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EVALUATION OF THE EFFECTS OF SOME PARAMETERS IN BIOGAS PRODUCTION USING COW DUNG

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ABSTRACT

Energy generation through biogas has gained relevance in recent years due to its potential capacity as renewal energy source, an analysis of these technology from the life cycle thinking is essential for sustainable development. The dependence on fossil fuels and primary energy source has led to global climate change, environmental degradation and human health problems. This study was carried out to evaluate the effects of some parameters in biogas production using cow dung. The various parameters measured were temperature, pH, and pressure and amount of gas produced. The results obtained showed that biogas production were more at biodigester temperature ranges from 40°C to 44°C and subsequent production were achieved which conforms with the fact that high temperature of mesophilic range is necessary for high gas production. Gas production started to decline towards the end of the production period; even though the temperature in the biodigester was fairly high between 31°C and 35°C, the least temperature was 20°C and production was equally at 0.0025m^3 this could be as result of the rainfall witnessed that period which could have affected environmental temperature hence biodigester. Pressure were relatively low all through the period of the anaerobic process it was between the range of 0.0010psi and 0.0015psi though stable pressure of 0.0010psi was observed for better part of research. The pH was equally stable, it ranged from 7.0 – 7.5 but predominant reading of 7.0 was observed during the process of the digestion which also conforms to the fact that for adequate biogas production, the pH must not fall below 6.7 units. Therefore, suggested that temperature and pH should be a determining factor to ensure adequate biogas production using cow dung

Keywords: Biogas, Biodigester, pH, Pressure, Temperature.

INTRODUCTION

Energy generation through biogas has gained relevance in recent years due to its potential capacity as renewable energy source. An analysis of this technology from the life cycle thinking is essential for sustainable development. It does not have negative impact on the environment hence its friendly nature to the eco system rather it can be optimized if the byproduct of the biogas, like the Slurry are processed as condition to their usage as soil improver Biogas plant construction if encourage by the government and multinationals. According to Omaliko (2006) reported that the channeling slaughter house waste which is a major source of local water pollution and green-house gas emission, if put into biogas production will improve lives by providing cheap, clean organic fertilizers to low income farmers, and, at same time to protect the entire environment. Biogas production has gained lots of acceptance even in the advance countries.

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Anaerobic digestion is the controlled degradation of organic waste in the absence of oxygen and in the presence of anaerobic microorganisms (Ojolo *et al.,* 2007). The digestion process is carried out using an air tight reactor and equipment used for waste pretreatment and gas retrieval. The process generate a product called "biogas" that is primarily composed of methane, carbon dioxide and compost product suitable as soil conditioners or farm land (Koberle, 1995).

Monnet (2013) reported that anaerobic digestion can be used either to treat biodegradable water or produce sealable products such as heat/electricity, soil amendment etc. the most valuable use of anaerobic digestion is to combine both waste management and the use of the bio product. It is unlikely that anaerobic digestion will be a viable treatment without using the biogas and the digestate (Monnet, 2013). The qualities of the biogas and digestate will vary depending in the feed stock and its contamination. Monnet (2013) further stated the process of anaerobic digestion can be further divided into four stages: pretreatment, digestion, gas upgrading and digestate treatment. He noted that the level of pretreatment depends on the types of feed stock for example manures need to mix whereas, municipal solid waste (MSW) are sorted and shredded.

LITERATURE REVIEW

The biogas produced in anaerobic digestion plant usually contain small amount of hydrogen sulphide (H_2S) and ammonia (NH_3) as well as trace amount of other gases (Monnet, 2013). The full process of anaerobic digestion occurs in the following four stages namely hydrolysis, acid genesis, acetogenesis, and methanogenesis (Monnet, 2013). Mata-Alvarez *et al.* (2010) reported that digestion is not complete until the substrate has undergone all of these stages, each of which has a physiologically unique bacteria population responsible that requires disparate environmental conditions. Also, they stated that the concentration of hydrogen, measured by partial pressure is an indicator of the health of a digester. In general, for reactions producing H_2, it is necessary for hydrogen to have a low partial pressure for the reaction to proceed. The transition of the substrate from organic material to organic acid in the acid forming stages causes the pH of the system to drop. This is beneficial for the acetogenic stage and less sensitive to change in the incoming feed stream. On the other hand, the drop in pH is problematic for the bacterial involved in the next of Methanogenesis (Igboro, 2014).

There are several conditions and variables that must applied in order to obtain a proper breakdown of the organic compound. The rate at which the microorganisms grow if paramount importance in the anaerobic digestion process, total solid (TS) content of the slurry in the digester reactors, temperature ranges, pH, retention time (Verma, 2014; Monnet, 2013). According to Verma (2014) the temperatures considered for production of methane are mesophilic (optimum to be 30^{o}C-35^{o}C) and thermophilic (ranges from 50^{o}C-65^{o}C). He observed that the higher temperature in a thermophilic range reduced the required retention time. The optimum temperature of digestion may vary depending on feed stock composition and type of digester, but in most anaerobic digestion processes, it should be maintained relatively constant to sustain the gas production rate (Monnet, 2013). On the other hand, when the ambient temperature goes down to 10^{o}C, gas production virtually stops and the pH values of the input mixture play a very important role in methane formation (Karki *et al.,* 2015). The acidic condition is not favorable for methanogenic process. The optimum biogas production is achieved when the pH value of input mixture in the digester is between 6 and 7. The pH in a biogas digester is also a function of the retention time. The initial period of fermentation as large amount of organic acid are produced by acid forming bacteria, the pH inside the digester can decrease to below 5. This inhibits or even stops the digestion or fermentation process. Methanogenic bacteria are very sensitive to pH and do not thrive below a value of 6.0 (Karki *et al.*, 2015).

Usually for a cow dung plant, a detention time of 40-60 days is required depending upon the temperature. Thus, the fermenting pit should have a volume of from 40 - 60 times the slurry added daily. But for a night-soil digester, a longer detention time (70 - 90 days) is needed in order to kill the pathogens present in human fasces. If the retention time is too short, the bacteria in the digester are ''washed out'' faster than they can produces so that the fermentation practically comes to a stand-still, this process rarely occur in agriculture biogas system. Moreover, the required retention time for completion of anaerobic digestion reactions varies with differing technologies, process temperature and waste composition. The retention time for waste treated in mesophilic digester range from 10-40 days (Verma, 2014).
Many plants have reported system failure due to over loading. OLR is expressed in Kg chemical oxygen demand (COD) or volatile solid (VS) per cubic meter of reactor. It is linked with retention time for any particular feed stock and anaerobic reactor volume (Monnet, 2013). Mixing also prevents the formation of scorn and the development of temperature gradients within the digester. However, excessive mixing can disrupt the microorganism and therefore slow mixing is preferred (Monnet, 2013).

In case of co-digestion, the different feedstock should be mixed before entering the digester to ensure a sufficient homogeneity, which will subsequently increase biogas production by 50% (Kossmann *et al*, 2012). Also mineral irons, heavy metals and detergents used in livestock husbandry are some of the toxic materials that inhibit the normal growths of pathogens in the digester. Small quantity of mineral irons (e.g. Sodium, potassium, calcium, ammonium and Sulphur) also stimulates the growth of bacterial while very heavy concentration of this irons will have toxic effects (Karki *et al*, 2015). In light of previous literatures, there is insufficiency of researches about the evaluation of the effects of some parameters in biogas production using cow dung. The aim of this study was to evaluate effects of temperature, pressure and pH during biogas production using cow dung.

METHODOLOGY

The experiment was carried out at Plot 142D Trans Amadi Industrial Layout in Oginigba in Obio Akpo Local Government Area, Port Harcourt, Rivers State, Nigeria (4° 49′ 27″ N, and longitude of 7° 2′ 1″ E). The map of the experimental area is shown in figure 1. Biogas plant (1000 liters GEEPEE tank) was constructed that suit the use of the cow dung; the fresh cow dung used in this study was collected from an abattoir in Oginigba (Plate 1). The abattoir at Oginigba, Port Harcourt, Nigeria was chosen because of the nearness to biodigester. Three bio-digesters volume of 1000 liters each was used as replicate to ascertain reliability of the experiment.

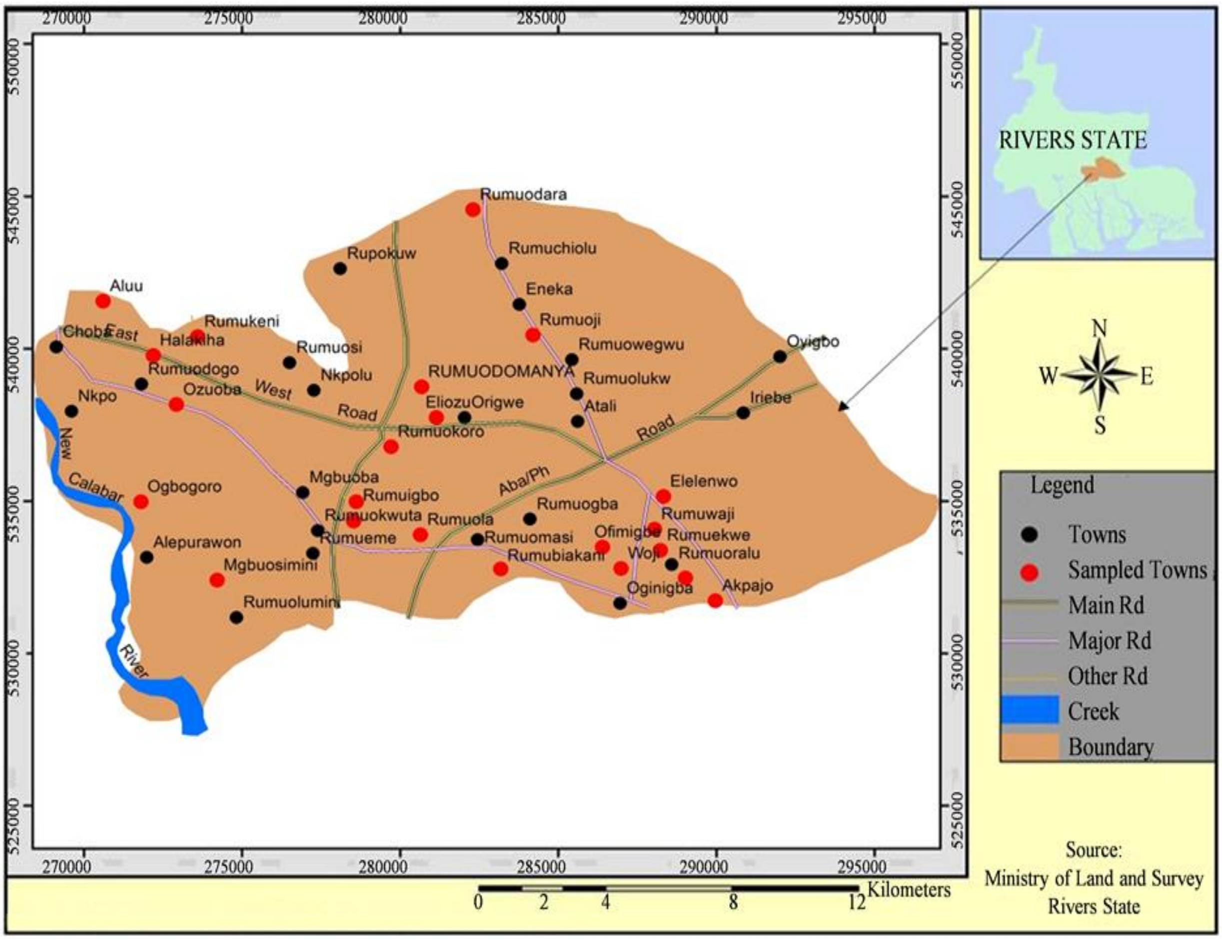

Figure 1: Map of Obio Akpo Local Government Area, Rivers State, Nigeria
Source: Rivers State Ministry of Land Survey

Plate 1: Collection of Cow Dung from an Abattoir in Oginigba

Digester Specification

A Plastic bio-digester made of locally available materials (Nigeria) was used for this study (Plate 2). The bio-digester is made up of 1000 liters tank (Manufacturer: GEEPEE, Country: Nigeria), ball gate valves, filters, pressure meter, male and female adopter, hose, PVC pipe, gas holder, plastic funnel, metal clip and two slots one for the entry of the biogas and another for the exits.

Plate 2: Bio-Digester

Experimental Procedure

Prior to the introduction Cow dung into the bio-digester and biogas generation started barely four day after, proper selections were performed on the cow dung to remove some non-essential materials (Plate 3). There after the slurry was introduced to the bio-digester (Plate 4). Some vital parameters were considered in order to ascertain some scientific background; these Parameters with respect to the anaerobic digestion process were measured. The temperature, pH and pressure in the bio digester were measured using the thermometer, pH meter and pressure meter respectively. These parameters (temperature, pH and pressure) were measured daily for the period of the study throughout the Process of breakdown before the biogas Production. The temperature was ascertained to know the effect it has on the feedstock and consequently the metabolism of the bacteria. Also gas produced was determined with the aid of the gas holder. The gas holder was placed on top of a calibrated machine scale before and after collecting gas and the initial and final weight were recorded. This was done on daily basis and was actualized mathematically by equation (1) (Marchaim, 1992).

$$Produced\ gas = N - P \tag{1}$$

Where;

N = weight of the gas holder and gas collected; and

P = weight of the gas holder

Plate 3: Sorting of Cow Dung before being Introduced into Biodigester

Plate 4: Introduction of Slurry into the Biodigester

RESULTS

The results of the biogester parameters which include temperature, Pressure, pH and the biogas produced are as shown in table 1.

Table 1: Results of Biogester Parameterc c

Days, 2019	Temperature (^OC)	Pressure (Psi)	Ph	Biogas (Litres)	Biogas (m^3)
15th June	5	0.000	2.5	Nil	Nil
19th June	25	0.0012	7.0	3.3	0.0033
20th June	35	0.0010	7.2	3.0	0.0030
21th June	36	0.0010	7.3	3.1	0.0031
30st June	28	0.0010	7.3	2.8	0.0028

1th July	38	0.0010	7.5	4.0	0.0040
2nd July	38	0.0010	7.5	3.2	0.0032
3rd July	40	0.0013	7.5	4.4	0.0044
4th July	40	0.0014	7.5	4.8	0.0048
5th July	30	0.0010	7.5	3.8	0.0038
6th July	37	0.0015	7.5	4.3	0.0043
7th July	25	0.0010	7.5	2.5	0.0025
8th July	20	0.0010	7.5	2.5	0.0020
9th July	20	0.0010	7.0	2.5	0.0025
10th July	34	0.0010	7.0	3.8	0.0038
11th July	41	0.0010	7.0	4.5	0.0045
12th July	42	0.0010	7.0	4.4	0.0044
13th July	44	0.0010	7.0	4.6	0.0046
14th July	42	0.0010	7.0	4.7	0.0047
15th July	41	0.0010	7.0	4.3	0.0043
16th July	43	0.0010	7.0	4.4	0.0044
17th July	42	0.0010	7.0	4.5	0.0045
18th July	41	0.0010	7.0	4.0	0.0040
19th July	35	0.0010	7.0	3.8	0.0038
20th July	40	0.0010	7.0	4.0	0.0040
21st July	40	0.0010	7.0	4.1	0.0041
22nd July	41	0.0010	7.2	4.0	0.0040
23rd July	36	0.0010	7.1	3.8	0.0038
24th July	24	0.0010	7.0	2.9	0.0029
25th July	40	0.0010	7.0	3.7	0.0037
26th July	32	0.0010	7.0	3.4	0.0034
27th July	41	0.0010	7.2	3.8	0.0038
28th July	38	0.0010	7.1	3.0	0.0030
29th July	38	0.0010	7.2	3.8	0.0038
30th July	32	0.0010	7.0	3.1	0.0031
31st July	30	0.0010	7.0	2.9	0.0029
Ist August	32	0.0010	7.0	3.2	0.0032
2nd August	29	0.0010	7.5	3.0	0.0030
3rd August	28	0.0010	7.5	3.0	0.0030
4th August	27	0.0010	7.2	3.0	0.0030

5th August	39	0.0010	7.1	4.0	0.0040
6th August	40	0.0010	7.0	4.4	0.0044
7th August	31	0.0010	7.0	4.5	0.0045
8th August	38	0.0010	7.0	3.7	0.0037
9th August	37	0.0010	7.2	3.5	0.0035
10th August	36	0.0010	7.1	3.4	0.0034
11th August	35	0.0010	7.0	3.4	0.0034
12th August	37	0.0010	7.4	3.5	0.0035
13th August	38	0.0010	7.4	3.8	0.0038
14th August	38	0.0010	7.2	3.3	0.0033
15th August	37	0.0010	7.3	3.2	0.0032
16th August	38	0.0010	7.1	3.2	0.0032
17th August	36	0.0011	7.2	3.1	0.0031
18th August	38	0.0010	7.3	3.1	0.0031
19th August	37	0.0010	7.1	3.3	0.0033
20th August	35	0.0010	7.1	2.5	0.0025
21st August	31	0.0010	7.2	1.9	0.0019
22nd Aug	31	0.0010	7.2	1.5	0.0015

Effect of temperature on biogas production

Figure 2 shows the effect of temperature on biogas production using cow dung.

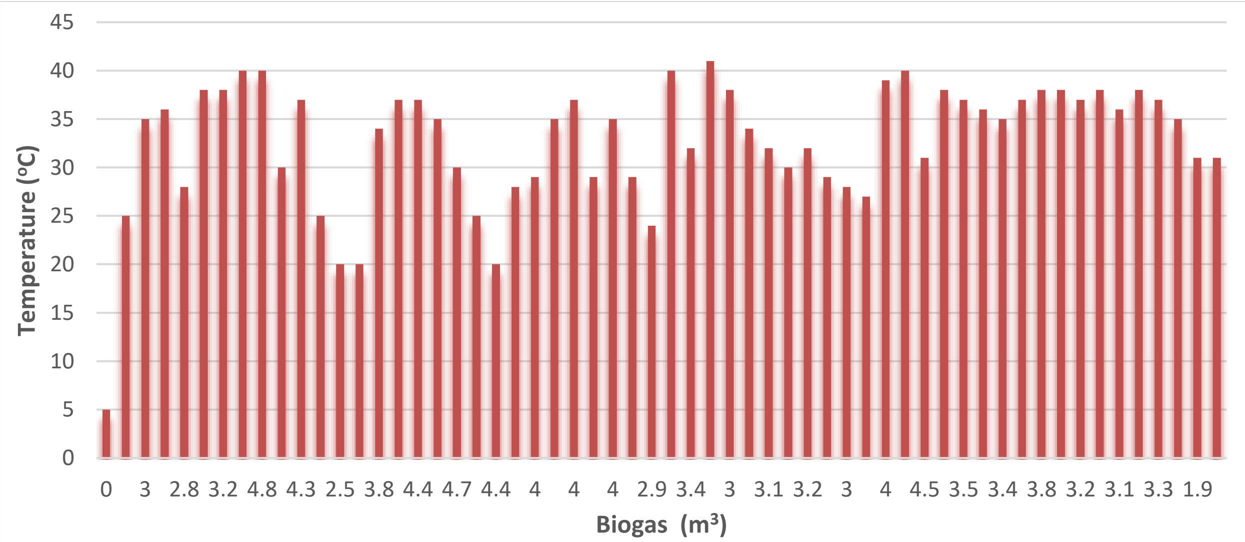

Fig 2: Temperature generated inside the biodigester during biogas production

Effect of pressure on biogas production

Figure 3 shows the effect of pressure on biogas production in a biodigester using cow dung.

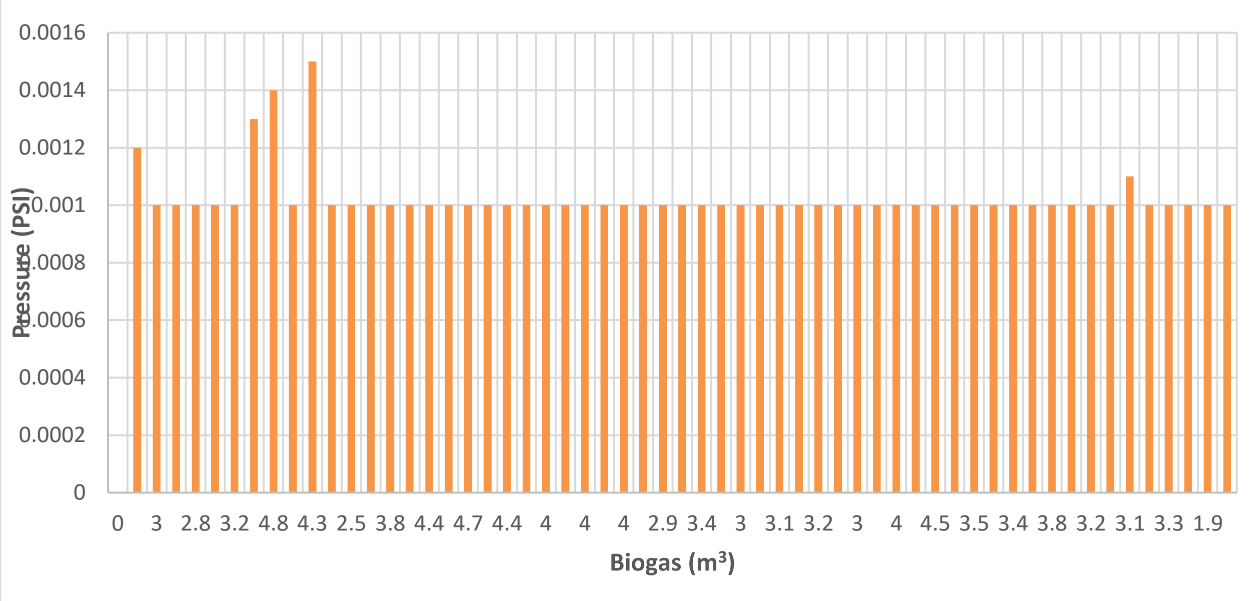

Fig 3: Pressure generated during biogas production in the biodigester

Effect of pH on biogas production

Figure 4 shows the effect of pH on biogas production in a biodigester using cow dung.

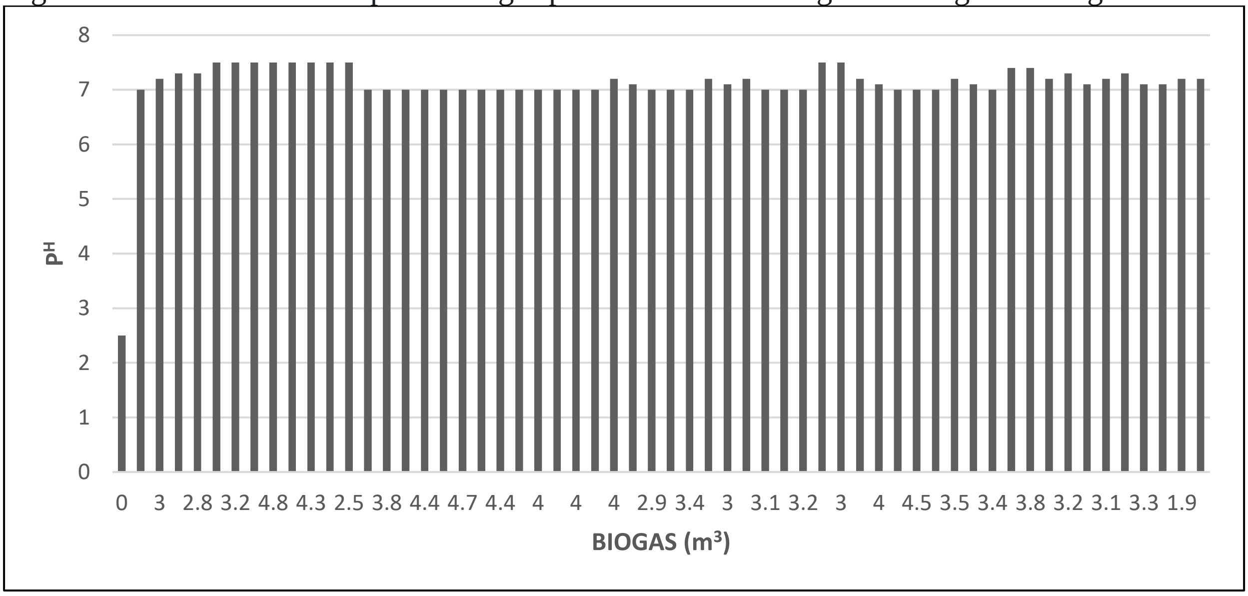

Fig 4: pH recorded during microbial activities in the biodigester

Daily Biogas Produced

Figure 5 shows the relationship between biogas produced and the number days involved in biogas production.

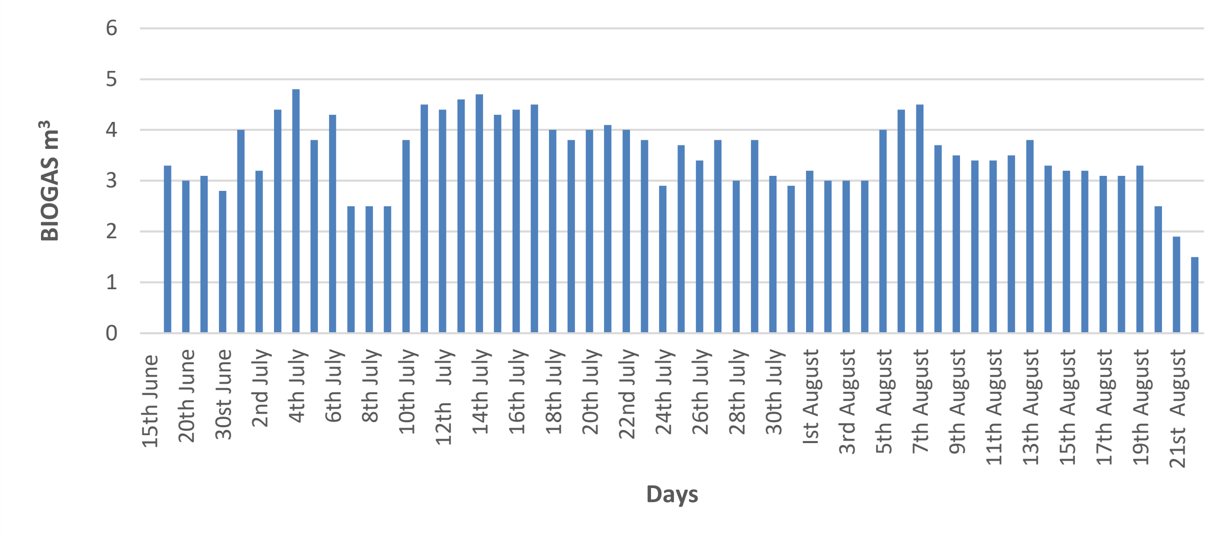

Fig 5: Daily biogas generated in the biodigester

DISCUSSION

Effect of temperature on biogas production

The relationship between temperature and biogas produced is shown in Figure 1. Biogas production started four day after cow dung was introduced into the biodigester, 0.0031m^3 of biogas was generated on the 19th day of July (22nd day), which contradicts the expected 20 days – 30 days (23rd to 33rd day) as speculated. The reason for these could be because of the introduction of succulent (algae) into the biodigester. Production of biogas was quite encouraging for long period until the 7th July – 9th July (12th to 14th day) where a drop of biogas generation was experienced, the reason can be attributed to the heavy rainfall at that period and subsequent dropped in temperature 20^{o}C and 20^{o}C (Table 1 and Figure 2). A tremendous amount of biogas of 0.0044m^3 and 0.0048m^3 were generated when the temperature rose to 40^{o}C, this can be justified research by Verma (2014) which states that the required temperature adequate for production should be at the mesophilic range of 30^{o}C – 55^{o}C optimum.The least production of 0.0025m^3 were generated when the temperature was 20^{o}C.

Also there were three days (4th July, o 14th July and 6th of August) that have the highest level of temperature range of 40, 42 and 40 ^{o}C respectively. These falls under mesophilic ranges as mentioned by Verma (2014) who supported the biogas production can be attained at these temperature ranges. Furthermore, lowest production of biogas was observed on the 7th, 8th and 20th of July where the temperatures were 25, 20 and 20 ^{o}C respectively. This confirms the need for high temperature for high level of biogas production. However, weather conditions were not favourable on the 1st, 2nd, 3rd and 4th of August, an average production of biogas was observed, this could be as a result of constant and heavy rainfall within the period that lower the ambient temperature. This conforms to Verma (2014) argument as regards mesophilic temperature being ideal for biogas production. Hence, little gas production occurs below 16^{o}C, this assumption conform with the study result where the bulk of biogas generated was achieve at the temperature range of 20^{o}C to 44^{o}C.

Effect of pressure on biogas production

The highest reading recorded was 0.0015 psi with a corresponding biogas production of 0.0034m^3 (Figure 3 and Table 1). Result showed that the pressure (psi) in which the biogas is generated does not necessarily needs to be high for biogas production to commence. The constant pressure rating of 0.001 psi for almost 90% of the production period in spite of different temperature recorded throughout the period of the biogas generation. Pressure generated by the biogas was quite low, this could not be far from the fact that the expected temperature of mesophilic (50^o C – 65^o C) was not attained, hence the decrease in pressure. This is in line with the finding of Monnet (2013). Pressure for biogas will be high if there are high microbial activities in the biodigester, which research has shown that temperature is one of the leading factors for these to happen. Highest pressure recorded was from the 3rd, 4th and 6th of July which conforms to the period where a fairly high temperature of 37^o C and 40^o C was recorded, the pressure on these days were 0.013, 0.014 and 0.015 psi respectively. The recorded pressure shows that the microbial activities are not at its peak, hence the low level of production. A constant pressure of 0.0010 psi was recorded for almost 95% of the period of the research.

Effect of pH on biogas production

Result showed that the pH recorded in digester was stable after the first three days when the cow dung was introduce, a constant reading of 7.0 was notice for the best period of the experiment (Figure 4 and Table 1). At the methanogenic stage bacteria seem to be very active at 7.0 level of pH. Though during the initial stages, a pH of about 2.5 was recorded**.** The pH for almost 95% of the duration of the research was recorded as 7.0 except for the first day, 15th of June when the cow dung was introduced recorded a pH of 2.5. This analogy is far from the argument made by Karki *et al* (2005) who mentioned that methanogenic bacteria are very active at the pH level was of 7.0 which was constant. Result revealed that the highest pH was observed from the 1st – 8th of July with the pH of 7.5. This is similar to the finding of Karki *et al*. (2005) Nemame et al. (2020).

Daily biogas production

Biogas production commenced after five days of introduction of the slurry after mixing with water in the ratio of 1: 3 (cow dung: water) (Table 1 and Figure 5). A sharp increase in production was noticed from 3rd July and 4th July where a huge production of 0.0044m^3 and 0.0048m^3 was recorded. Another high production was recorded from 11th July to 18th July with a production of 0.0040m^3 to 0.0047m^3. Drop in production was noticed from the 17th August, from 0.0031m^3 to 0.0015m^3 though an abnormal rise was noticed on the 19th August (0.0033m^3).The drop in Production was expected since the production period of forty (40) days has started approaching the elapse period though production continued till fifty-four (54) days which can be said to be another form of change as it concerns biogas production. This contradicts the finding Igboro (2011) which stated in his research that biogas production will cease after the 50th day of introduction of the slurry. There was drop in biogas Production from the 21st – 30th June the reason might not be too far from the constant rainfall observed that period which off course would have resulted to drop in temperature hence the production.

CONCLUSIONS

This study was on the evaluation of the effects of some parameters in biogas production using cow dung. It was found that 58 days of data collection, a considerable amount of biogas generated was 0.2012m^3. Various parameters like pressure, temperature and pH were analyzed and recorded for the period the research lasted. Result revealed that little gas production occurs below temperature of 16^{o}C and bulk of biogas generated was achieved at the temperature range of 20^{o}C to 44^{o}C. Also, a constant pressure of 0.0010 psi and pH of 7.0 was recorded for almost 95% of the period of the research. In addition, gas production varies with the ambient temperature. It is therefore, recommended that biogas production depends on temperature, irrespective of pressure and pH.

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