EXPERIMENTAL INVESTIGATION ON THE EFFECTS OF DIGESTER SIZE ON PRODUCTION OF BIOGAS

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ABSTRACT

Experimental investigations were carried out to investigate whether there is any effect on the digester size on the production of biogas with three different lactogen tins as digester sizes of 1 liter, 3 liters and 5 liters of 3 replicates each. From the result obtained, the production of biogas in the smaller digester of 1-liter size produced more gas than digester B of 3 liters and followed by digester C of 5 liters sizes, and record increased with increase in temperature and production decline with drastic fall of temperature. The average production of biogas was 8198.8cm^3, 6140.5cm^3, and 4043.8cm^3 from digester A, B,and C respectively. The experiment run for 30 days with anaverage temperature of 31.9^{0}C, and records were taken at 12:00 noon from day one to last day of the experiment.

Key Words: Experiment, digester, biogas, biomass, production.

INTRODUCTION

The role of energy in the development of any nation has been widely acknowledged. Policymakers and even business communities have expanded a significant amount of effect exploring its contributions to the development process. Moreover, societies are often characterized as developed or developing by their capital energy consumption. In fact, the level of country's economic and social development is gauged not only by the average unit of energy consumption but by the source and variety of its energy source. Thus, societies on the lower level of economic development tend to rely on solid fuels like wood, while those on higher level make extensive use of fossil fuel, hydro and nuclear energy source. Unfortunately, those are non-renewable,hence face the threat of depletion. For this reason, there is need to diversify the sources of energy consumption with emphasis on the renewable energy source, particularly, biomass, solar, wind, hydro and geothermal (Sahabi *et al*, 2011).

LITERATURE REVIEW

*Biogas*is a clean and cheap fuel in the form of gas, of which the major component of the gas is methane.It is flammable and is produced from biomass through the usage of a biogas digester based on the process known as *anaerobic digestion*(Sahabi *et al*, 2011).

Biogas is a by-product of wastes and has proved to be an efficient way of waste management. Various countries of the world have experimented on converting waste into biogas using digesters.

In Africa, trials have been conducted to produce biogas in different countries. The rapid population growth in rural areas of these countries continues to show concern over environmental issues. Nigeria has been reported to be losing nearly 14,000 hectares of tropical forest per annum due to wood burning in form of charcoal (FAO, 1996). Exploitation of animal dung for production of biogas in Nigeria is in its infancy. The pioneer biogas plants are $10m^3$ biogas plant constructed in 1995 by the Sokoto Energy Research Centre (SERC) in Zaria, and the $18m^3$ biogas plant constructed in 1996 at Ojokoro Ifelodun Piggery Farm, Lagos by the Federal Institute of Industrial Research Oshodi (FIIRO) Lagos (Zuru *et al*., 1998). Generally, it is now recognized that biogas/biomass projects can be more than a means of handling manure or sewage sludge (Aduba et al, 2013).

Batch Reactor

Batch reactors are operated by filling the reactor with slurry, letting the reactions that take place in the reactor proceed to completion, and then removing some or all of the contents of the reactor. This procedure is then repeated. Stirring may or may not be part of the operation of a batch reactor. Advantages of a batch reactor include ease of operation, theabsence of mechanical mixing, and high removal efficiency of an individual contaminant. Kinetics in a batch reactor is similar to the kinetics in an ideal plug flow reactor. Biosolids from one batch of operation may be used to seed the subsequent batch reaction with microbes (Rowse, 2011).

OBJECTIVE

The objective of this paper is to investigate through an experiment, whether there is any effect on digester size on the production of biogas when the same quantity of slurry is fed within different sizes of thedigester.

MATERIALS AND METHODS

Apparatus Used

i. Three (3) lactogen tins of 1 liter, 3 liters and 5 liters sizes as digesters with three replicates each,
ii. Nine (9) gas collectors (measuring cylinders) of $500cm^2$each,
iii. Nine (9) stands and clamps,
iv. Nine (9) plastic bowls containing salt (sodium chloride) solution
v. Rubber Hose
vi. One (1) trough for mixing

Materials Used

Cow dung, sodium chloride (NaCl), putty (used as seal out).

Experiment Procedure

The cow dung was collected at Tudun Wada area, Birnin Kebbi metropolis. It was sundried and grinded with mortar and pestle, and sieved to get fine cow dung powder.The slurry prepared was 5kg of cow dung powder and 9 liters of water to obtain a ratio of 1:8 cow dung powder and water. Three different sizes of lactogen tins of 1 liter, 3 liters, and 5 liters were used as digester sizes, and each size was a replicate of three.0.8 liters of the slurry prepared was then transferred into each digester. A rubber hose was used to pass the gas produced from the digesters to the gas collectors (measuring cylinders), which were filled with aqueous salt solution and invertedly placed on plastic bowl containing the aqueous salt solution. Putty was used for sealing out the digester mouth and was also covered everywhere, i.e. whereverthe gas was expected to escape or against any leakage from joints. The gas production was noticed by downward displacement of the solution in the gas collector (measuring cylinder). The volume of gas produced and the room temperature were recorded at 12:00 noon each day for a period of 30 days.

RESULT AND DISCUSSION

The quantities of gas produced for a period of 30days with temperature recorded are shown in table 1 below for each digester of 3 replicates in cm^3. Digester A of 1-liter sizes started producing the third day and digester B of 3 liters sizes started producing thefourth day, while digester C of 5 liters sizes started producing on the fifth day.

From the result obtained, it was observed that the average production of gas was $8189.5cm^3$, $6140.8cm^{3,}$and $4043.8cm^3$ from digester A, B,and C respectively with an average temperature of 31.9^0C. The highest temperature recorded during the experiment was 35^0C from day one to the last day of the experiment. It was noticed that the production of biogas from the smaller digester of 1-liter size was more than that of digester B of 3 liters, and followed by digester C of 5 liters size. The production of gas increased with increase in temperature, and it declined with drastic fall in temperature. The peak of production was recorded on 22^{nd} day of about $730cm^3$ of gas produced from digester A, $638cm^3$ of gas produced from digester B and $485cm^3$ of gas produced from digester C respectively.

Table 1: Record of quantities of gas produced/digester through 30days

	Digester A (cm^3)			Digester B (cm^3)			Digester (cm^3)			Temp. ^0C
Date/2009	A1	A2	A3	B1	B2	B3	C1	C2	C3	
21/08										34^0C
22/08										33^0C
23/08	60	65	72							30^0C
24/08	64	67.5	72	55	62	75				31^0C
25/08	96	80	85	75	67.5	75	45	55	55	31^0C
26/08	140	125	155	107	90	95	48	52	67.5	33^0C
27/08	130	100	115	97	47.5	90	65	70	67.5	32^0C
28/08	100	125	100	50	47.5	42.5	42	48	45	30^0C
29/08	70	60	90	50	58	61	48	50	42	29^0C
30/08	80	100	110	85	85	75	60	71	68	31^0C
31/08	115	125	130	90	102	95	72	68	68	30^0C
01/09	90	95	95	60	55	65	36	34	36	30^0C
02/09	130	100	135	100	102	95	58	52	55	32^0C
03/09	180	160	188	135	150	142.5	82	82	77.5	33^0C
04/09	80	75	90	60	60	68	58	60	50	30^0C
05/09	160	160	165	110	99	105	90	82	100	31^0C
06/09	195	187	200	160	160	175	102	112	101	32^0C
07/09	260	260	325	205	235	200	128	118	105	32^0C
08/09	592	590	595	325	340	310	198	208	118	34^0C
09/09	670	664	670	562	592	592	345	369	380	33^0C
10/09	648	665	610	555	545	580	422	408	420	35^0C
11/09	730	700	722	600	645	638	439	485	475	35^0C
12/09	350	350	325	315	290	275	208	235	218	34^0C
13/09	700	715	695	420	540	560	365	380	305	33^0C
14/09	620	605	600	405	460	455	325	350	310	34^0C
15/09	450	400	480	330	402	310	225	210	275	31^0C
16/09	420	410	345	290	290	260	150	199	210	31^0C
17/09	445	430	410	248	230	255	190	190	157	33^0C
18/09	380	350	365	275	185	260	85	100	105	33^0C
19/09	300	295	305	260	200	255	90	110	105	34^0C
Ave. Total	**8189.5 cm^3**			**6140.8 cm^3**			**4043.8 cm^3**			**31.9^0C**

STATISTICAL ANALYSIS OF VARIANCE

$V = 9 - 1 = 8$, $V_2 = 243 – 1 = 242$

8,242 = 1.94(0.050)

2.19(0.025)

To find out if digester size has an effect on theproduction of biogas using theamount of biomass on each digester:

H_0: there is no significant difference in the effects of digester size on theproduction of biogas.

Reject H_0 if F cal > F table

F cal = 2.78; $F_{0.05}$ (8.242) = 1.94

Since F calculated > F table, we reject H_0.

DISCUSSION

Biogas is environmentally friendly and one of the most efficient and effective options for renewable energy among various other alternatives (Muhammad *et al*, 2016). Therefore, its production and utilization would go a long way in enhancing the development of African countries like Nigeria in the following ways, among others:

1. It is a medium of waste management in engineering
2. Cow dung is available in Nigeria
3. It is an alternative energy source, which could help cater for the blessed mass population.
4. Engagement in biogas production could also be an avenue for employment to the country.

Also, from this investigation, smaller digester sizes should be preferred to the bigger ones for higher production.

CONCLUSION

The cumulative biogas yielded from digester A, B and C (1:8 dung to water ratio) slurry of cow dung anaerobic digester over a period of 30 days and average ambient temperature of 31.9^0C was found to be 8198.5cm^3, and 4043.85cm^3 from digester A, B and C respectively. Thus, digester A of 1 liter size produced the highest quantity of biogas followed by digester B of 3 liters size and lastly digester C of 5 liters sizes.

However, analysis of variance at the significance level of = 0.05 shows that the difference in biogas yield between digesters is significant. It is therefore, concluded that the smaller the digester the higher the rate of biogas it will produce; and that large digester produced it less.

RECOMMENDATIONS

Based on the foregoing, this paper wishes to put forward the following recommendations:

i. The general public should be well educated on alternative energy sources such as the biogas.

ii. Setting up of biogas production plants (whether at small or large scale) should be encouraged and facilitated by governments and philanthropists.

iii. In designing digester, smaller size (like 1 liter capacity) should be preferred.

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