Comparative Study of Biogas Generation Using Locally Constructed Bioreactor

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Abstract: **This research work is focused on the construction of bioreactor for the production of biogas. This is due to the fact that Nigeria is facing energy problem. Biogas generation is an alternative area of research work and an alternative method for waste management. In this research work, two bioreactors were constructed using locally sourced materials and feed them with substrates, they are cow dung and kitchen waste in the ratio 1:2 (i.e. substrate to water) to form slurry. The slurry was transferred into the bioreactors for fermentation to generate biogas. The parameters such as temperature within and outside the bioreactors were observed and recorded weekly, the cumulative volume of biogas generated by each bioreactor were observed and recorded daily. The biogas generated was analyzed using gas chromatography. the result revealed that the average daily temperature in the bioreactors and ambient per day for the first week, for kitchen waste and cow dung and ambient were 32.224^{0}C, 32.212^{0}C, 28.789^{0}C, second week, 32.76^{0}C, 32.072^{0}C, 28.441^{0}C,the third week, 30.882^{0}C,31.036^{0}C and 28.612^{0}C and the fourth week,30.095^{0}C, 30.509^{0}C and 28,744^{0}C respectively. It was observed that the biogas analysis using gas chromatography showed that kitchen waste had the gas component as follows CH_4, NH_3,CO,H_2S and CO_2, 70.29%, 0.58%, 1.62%, 0.75% and 26.76% whereas cow dung had 68.26%, 0.49%, 1.18%, 0.15% and 29.92% respectively. Daily cumulative volume of biogas generated indicates that the first twenty hours had no gas generated, due to the fact that the organisms are trying to adapt to the new environment. The total volume of biogas generated from cow dung and kitchen waste after twenty eight days of fermentation were 167.4cm^3 and 192.7cm^3 respectively. It was revealed from this research work that the two subtracts used in this locally constructed bioreactors are excellent materials for biogas generation.**

I. INTRODUCTION

Developed countries have a major advantage over the control of pollutions as they provide highly advanced methodologies in controlling various types of pollutants (1),

Biogas refers to a gas made from anaerobic digestion of substrates for biogas generation, kitchen waste and cow dungs are organic materials having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increases. Inadequate management of wastes live uncontrolled dumping bears adverse consequences. It not only leads to polluting surfaces and groundwater through leachate and further promotes the breeding of flies, mosquitoes, rates and other disease bearing vectors (2). Kitchen waste and cow dung comprises high fraction of organic matter which causes environmental and health risks, have the need for a strong appropriate management system. In most cities in Nigeria, waste is disposed off as landfills or discarded which causes health hazard (2).

Historical evidence indicates that the anaerobic digestion process is one of the oldest technologies (3). The industrialization of anaerobic digestion began in 1859 with the digestion plant in Bambay, by 1895; biogas was recovered from a sewage treatment facility and used to fuel street lamps in Exeter, England (3). In Nigeria, research into biogas technology and its practical application in on-going, though, has not really received the deserves attention. The Sokoto Energy Research Centre Usman Danfodio University, Sokoto has carried out a number of pilot projects on construction of house hold size digesters.

In addition to this, the centre has constructed biogas digester plants of 20cm^3 capacities at three locations in Nigeria (4).

II. METHODOLOGY

The materials for the construction of the bioreactors are plastic drum, PVC pipe 4 inches, PVC accessories, gas hose, gas burner, ¾ air valve, ½ air valve, thermometer, pressure gauge, gas storage device.

III. CONSTRUCTION METHODS

The top of the plastic drum were marked with the diameter approximately equal to the PVC pipe and was perforated and drilled using a hand drilling machine and round file was used to file the holes until the PVC pipe tightly fitted into the holes, four holes were differently measured and marked on top of the drum, they are thermometer, substrate inlet and overflow opening, gas outlet opening. A pipe measuring 60cm in height was inserted at the substrate inlet and overflow opening from the top. This is the point for inlet and overflow of slurry. A measured hole with the PVC pipe was also drilled on the bottom of the drum, this serve as the outlet of sludge. The pipes were tightly fitted in the holes of the drum with aid of braces, PVC glue and four minute glue, which aided in appropriate sealant of the joints to avoid escape of gases that will be generated during the fermentation in the bioreactor. A pipe with gas tap was inserted into the gas outlet opening, which was connected to the manifold tester to trap the gas and measure its pressure while transferring the gas into the collator and finally, thermometer was inserted into its opening (5)

Figure 1: Biogas Generated from Chicken Waste

Figure 2: Biogas Generated from Cow Dung

1.3 Source of Waste Use

The cow dung used in this work was obtained from Abattoir Dump Site from Ndibe Beach, Afikpo, Ebonyi State, Nigeria while the kitchen wastes (vegetable lefts over, plantain peels and left over garri and rice was obtained from different eatery centers in Akanu Ibiam Federal Polytechnic, Unwana, Ebonyi State).

1.4 Preparation and Measurement of Waste

Fifty kilogram of cow dung were sun dried for 20 days while the kitchen wastes were milled into a coarse form followed by sun drying for 20 days. The slurry was prepared by measuring 50 liters ($0.05m^3$) of cow dung and poured into a pre-treatment drum. One hundred liters ($0.1m^3$) of water was added to the cow dung inside the pre-treatment drum (i.e. in ratio 1:2, cow dung to water). The same procedure was applied to kitchen waste and stirred manually.

Finally, the slurry was transferred to the bioreactor for digestion process. The bioreactor was stirred at intervals. The thermometer at the top of the bioreactor measures the temperature. The temperature was weekly observed and recorded while the ambient temperature was also observed and recorded. Daily records of the biogas generated were also observed for twenty eight days. A GC Hp 68900 with HP Chemstation Rev A 0901 (1206) software was used to analyze the biogas generated by determining the constituents and percentage of each gas contained in the biogas generated and daily biogas generation was recorded.

Table 1: Average Daily Temperature in the Bioreactor and Ambient Per Day for the First Week

	Average Daily Temperature		
Time/Day	Kitchen Waste	Cow Dung	Ambient
1	32.556	32.555	29.564
2	32.200	31.327	28.833
3	31.667	31.473	27.957
4	33.000	33.988	27.073
5	32.302	32.147	28.147
6	33.573	33.763	29.625
7	30.268	30.231	30.321
Average	32.224	32.212	28.789

Table 2: Average Daily Temperature in the Bioreactor and Ambient Per Day for the Second Week

	Average Daily Temperature		
Time/Day	Kitchen Waste	Cow Dung	Ambient
1	32.926	32.589	29.264
2	32.538	31.327	29.133
3	31.473	31.269	28.217
4	32.153	32.987	27.675
5	32.302	32.214	27.974
6	32.854	32.879	28.425
7	31.684	31.239	28.421
Average	32.276	32.072	28.444

Table 3: Average Daily Temperature in the Bioreactor and Ambient Per Day for the Third Week

	Average Daily Temperature		
Time/Day	Kitchen Waste	Cow Dung	Ambient
1	31.546	31.452	28.884
2	31.221	30.983	28.563
3	30.637	31.273	27.857
4	30.256	31.423	28.072
5	31.102	31.127	28.267
6	30.873	30.663	29.127
7	30.542	30.331	29.512
Average	30.882	31.036	28.612

Table 4: Average Daily Temperature in the Bioreactor and Ambient Per Day for the Fourth Week

	Average Daily Temperature		
Time/Day	Kitchen Waste	Cow Dung	Ambient
1	30.436	30.654	29.326
2	30.321	31.132	28.798
3	30.397	30.273	28.534
4	30.126	30.938	28.077
5	29,978	30.128	28.523
6	30.261	30.163	28.625
7	29.148	30.281	29.331
Average	30.095	30.509	28.744

Table 5: Result of Biogas Analysis of Cow Dung and Kitchen Waste using Gas Chromatography

	Biogas Component (%)					
Waste	CH_4	NH_3	CO	H_2S	CO_2	Tot al
Kitchen Waste	70.29	0.58	1.62	0.75	26.7 6	100
Cow Dung	68.26	0.49	1.18	0.15	29.9 2	100

Table 6: Daily Volume of Biogas Generated

Waste	Cow Dung (cm^3)		Kitchen Waste	
No. of Day	Daily Volume of Gas	Cumulative Volume of Gas	Daily Volume of Gas	Cumulative Volume of Gas
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	5.6	5.6	6.4	6.4
4	7.4	13.0	7.2	13.6
5	7.9	20.9	7.7	21.3
6	8.1	29.0	8.1	29.4
7	8.0	37.0	8.4	37.8
8	8.4	45.4	8.7	46.5
9	8.9	54.3	8.9	55.4
10	9.2	63.5	9.6	65.0
11	9.8	73.3	9.7	74.7
12	9.9	83.2	9.9	84.6
13	10.2	93.4	10.6	95.2
14	10.3	103.7	10.4	105.6
15	9.6	113.3	10.0	115.6
16	8.4	121.7	9.7	125.3
17	6.2	127.9	9.2	134.5
18	6.0	133.9	9.7	144.2
19	5.8	139.7	8.3	152.5
20	5.4	145.1	7.6	160.1
21	4.6	149.7	7.1	167.2
22	4.4	154.1	6.2	173.4
23	3.6	157.7	5.8	179.2
24	3.2	160.9	4.6	183.8
25	2.4	163.3	3.1	186.9
26	2.1	165.4	3.6	190.5
27	2.0	167.4	2.2	192.7
28	1.6	169	2.9	195.6

IV. DISCUSSION

The result of this research reveals that the generation biogas was not immediate; it was delayed for the first 24 hours. This can be traced to the fact that most cows feed on fibrous materials and the kitchen waste also contains fibrous materials. This is in conformity with the findings of (6), the absence of biogas generation in the first three days could be as a result of multiple carbon sources in the cow dung as one carbon source is exhausted due to the change to anaerobic condition, the microbial cells divert their source of energy for growth to a new carbon supply, (7). There was a gradual generation of biogas from the third day of fermentation. This suggests that the biogas generating microorganisms are in the lag phase of growth where adaptation of cells takes place. Daily volume of biogas generated showed that the third day, cumulative volume of biogas for cow dung was 5.6cm^3 to the 28th day 169.0cm^3 whereas, that of kitchen waste had the third day of cumulative biogas generate to be 6.4 cm^3 and the 28th day had 195.6 cm^3. The temperature of the bioreactor was observed weekly, it was show the first two week had a little different in temperature than the last third and fourth week. The biogas analysis using chematography revealed that the component of methane was high in kitchen waste 70.29% and cow dung had 68.26%.This is in line with the work of (8), and (9) that biogas, product of anaerobic digestion process mainly contain methane (up to 60%) and low quantities of other gases.

V. CONCLUSION

In this research work, bioreactors were constructed to generate biogas and biofertilizer. The daily temperature and ambient of the substrates were recorded and their graph were plotted against time. The biogas generated by each bioreactor was taken for a gas chromatography analysis, it was observed that methane, carbon (II) oxide, hydrogen sulphide, ammonia were part of the component of the biogas. The daily biogas generation and its cumulative were also recorded.

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