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INCREASING THE BIOGAS YIELD OF A FLOATING DRUM ANAEROBIC DIGESTER USING POULTRY DROPPINGS WITH BANANA (*Musa Paradisiacal*) PEELS

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Abstract: An anaerobic digester was used to generating biogas using poultry droppings and banana (*Musa paradisiacal*) peels. The digester was tested twice with a retention period of 35 days. The first test (control) was carried out using poultry droppings and water as the feedstock using a ratio of 1kg : 2kg. The second test was carried out using poultry droppings, water and banana (*Musa paradisiacal*) peels as the feedstock using a ratio of 1kg : 2kg : 3kg. Temperature of the slurry in the bio-digester was monitored and recorded three times daily. The ambient temperature measured during the first stage of the study was between 21°C – 34°C while the slurry temperature was between 21°C and 39.3°C. For the second stage of the study, the ambient temperature measured was between 21°C and 32°C while the temperature of slurry measured was between 19.8°C and 38°C. Higher ambient temperatures during the first test were responsible for the slurry temperature. The total volume of biogas produced during digestion for the first test was 83.38 litres while 121.3 litres was generated during the second test. The study shows that the biogas yield of the anaerobic digester was increased when poultry droppings were mixed with banana (*Musa paradisiacal*) peels.
Keywords: Floating drum anaerobic digester, slurry, biogas

1. INTRODUCTION

In most developing countries, wastes discharged from homes, industries and agricultural fields are indiscriminately released into natural water bodies. The gases generated by these wastes are wasted or not effectively utilized causing pollution of atmosphere, greenhouse effects (global warming and climatic changes) and the release of foul odours. Survival of aquatic animals is being threatened; pollution of the air causing environmental discomfort and high health hazards of human beings and animals. To satisfy the needs of energy for domestic and industrial uses and reduce appreciably the local pollution and greenhouse effects, there is need for the prospection and development of a new source of energy (biogas). The dependence on fossil fuels as primary energy source has lead to global climate change, environmental degradation and human health problems. Biogas digesters can be used for generation of combustible gas (methane) used for the generation of electricity and heating (IEA Bioenergy, 2006). Floating-drum digesters are recommended for biogas production because of their reliability and high performance (Morel and Diener, 2006). Gas production from a given amount of feedstock depends on the type of feedstock used (Earth Trends, 2005). Nagamani and Ramasamy (2007) and Roos (2009) reported that feedstocks that are commonly used in anaerobic digesters include livestock manures, waste feeds, food-processing wastes, slaughterhouse wastes, farm mortality, corn silage, ethanol stillage, glycerine as the product from biodiesel production, milkhouse wash water, fresh produce wastes, industrial wastes and sewage sludge. Adeniran *et al*., (2014a) developed and tested batch and floating drum bio-digeters used for producing biogas from animal wastes. Sanathianathan (1999) and Adeniran *et al*., (2014b) reported the relative effectiveness of biogas production of different proportions of poultry wastes and cattle dung. The study shows that the largest volume of biogas production was obtained using high concentration of poultry wastes to cow dung. Poultry wastes therefore are effective for production of biogas than cow dung. Past studies show that potato and orange peels improved biogas yield of anaerobic digesters (Sanaei-Moghadam *et al*., 2014, Wikandari *et al*., 2015).The objective of this project was to increase the biogas yield of a floating drum anaerobic digester using poultry droppings mixed banana (Musa paradisiacal) peels.


Figure 1. The floating drum anaerobic biogas digester

2. MATERIALS AND METHOD: Equipment and Experimental work

A floating drum anaerobic digester (Fig 1) with a capacity of 223.5 litres tank and a 191 litres gas tank was used in generating biogas using poultry droppings and banana (*Musa paradisiacal*) peels as feedstock. The first test (control) was carried out on the digester with a ratio of 1kg of poultry droppings to 2kg of water and the second test was carried out with a ratio of 1kg of poultry droppings to 2kg of water to 3kg of banana (*Musa paradisiacal*) peels to improve the biogas yield.

The major components of the anaerobic digester are slurry mixing tank, digester tank, gas holder tank, a scrubber tank and a storage container. Other accessories include; stirrer/mixer, hoses, valves, metallic inlet fittings, waste conduit and frame. The scrubber absorb the carbon dioxide (CO_2) and sulphur dioxide (SO_2) content of the gas and pass the gas to the storage container. A frame structure with mechanical grooves was constructed to a specific length above the tank to prevent the gas tank from tilting as well as also not to allow it fall off due to the pressure of the gas.

3. RESULTS AND DISCUSSION

Temperature variations during the first test using poultry droppings with water

Table 1 shows the temperatures in the morning temperature variations for both ambient and slurry conditions for a period of 30 days for the first test using poultry droppings mixed with water. The temperature varied from 20°C to 45°C (mesophilic range). Minimum and maximum ambient temperatures of 21°C and 29°C respectively were obtained during the period of study, while for the slurry condition, minimum and maximum temperatures of 21°C and 28.2°C respectively were obtained. The temperatures of the slurry obtained in the morning were lower than that of the ambient condition because of the ability walls of the digester to absorb more heat from the environment than it is able to emit heat.

Table 1: Temperature variation during the first test (control)

Day	Morning		Afternoon		Evening	
	Ambient Temp. °C	Slurry Temp. °C	Ambient Temp. °C	Slurry Temp. °C	Ambient Temp. °C	Slurry Temp. °C
6	25	23.8	34	39.2	32	39.2
7	25	23.8	34	39.0	32	39.0
8	28	27.5	28	33.5	27	33.5
9	27	26.3	33	38.4	31	38.4
10	25	23.8	33	38.7	31	38.7
11	25	24.5	33	38.4	31	38.4
12	29	28.2	33	38.3	32	38.3
13	26	24.5	28	33.2	27	33.2
14	27	26.3	30	35.7	27	35.7
15	25	23.8	32	36.8	30	36.8
16	27	26.4	32	36.6	31	36.6
17	27	26.4	33	37.9	31	37.9
18	26	25.6	34	39	32	39
19	26	24.5	31	34.4	29	34.4
20	26	24.5	32	36.7	31	36.7
21	26	24.8	34	39.2	32	37.2
22	26	24.8	33	37.8	30	35.7
23	25	25	33	37.6	30	35.3
24	27	25.6	34	39	31	36.7
25	28	27.2	33	37.7	29	35.6
26	24	23.8	34	39.1	32	38
27	22	22	33	37.6	31	35.3
28	22	21.7	34	39	32	36.7
29	21	21	33	38	31	35.8
30	26	25.3	31	34.6	28	31
31	24	23.2	32	37	30	34.1
32	24	24	34	38.8	32	34.9
33	22	21	33	38.2	31	35
34	26	25.3	33	38	31	35
35	27	26.6	33	38.1	32	35

Table 1 also shows minimum and maximum ambient temperatures of 28°C and 34°C respectively were obtained for the afternoon variations, while for the slurry condition, the minimum and maximum temperatures obtained were 33.2°C and 39.2°C respectively. At this time, the ambient temperature increased, resulting in corresponding increase in the slurry temperature because the digester tank walls absorbed more heat from its surrounding. Table 1 shows that the evening temperature variations, minimum and maximum ambient temperatures of 27°C and 32°C respectively were obtained, while for the slurry condition, the minimum and maximum temperatures obtained were 31°C and 39°C respectively. The slurry temperatures were higher than the ambient temperatures because of the digester body coated black, which increases the amount of heat absorbed and thereby increasing the action of mesophilic bacteria (Miah *et al., 2005*).

Temperature variations during second test using poultry droppings, water and banana (*Musa paradisiacal*) peels

Table 2 shows that the temperatures in the morning temperature variations for both ambient and slurry during the second phase of the experiment (using poultry droppings, water and banana (*Musa paradisiacal*) peels. The digester was able to keep the temperature within the mesophilic range (20°C to 45°C). Minimum and maximum ambient temperatures of 21°C and 26°C respectively were obtained, while for the slurry condition, minimum and maximum temperatures of were 19.8°C and 24.8°C respectively. The afternoon temperature variations show that the minimum and maximum ambient temperatures of 26°C and 37°C respectively were obtained, while for the slurry condition, the minimum and maximum temperatures obtained were 31°C and 39.3°C respectively. During this period, the ambient temperature increased, resulting in increase in the slurry temperature because of the ability of the digester tank material and coating to absorb more heat from its surrounding. During the evening period, minimum and maximum ambient temperatures of 25°C and 35°C respectively were obtained, while for the slurry condition, the minimum and maximum temperatures obtained were 27.5°C and 39.3°C respectively. The slurry temperatures were higher than the ambient temperatures because of the digester body coated black, which increases the amount of heat absorbed and thereby increasing the action of mesophilic bacteria.

Table 2: Temperature variation during the second test

Day	Morning		Afternoon		Evening	
	Ambient Temp. °C	Slurry Temp. °C	Ambient Temp. °C	Slurry Temp. °C	Ambient Temp. °C	Slurry Temp. °C
6	25	23	34	38.5	33	38.5
7	26	24	31	33.3	32	33.3
8	25	23.1	31	33.7	29	33.7
9	26	24.7	32	35.6	32	35.6
10	26	23.7	33	38.2	31	38.2
11	24	22.1	34	38.7	29	38.7
12	26	24.8	29	32.6	27	32.6
13	24	22.4	33	35	29	35
14	24	22.1	37	39.3	35	39.3
15	26	24.8	33	36.8	31	36.8
16	25	23.3	32	34.3	29	34.3
17	26	23.9	33	36.5	31	36.5
18	26	24.6	31	34.3	27	34.3
19	25	23.3	33	34	31	34
20	26	24.5	34	36	33	36
21	24	22.8	28	32.3	26	31.6
22	23	22	32	35.1	30	34.7
23	25	23.7	32	35.2	30	33.7
24	26	24.6	32	34.8	29	32.5
25	26	24.3	32	35	30	33.9
26	26	24.8	31	33.5	30	33.5
27	22	20.3	32	35	31	33.9
28	24	21.9	32	35.3	28	32.3
29	25	23.6	31	33.6	29	31.4
30	25	23.6	30	33.1	29	31.5
31	21	19.8	28	31	27	29.7
32	25	23.4	29	31.7	28	31.5
33	25	23.7	30	33.4	27	30
34	22	21	26	27.3	25	27.5
35	22	21.1	31	33.4	28	31.4

Volume of gas produced during the two tests

Figure 2 shows the total volume of biogas obtained per day for each of the two tests conducted with digester. The digester was first tested with slurry made of poultry droppings and water mixed in a ratio of one 1kg to 2kg. The hydraulic retention period was 35 days. After the 35th day, the total volume of gas produced in the bio-digester was 83.38 litres after which the gas was burnt off. With the valve opened half way, the gas burned for about 40minutes.The volume of slurry retained in the digester tank was about 37.4litres which means about 22.6litres of slurry was converted to gas. Change in the colour of the slurry evacuated was noticed with none offensive odour.

The second test was carried out using poultry droppings, water and banana (*Musa paradisiacal*) peels at a mixing ratio of 1:2:3 for a retention period of 35 days. The hydraulic retention period was 35 days. On the fifth day after loading, the gas was again released into the atmosphere because it was none-combustible. No appreciable rise in the height of the gas tank was noted until the 14th day to about 7.6cm after which combustibility test was carried out. The gas was combustible with red-blue flame which indicated the presence of CH_4 gas. After the 35th day, the total volume of gas produced in the bio-digester was 121.3 1litres after which the gas was burnt off. With the valve opened half way, the gas burned for about 55 minutes. The volume of slurry retained in the digester tank was about 24.7 litres which means about 35.3litres of slurry was converted to gas. Change in the colour of the slurry evacuated was noticed with non-offensive odour. The total volume of biogas produced during the second test was 131.82 litres while that of the first test was 83.38 litres. Mixing banana (*Musa paradisiacal*) peels with poultry droppings therefore increased biogas by 50%. Ofoefule (2010) obtained similar results, using cow dung blended with paper wastes increased cumulative biogas yield from 6.23±0.07dm³/kg to9.34±0.11dm³/kg. Uzodinma (2011) also observed that low flammable biogas from the maize bract waste can be enhanced significantly by blending with cow and swine dung.

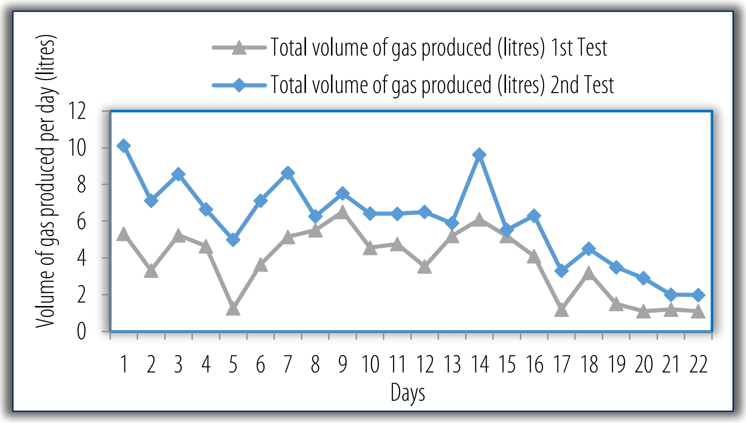

Figure 2. Comparing the volume of biogas produced during the two tests

4. CONCLUSION

The study shows that the biogas yield of poultry droppings can be increased by mixing it with banana (*Musa paradisiacal*) peels. The poultry droppings banana (*Musa paradisiacal*) peels blend gave the best results in terms of volume of biogas yield. Consequently, apart from chemical treatment, energy could also be tapped from banana (*Musa paradisiacal*) peels by blending it with the wastes from domestic animals that are readily available. The rate of biogas production was greatly affected by the temperature and the colour of the slurry.

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