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Comparative Study on the Efficacy of Biogas Production from Mixture of Animal Waste and *Pistia stratioles* (Water Lettuce)

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Abstract
Biogas was produced from the mixture of Sheep dung and Water lettuce *(Pistia stratioles*) in the ratio of 2:1 and 1:2 over a period of 77 days. Proximate analysis was done to determine the physicochemical parameters of each dried sample. Daily temperature of the laboratory, initial and final pH of the digesters containing slurry was recorded. This work was done to investigate the production of biogas from the mixture of sheep dung and water lettuce in other to improve the biogas production. Proximate analysis was done according to the methods described by Khanadainal and Malidi (1981) and AOAC (1990). Sheep dung and water lettuce was mixed in the ratio of 2:1 and 1:2 each in 900g empty milk tin and mixed with water to form slurry. Initial pH of each slurry was determined by inserting a digital pH meter. Final pH was determined after digestion. The gas was collected through a pipe connected to the digester which was inserted in to a measuring cylinder filled with water and inverted in a container with water. Physical parameters determined for both sheep dung and water lettuce respectively includes: Moisture (11% and 8.5%), Volatile Solid (6.2% and 8.7%) and Ash (19.5% and 44.5%). Initial and final pH of each digester was (7.30 and 7.20), and (6.67 and 6.38) for 2:1 and 1:2 ratio respectively. A total biogas of 17983.33cm^3 and 8546.67cm^3 were recorded by 2:1 and 1:2 ratio of sheep dung and water lettuce respectively. The production temperature ranges from 28^{o}C to 36^{o}C. Nature of substrates affect biogas production as revealed in this research.
Key words: Biogas, sheep dung, water lettuce, temperature and ratio.

INTRODUCTION

The diminishing and environmental degradation of fossil fuels have forced the researchers to look for suitable source of energy that is sustainable and environmentally friendly to ensure sustainable development (Ramaraj *et al*., 2015a). Renewable energy is the alternative source of green energy which is cheaper in production and safer in term of environmental pollution as well as energy security (Unpaprom *et al*., 2015a). Biogas is a renewable gaseous fuel produced from anaerobic digestion of organic material with methane as the major product which is converted to carbon dioxide when use as source of heat, thus reduces the burden to the environment (Unpaprom *et al*., 2015b).

Farming is one of the major sources of income in Nigeria. This includes food production and animal production. Large quantity of manure is generated from animal production such as sheep, cattle, goat and poultry which is majorly used as manure (Ikpeze *et al*., 2008). The application of animal manure on the farm can pose contaminations of the area because the manure may contain some pathogenic microorganism which can subsequently results to soil, water and air pollution and also when composting releases methane gas in to the atmosphere which contribute to the greenhouse effect and global warming living behind an unpleasant odour that also affect the environment (Onwumelu *et al*., 2009).

Biogas is one of the alternative of reducing environmental problems and source of renewable energy. The main aim of this study is to quantify the gas produced from the Animal waste and *Pistia stratioles* (water lettuce) using water displacement method.

MATERIALS AND METHODS

Sample Collection and Processing

Fresh *Pistia stratioles* (water lettuce) was plucked from Sidi Mamman Farm along western bypass road in Sokoto and sheep dung was collected at veterinary clinic at Kofar Aliyu Jedo Area in Sokoto metropholis. All the samples were collected in a clean polyethene bags. The fresh samples were taken to the chemical laboratory of Energy Research Centre Sokoto and dried at room temperature for a period of two weeks before grounded into powdered form using a pestle and mortar (Baki, 2004).

Proximate Analysis of dried Sheep dung and Water lettuce

Moisture, Ash and nitrogen content were determined using Khanadainal and Malidi (1981) method. While crude protein, fat, crude fibre, carbohydrate, Carbon, total solid and volatile solid content was determined using method of (AOAC, 1990).

Moisture content was determined by weighing 2g of each dried sheep dung and water lettuce into an empty crucible and heated in an oven at 105^0C for 24 hours. The crucibles were removed and allowed to cool to room temperature. The moisture content in each sample was calculated using the following formula:

$$\%\ Moisture\ content = \frac{W_1 - W_2}{W_1 - W_o} \times 100\%$$

$$Where:\ W_1 = Weight\ of\ crucible\ sample\ samle$$

$$W_2 = Weight\ of\ crucible\ and\ heated\ sample$$

$$W_o = Weight\ of\ empty\ crucible$$

Ash content was determined by weighing 2g of each dried sample of sheep dung and water lettuce in an empty crucibles and placed in a furnace at 600^0C for three 3 hours. The samples were removed and allowed to cool to room temperature and calculated using the formula bellow:

$$\%Ash = \frac{W_2 - W_o}{W_1 - W_o} \times 100$$

$$where\ W_1 = Weight\ of\ crucible\ and\ sample$$

$$W_2 = Weight\ of\ crucible\ and\ ash$$

$$W_o = Weight\ of\ empty\ crucible$$

Preparation of Slurry and Experimental Set Up

Fifty grams (50g) of water lettuce *(Pistia stratioles)* was weighed and mixed with 100g of sheep dung into a 900g empty tin serving as digester A and another 100g of water lettuce *(Pistia stratioles)* was mixed with 50g of sheep dung into digester B which was followed by the addition of 1500ml (1:10 waste to water ratio) of water in each digester. The mixture was stirred to obtain homogeneity; the slurry is formed when a saturated solution is formed. Each sample was replicated into three times. All the digesters were sealed with a candle wax in order to check leakage to maintain anaerobic condition (Baki, 2004).

A hose pipe was connected at the top of each digester by making a hole and covered with epoxy steel gum to avoid liking of the gas. The pipe conveyed the gas from the digester to a measuring cylinder (1000cm^3 capacity) filled with water and placed in an inverted position in a basin filled with water (water displacement method). The cylinder was held firm by a retort stand. The gas produced from the digesters was conveyed through the hose pipe to the measuring cylinder which displaced the water downward. The volume of gas produced was measured by the amount of water being displaced from the measuring cylinder. Daily production temperature was recorded at 12:00 noon throughout the retention period (Baki, 2004).

pH Determination

The pH value of the prepared slurry for each sample was determined using a digital pH meter before digestion and after digestion by inserting the pH meter inside the digester and carefully observing the value (Baki, 2004).

RESULTS

Proximate analysis is an important analysis that determines the physicochemical composition the substrate. From table 1, sheep dung was found with high moisture and carbohydrates content while water lettuce has the high content of ash and total solids.

Table 1: Proximate composition (%) of the substrates.

Parameter	Sheep dung	Water lettuce
Moisture (%)	11.00	8.50
Ash (%)	19.50	44.50
Crude nitrogen (%)	1.47	1.50
Crude protein (%)	9.19	9.38
Crude fibre (%)	33.50	13.00
Volatile solid (%)	6.20	8.70
Total solid (%)	89.00	91.50
Fat (%)	9.50	13.00
Carbohydrates (%)	28.31	20.12
Carbon (%)	63.30	38.20
C to N ratio	43.06	25.47

pH is one the parameter that affect the rate of biogas production as most of the microorganisms that are involve operate within the neutral value. Table 2 below shows that the pH of both sheep dung and water lettuce before digestion is within the range value.

Table 2: Initial and final pH of the slurries before and after digestion

Samples	Initial pH	Final pH
A	7.30	6.67
B	7.20	6.38

Keys;
A = mixture of sheep dung and water lettuce (2:1)
B = mixture of sheep dung and water lettuce (1:2)

Temperature is also another parameter that affects biogas production. Table 3 showed the average weekly temperature recorded throughout the production period. It revealed that the temperature was within the mesophilic range which is suitable of optimum biogas generation.

Table 3: Average weekly ambient temperature recorded

Retention Time (week)	Temperature (^oC)
1	33.43
2	33.43
3	34.00
4	32.57
5	33.57
6	32.00
7	32.71

The figure bellow shows clear patterns of weekly biogas production from the mixture of sheep dung and water lettuce. Gas production started gradually until it reaches a certain point (peak point) and then started declining. The ratio of 2:1 sheep dung and water lettuce produced more gas (17,983.33cm^3) with its peak volume at 4^{th} week (3850cm^3). A total of 8,546.67 cm^3 was recorded in the ratio of 1:2 with its peak volume at the 8^{th} week (2703.34 cm^3). This revealed that digester with 2:1 ratio of sheep dung and water lettuce produced higher volume of gas. Moreover, statistical analysis (t-Test) showed significance difference between the two digesters (1.745 < t Critical two-tail of 2.100).

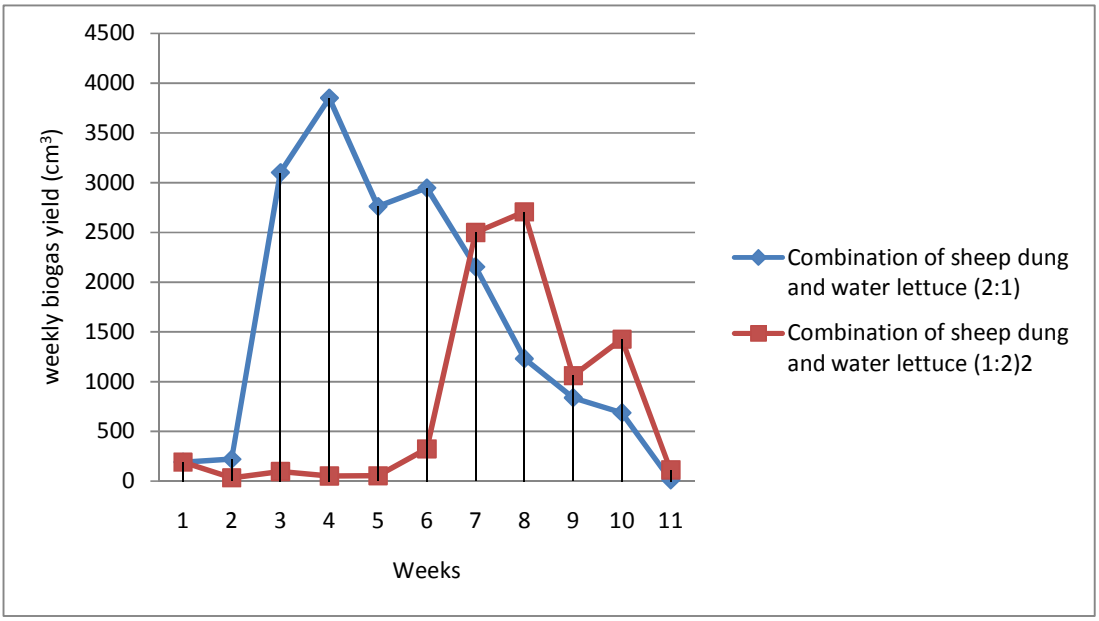

Fig.1: Weekly Biogas produced from mixture of sheep dung and water lettuce at different periods (weeks).

DISCUSSION

Proximate analysis was carried out in which physicochemical parameters were identified. Moisture content from dried sample of sheep dung was found to higher than that of water sample. Substrate with more moisture is expected to generate more volume of gas as microorganisms proliferate in an environment that containing high percentage of moisture (Zuru and Dangwaggo, 2004)). This is in line with the result of gas production found of the present study as the digester containing more sheep dung produced more gas because of the percentage of moisture in sheep dung is higher than that of water lettuce .Total solid, volatile solid and fiber are parameters that indicated the cellulosic content of a particular substrate and affect biogas production. Substrate with low total solid produced more gas than those with high total solid (Ugwuoke *et al.*, 2015). This agreed with the results obtained in this research where water lettuce was found to have high percentage of total solid and the digester containing 1:2 ratio of sheep dung and water lettuce produced lower gas. This means that, the substrate with low solid content tend to be degraded more quickly than the one with higher solid content.

pH of the slurry determines the yield of the gas, because methanogenic microorganisms are more active at optimum pH for which is between 6.4 - 9.2 (Farida, 2008). The results of pH obtained from this research conformed to this as they were all within the range.

Temperature recorded during the production period was found to be within themesophilic range. Baki, (2004) reported that methanogenic microorganisms are mesophiles which perform well at mesophilic temperature range and inactive at very low (below 20^{O}C) and high (above 50 ^{O}C) temperature.

A total of 26,530cm^3 (26.53 liters) of biogas was recorded in this research. Digester with the ratio of 2:1 sheep dung and water lettuce produced more gas (17,983.33cm^3) than the digester with 1:2 (8546.67cm^3). Statistical analysis (t-Test) was applied to further investigate whether the results differ significantly. The result revealed that there is significance difference between the two digesters (1.745 < t Critical two-tail of 2.100). This might be due to the fact that animal wastes are reservoir of microorganisms that may initiate the fermentation faster as well as the physicochemical parameters.

CONCLUSION

The cumulative Biogas yielded from the combination of sheep dung and water lettuce in the ratio of 2:1 and 1:2 (sheep dung: water lettuce), anaerobically digested over a period of 77 days retention time and average ambient temperature of 32.8^{o}C was found to be 17983.33cm^3 and 8546.67cm^3 respectively. Thus, 2:1 combination produced the largest quantity of Biogas. It can be concluded that the percentage composition of sheep dung should be greater than that of water lettuce when combining them for biogas production.

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Appendix

The table above shows the production of biogas from the substrates. Since t Stat of 1.745 < t Critical two-tail of 2.100, we reject the null hypothesis. There is statistical significance difference between the two Samples A (cm^3) and B (cm^3). In Addition P value is less than alpha level of significance, Therefore there is significant difference between the two digesters.

Appendix 1: Statistical Analysis of the biogas produced (t-Test: Two-Digesters)

	188.34	*190*
Mean	1779.03	835.63
Variance	1827844.969	1094416.488
Observations	10	10
Pooled Variance	1461130.728	
Hypothesized Mean Difference	0	
Df	18	
t Stat	1.745164367	
P(T<=t) one-tail	0.049002097	
t Critical one-tail	1.734063607	
P(T<=t) two-tail	0.098004194	
t Critical two-tail	2.10092204	