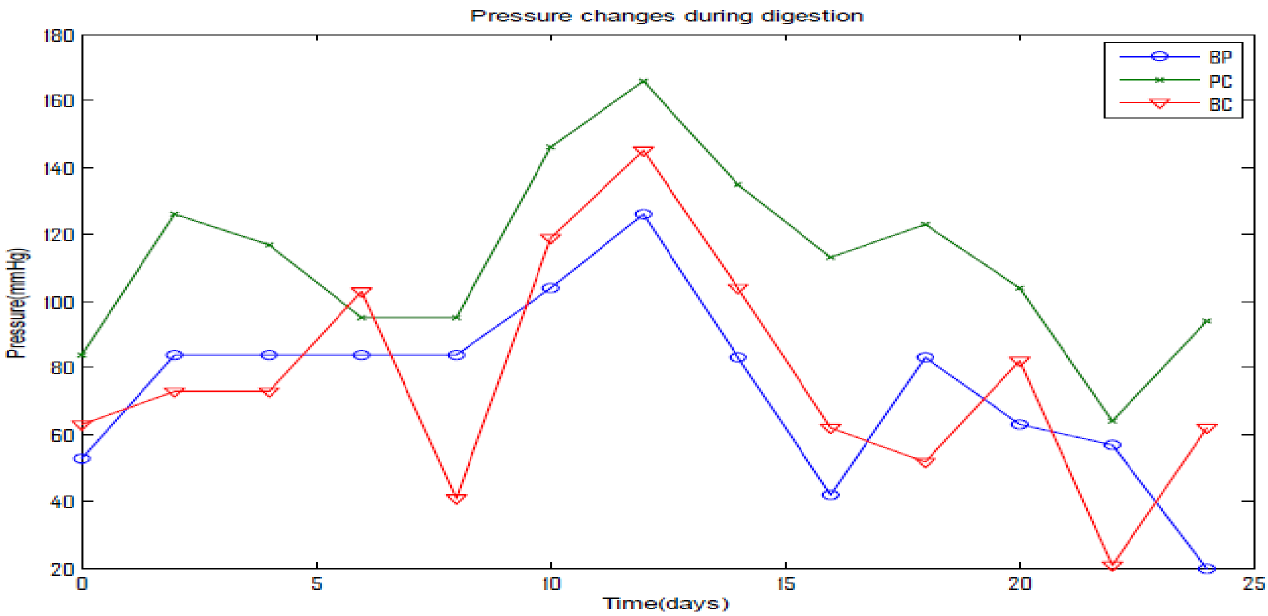

Figure 4: Pressure changes during the digestion of 3 different categories of wastes. A-Cassava peelings + Cow dungs +Water. B-Beans waste + Cow dungs +water, C-Cassava Peelings + Beans waste +water

A) Waste aggregate and effect on quantity of biogas generated

The quantities of biogas produced by each run of the constituents of A(cassava peelings + cow dung + water), B(beans waste + cow dungs +water) and C(cassava peelings + beans waste+ water) within the retention period of 24 days are displayed in figure1 above. Within the first five days, there was no biogas generation. The highest volume generated was within 18th- 20th days and was 35.2l\kg\day of biodegradation in cassava and cow dung mixture. The temperature at which this maximum gas yield was attained is 32.4°C as seen in figure 2. In beans waste and cow dung, a maximum of 33l\kg\day was generated while that of the mixture of cassava peelings and beans wastes generated 28.4l\kg\day under the same period of time.

B) Effect of Temperature on gas yield by wastes

Temperature has long been a factor in any bacterial of microbial activity. In anaerobic digestion process of biogas, methane generating bacteria operate most effectively within a temperature range of 30°C -40°C or 50°C -60°C [8]. Here in this treatise, a temperature range of 26°C – 32.5°C was used. In figure 2, the effect of temperature on the biogas generation is displayed. In the process, a temperature run of 25°C-45°C is regarded as the mesophilic fermentation temperature and that of 45°C – 50°C is regarded as thermophilic. So far from the foregoing, it could be seen how temperature influences

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volume of gas production. A certain temperature is reached and the volume of gas production becomes no more function of temperature. The digestive feedstock also plays a very important role.

C) PH effect on gas yield by plant and animal wastes

Figure 3 depicts the pH changes during the experiment. The pH of a given medium affects microbial activities in that medium. This directly affects the volume of gas production since the biogas is one of the products of the entire reaction. In the figure, it could be seen that initially the pH was low below 7.0 within the first 6 days of the experiment. This saw the breaking down of organic matter while producing volatile fatty acids by the action of the acid forming bacteria. The Methane forming bacteria dutifully dislodged the acid forming bacteria. The gradual rise in pH was as a result of breaking down of acids by methanogens to methane in figure3, beans waste and cassava had a maximum pH of 7.4, closely followed by beans and cow dung waste with 7.36. Cow dungs and cassava had the lowest pH of 7.31.It could also be observed that within 18th- 20th days of the fermentation, PH attained its maximum level. Beyond the 20th day, a gradual drop in PH starts and continues till the end showing once again that the methane producing bacteria has dislodged the acid forming bacteria thus inhibiting gas production.

The observed changes in pH might probably have occurred due to temperature changes or pressure of toxicants or inhibitors or both. This result shows that biogas production continued even at pH of 6.7. Biogas production proceeds quite well as long as the PH is maintained within the bandwidth of 7.0 - 7.4[9] Outside this, toxicity becomes acute and can impair gas production [10].Equally, pH lower than 6.0 or greater than 8.0 rapidly inhibits methanogenesis under most operating conditions [11]. The rule of the thumb is always to maintain the pH of an anaerobic digester within 6 - 8, otherwise, methanogenesis growth would be seriously inhibited [12].

D) Pressure effect on gas yield by plant and animal wastes

Biogas being a gas obeys gas laws thus expanding more with increased temperature or production of more biogas from the process or both. The pressure of the cow dungs and beans waste mixture attained its highest level of 126mmHg on the 12th day. The waste mixture of cow dungs and the cassava peelings attained its highest pressure of 166mmHg also on the 12th day of the digestion process. The mixture of beans waste and cassava peelings also attained its highest pressure of 145mmHg on the 12th day of the digestion process.

It is worthy of note to state that as we were approaching the 24 days of the process of the digestion all the pressures from the three different categories of wastes- cow dungs and beans waste, cow dungs and cassava peelings, and beans waste and cassava peelings continued to decrease as was seen earlier by other researchers. In the production of biogas, pressure is of great importance [13].

IV. CONCLUSIONS

The study of the effect of temperature, pressure and PH on the production of biogas from the anaerobic digestion of mixtures of cassava peelings + cow dung, cow dung+ beans waste, cassava peelings + beans waste has shown that these factors actually play a very important role the volume biogas produced. An offshoot of the work also demonstrates that the nature of the substrate being digested also influences the volume of gas generated.

Analysis of the biogas generated from this work contains up to 65% methane which supports combustion. The results found out shows that temperature variations, changes in pH and pressure fluctuations all contribute to the quantum of biogas produced. Temperature range of 25°C–45°C is for mesophile thermal stage for biogas production. It has also been seen that for maximum biogas production, experimentation with various ratios of mixes is very important. It has also been proved that that mixing of Nitrogen rich and Carbon rich wastes at a presumed ratio produce more gas than Nitrogen – Nitrogen or Carbon – Carbon rich wastes.

In summary, for optimal production, the understanding of the roles of factors like Temperature, Pressure, pH and constituent mix should be well addressed before engaging in anaerobic biodegradation process on environmental pollutants for biogas production.

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