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RELATIVE EFFECTIVENESS OF BIOGAS PRODUCTION USING POULTRY DROPPINGS AND SWINE DUNG

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Abstract
Cow dung, poultry droppings and swine dung usually constitute refuse causing environmental pollution in Nigeria where these animals are reared. A study was conducted on the effectiveness of biogas production using poultry droppings and swine dung. The poultry droppings, swine dung and water were mixed in different ratios of 3:1:8 as sample A, 1:1:4 as sample B and 1:3:8 as sample C. The study was carried out using Completely Randomised Design replicated two times. Six biogas digesters of the same size were used and each sample was loaded into the digester which was monitored for 13 days. The production of the biogas from the three samples started on the 6th day at temperatures between 20^{o}C and 40^{o}C and the volume produced daily was measured by displacement method. Samples B and C attained peak production on the 11th day but sample A attained peak production on the 12th day. Average biogas total volume production for samples A, B and C were 429.75 ml, 440.3 ml and 467.2 ml respectively. The mean volumes of biogas produced from the three digesters were significantly different from one another. Thus Digester C with the highest swine dung composition (1:3:8) was found to be more effective for producing biogas than poultry droppings (3:1:8).

Key Words*: Biogas***,** *biogas production, biogas digester, swine dung, poultry droppings*

Introduction

Agricultural wastes from animals such as poultry droppings, cow dung, and swine dung usually produce obnoxious odour and environmental problems for the people living around the areas where such wastes are dumped. These animal wastes have been found to consist of exploitable gas and energy which can be obtained by a process called biomethanisation and the gas produced can be used as a source of energy or burning it directly for heating effect (Dupont and Accorsi, 2006). Biological process of treating solid and liquid organic residues that leads to formation of digestate and biogas production is called biomethanisation (Karellas *et al*., 2010). The negative impact of these waste products on the environment and man can be converted to useful materials in Nigeria as source of energy, biogas and organic fertilizer as pointed by (Karellas *et al*., 2010). Guendouz *et al*. (2010) pointed out that biogas is inexpensive, none polluting gas and can be used as a supplement for non renewable fossil energy. Biogas can be produced from almost all organic materials that could be decomposed or processed by anaerobic digestion (Crow, 2006). These include animal dung, sewage, landfills and industrial wastes. (Nagamani and Ramasamy, 2007) stressed that animal wastes are available and close to the point-of-use of the feedstock and economical for biogas production. The biogas can be used as a

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substitute for natural gas for cooking, heating and electricity. Digesters are effective at reducing problems of odours, pathogens and green house gas emission from animal waste or sewage sludge though the digesters cannot remove chemical contaminants in the waste (Lusk, 1998). Nigeria has been reported to have lost 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 rare and this can improve the economy of the country. The pioneer biogas plants are a 10 m^3 biogas plants constructed in 1995 by the Sokoto Energy Research Centre (SERC) in Zaria and 18 m^3 biogas plants constructed in 1996 at Ojokoro Ifelodun piggery farm, Lagos by the Federal Institute of Industrial Research Oshodi (FIIRO) Lagos (Zuru *et al*., 1998). Eze et al. (2007) reported that if all the livestock waste in Nigeria are recovered and utilized to produce methane, approximately 7 – 10% of the total energy consumption could be replaced. Eze *et al*., (2007) reported the Nigeria's biogas potentials (minimum value) from solid waste and livestock excrements in 1999 is about 1.382×10^9 m^3 of biogas/year or an annual equivalent of 4.81 million barrels of crude oil. The abundant availability of animal manure in Nigeria (particularly from poultry enterprises), which could cause health hazards during decay could be turned to biogas for utilization by the rural communities and later in future be commercialised for sale to urban dwellers. Ojolo *et al*., (2007) conducted a comparative study of biogas production from poultry droppings, cattle dung, and kitchen under the same operating conditions. Poultry droppings produced more biogas than cow dung and kitchen wastes. Uzodinma *et al*., (2011) investigated biogas fuel production from blends of biological wastes such as pumpkin pod, cow dung and swine dung with maize bract. Results indicated that the low flammable biogas from the maize bract waste could be enhanced significantly by blending with cow and swine dung. Ofoefule *et al*., (2010) investigated the production potential of paper waste and its blend with cow dung in the ratio 1:1. The study showed that paper waste is a very good feedstock for biogas production. It also indicates that blending paper waste with cow dung or any other animal waste will give sustained gas flammability throughout the digestion period of the waste since animal wastes are good starters for poor biogas producing wastes. Results indicated that the low flammable biogas from the maize bract waste can be enhanced significantly by blending with cow and swine dung. Adeniran *et al*., (2014) reported that poultry wastes produced more biogas than cow dung. The main objective of this study was to determine the relative effectiveness of biogas production from different feedstock composition of 3:1:8, 1:1:4 and 1:3:8 (poultry droppings: swine dung: water).

Materials and Methods

An anaerobic digester is equipment used for the production of biogas from mixture of gases created by methanogenic bacteria which break down the organic matter in an anaerobic condition and nutrient rich in substrates can be used as fertilizers and fish meal. The digester is often also referred to as biogas chamber, biogas plant or an anaerobic reactor. The materials used for the biogas production in this study were poultry droppings; swine dung and water were collected from Tanke area, Ilorin (Figure 1). The study was conducted in the Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria. The study site is located between Latitude 8° 24′ N and 8° 36′ N and Longitude 4° 10′ E and 4° 36′ E as shown in Figure 1. It has an approximate area of about 32,500km^2 (Fadeyi *et al*., 2009). It is situated in the North central of Nigeria at about 302km North of Lagos and 475km south of Abuja (FCT). The climate of Ilorin is characterized by both wet and dry seasons. The mean monthly temperatures are very high varying from 25°C to 28.9°C (Ajadi *et al*., 2011). Ilorin with an elevation of about 340m above mean sea level falls within the Southern Guinea Savannah Ecological Zone of Nigeria. The total annual rainfall in the area is about 1200mm (Olaniran, 2002). The rainfall pattern is bimodal distribution. The rainy season starts around March, with a short dry spell in July. The long dry spell begins in November and ends in March.

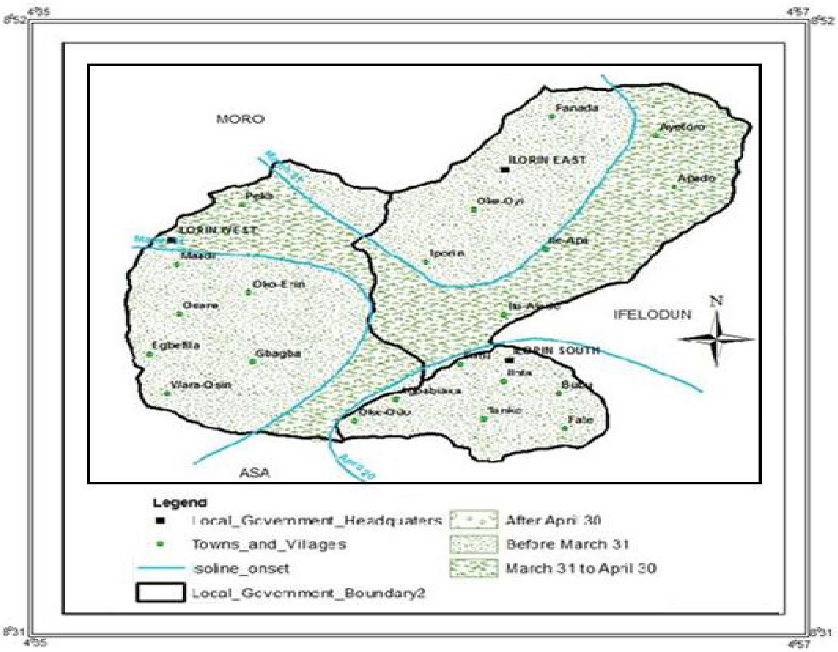

Figure 1: Location Map of the study area (Ajadi *et al*., 2011)

The samples A, B and C were the treatments fed into the digester at three different mix ratios of 3:1:8, 1:1:4 and 1:3:8 respectively. The mixing ratio of the sample A contained 1.5 kg of poultry droppings, 0.5 kg of swine dung and 4.0 kg of water. Sample B contained 1.0 kg of poultry, 1.0 kg of swine dung and 4.0 kg of water. Sample C contained 0.5 kg of poultry droppings, 1.5 kg of swine dung and 4 kg of water. Each treatment was replicated twice. Based on the composition of animal waste with water as a solvent for mixing the two organic matters, Sample A had 75% poultry droppings and 25% swine dung. Sample B contained 50% poultry droppings and 50% swine dung. Sample C contained 25% poultry droppings and 75% swine dung. Six digesters of the same design and capacity were used for this study. The digesters labeled A_1 and A_2 were used for samples A_1 and A_2, digesters B_1 and B_2 for samples B_1 and B_2, and digesters C_1 and C_2 for samples C_1 and C_2. The slurry was prepared in the slurry tank of the digester by addition of water to the animal waste in the right proportion. The volume of biogas produced in the digester was measured by the volume of water displaced in the scrubber by the gas and recorded as the biogas produced. Statistical analysis was carried out using Duncan's multiple tests.

Results and Discussion

The quantity of biogas produced daily from mixing ratio of poultry droppings, swine dung and water as samples A, B and C for a period of 13 days were shown in Tables 1, 2, and 3. The biogas production from the digester started on the 6th day of the experiment from the three samples. The volume of biogas produced was highest with sample C which contained high percentage content of swine dung with 75% and 25% of poultry droppings, followed by sample B that contained 50% poultry droppings and 50% swine dung. Sample A which contained the lowest content of swine dung of 25% and 75% poultry droppings produced the least volume of biogas. This shows that swine dung has a better potential of generating biogas than the poultry droppings as shown in Tables 1, 2 and 3. Average biogas production from samples A, B and C were 429.3 ml, 440.3 ml and 467.2 ml respectively. The mean volumes of biogas produced from the three digesters were as shown in Fig 2. The result of the estimated marginal mean test presented in Table 4 revealed that digester C produced higher mean values of biogas in all the days of the experiment. Digester B was also seen to produce more than digester A in terms of biogas production. Table 5 showed the effect of types of digester and days of the experiment using two ways analysis of variance. The analysis reveals that both types of digester and days of experiment were significant at 95% confidence level. The hypothesis of equal mean treatment effect of digester and days of experiment was therefore rejected. This probably implies that the days of the experiment did not record the same mean values of biogas production. This assertion was confirmed using Duncan's multiple tests for days, as seen in Table 6. The table indicates that if digester was not the case, then day eleven generally appear to record the highest mean value of biogas which was significantly higher than that recorded from day twelve and day thirteen. Days ten, twelve and thirteen produced relatively the same quantity of biogas but were statistically higher compare to the yield from day six, seven and eight respectively. The three digesters were filled using different composition of swine and poultry wastes. These digesters proved to be statistically different from each other in term of swine dung and poultry droppings composition as shown in Tables 1, 2 and 3. Further investigation using Duncan's multiple tests showed that Digester C produced the highest mean biogas of 58.4 ml and this value was significantly higher than that produced from the two other digesters A (53.72 ml) and B (55.11 ml) as shown in Table 7. This is may be due to higher carbon-nitrogen ration in swine dung as compared to poultry droppings. The higher biogas production for swine dung could also be attributed to the available nutrients in the droppings. The higher volume gas produced by Digester C may be due to higher nitrogen content in poultry droppings as compared to other feed stocks (Ojolo *et al*., 2007). Also, the higher biogas production from swine dung could also be attributed to large amount of available nutrients presented in the dung (Adeniran et al., 2014). According to Hill and Brath (1997) substrates for biogas production should contain adequate amount of carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorous, potassium, calcium, magnesium and a number of trace elements.

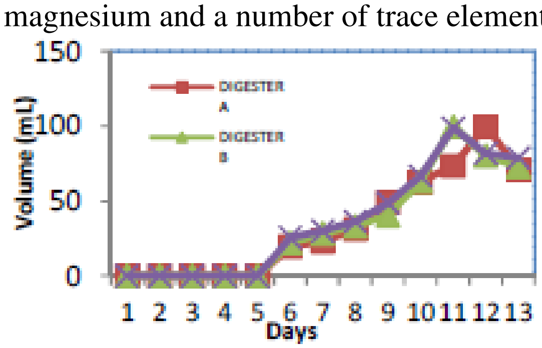

Figure 2: Volume of Gas produced during the study

Conclusions

Waste products from animals such as poultry droppings and swine dung that normally constitute refuse in the areas where they are dumped and on the farm where the animals are reared thereby creating environmental pollution could be converted to useful materials like biogas and organic fertilizer. Biogas from animal droppings/dung does not contain odour and free from pathogen. The study revealed that swine dung can produce more biogas than the poultry droppings.

Table 1: Volume of biogas produced using sample A with 25% swine dung and 75% poultry droppings

Day	Volume of biogas produced in sample A (ml)		Mean volume of biogas (ml)
	A_1	A_2	
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	19.90	19.40	19.65
7	23.10	22.90	23.00
8	30.60	31.90	31.25
9	49.20	48.60	48.90
10	62.60	62.60	62.60
11	73.30	73.90	73.60
12	99.90	99.70	99.80
13	70.60	71.30	70.95
Total	429.20	430.30	429.75

Table 2: Volume of biogas produced using sample B with 50% swine dung and 50% poultry droppings

Day	Volume of biogas produced in sample B (ml)		Mean volume of biogas (ml)
	B_1	B_2	
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	22.60	21.90	22.25
7	28.50	28.20	28.35
8	33.30	32.90	33.10
9	40.10	40.70	40.40
10	63.30	63.50	63.40
11	99.60	99.90	99.75
12	80.60	79.90	80.25
13	73.30	72.30	72.80
Total	441.30	439.3	440.30

Table 3: Volume of biogas produced using sample C with 75% swine dung and 25% poultry droppings

Day	Volume of biogas produced in sample C (ml)		Mean volume of biogas (ml)
	C_1	C_2	
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	25.30	25.90	25.60
7	30.10	29.90	30.00
8	36.60	36.20	36.40
9	48.10	49.40	48.75
10	66.70	66.50	66.60
11	99.50	98.30	98.90
12	82.30	81.60	81.95
13	79.30	78.70	79.00
Total	467.90	466.50	467.20

Table 4: Marginal means of biogas production from the digesters for days 6 to 13

				95% Confidence Interval		
Days	Digesters	Mean	Std. Error	Lower Bound	Upper Bound	Sig
Day 6	Digester A	20.500	4.670	10.483	30.517	
	Digester B	21.819	4.670	11.802	31.836	
	Digester C	25.181	4.670	15.164	35.198	0.001
Day 7	Digester A	25.117	4.670	15.100	35.134	
	Digester B	26.435	4.670	16.418	36.453	
	Digester C	29.798	4.670	19.781	39.815	0.233
Day 8	Digester A	31.583	4.670	21.566	41.600	
	Digester B	32.902	4.670	22.885	42.919	
	Digester C	36.265	4.670	26.247	46.282	0.235
Day 9	Digester A	44.017	4.670	34.000	54.034	
	Digester B	45.335	4.670	35.318	55.353	
	Digester C	48.698	4.670	38.681	58.715	0.005
Day 10	Digester A	62.200	4.670	52.183	72.217	
	Digester B	63.519	4.670	53.502	73.536	
	Digester C	66.881	4.670	56.864	76.898	0.003
Day 11	Digester A	88.750	4.670	78.733	98.767	
	Digester B	90.069	4.670	80.052	100.086	
	Digester C	93.431	4.670	83.414	103.448	0.001
Day 12	Digester A	85.333	4.670	75.316	95.350	
	Digester B	86.652	4.670	76.635	96.669	
	Digester C	90.015	4.670	79.997	100.032	0.001
Day 13	Digester A	72.250	4.670	62.233	82.267	
	Digester B	73.569	4.670	63.552	83.586	

Table 5: Two way analysis of variance for the digesters

Source	Sum of Squares	df	Mean Square	F	Sig.
Intercept	74509.898	1	74509.898	1423.252	.000
Days	15443.042	7	2206.149	42.141	.000
Digesters	93.226	2	46.613	.890	.433
Error	732.926	14	52.352		
Total	90779.093	24			

Table 6: Duncan's multiple range tests for the days

		Subset			
Days	N	1	2	3	4
Day6	3	22.5000			
Day7	3	27.1167			
Day8	3	33.5833	33.5833		
Day9	3		46.0167		
Day10	3			64.2000	
Day13	3			74.2500	
Day12	3				87.3333
Day11	3				90.7500
Sig.		.096	.054	.111	.572

Table 7 Duncan multiple range test for digesters

		Subsets		
Digester	N	1	2	3
Digester A	8	53.7188		
Digester B	8		55.0375	
Digester C	8			58.4000
Sig.		.239	.239	.239

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