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EFFECT OF SUBSTRATE ON BIOGAS YIELD

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ABSTRACT

Biogas technology converts biological matter or biological waste (substrate) into energy and simultaneously helps to improve the quality of life and the environment. The effect of substrate on biogas yield was studied by using different substrate in laboratory scale experiment using water displacement method to monitor the volume of biogas produced. The substrates used are waste tomatoes, waste fluted pumpkin leaves, chicken manure, sheep manure and cow dung.

The cumulative biogas produced by each of the substrate was monitored and recorded over a period of 22 days. the results show that sheep dung gave the highest cumulative volume of biogas per 100 g of substrate of 240 ml followed by cow dung 200 ml and the least being waste tomatoes and chicken manure with cumulative volume of 170 ml each. Analysis of the biogas produced indicated that the average content of methane is 65.34 mol%, carbon dioxide 22.81mol%; other components present are; hydrogen 7.49 mol%, Oxygen 0.95 mol%, Nitrogen 3.39 mol% and trace amount of carbon monoxide and water vapor. Hydrogen sulfide was not detected. Based on these results it can be conclude that sheep manure gave the highest cumulative volume of biogas and that the biogas produced from all the substrates is free from hydrogen sulfide.

KEYWORDS; Biogas, Yield, Substrate, Analysis, Digester.

INTRODUCTION

Over the last few years, the interest in bio-energy production has increased significantly. A number of different technologies and processes are used to recycle organic waste and one of them is biogas production. Biogas typically refers to gas containing mainly methane and produced by anaerobic decomposition of organic material. Common organic materials for biogas production include; biomass, manure, sewage, municipal waste, green vegetable wastes and energy crops. Anaerobic decomposition (fermentation) of organic matter produces methane carbon-dioxide, some hydrogen and other gases in traces, and a final residual product with high nitrogen content (Vesilind et al, 2010). Biogas production is a technology that can make efficient use of organic substance despite high water content (Bauer et al, 2013). The yield and composition of biogas depend on the nature or type of substrate fed to the digester.

The process of producing biogas is by anaerobic fermentation of organic matter (substrate) which is gaining popularity daily and is more widely adopted for use. This development is due to its ability to provide relief to man from two of the problem encountered in the course of living from day to day. They are the problems of how to acquire energy in sufficient amount for purpose of cooking, heating, lighting and running of machinery, on one hand the problem of proper disposal of waste in a manner that it wouldn't cause harm to man. The potential for many different types of substrate have been studied, this was reviewed by Mursec et al (2009), Nagamani & Ramasamy (1996) and Fantozi & Buratti (2009).

This work focuses on determination of the effect of substrate such as cow dung, sheep manure, chicken manure, waste fluted pumpkin leaves and waste tomatoes on biogas yield.

2. BIOGAS DIGESTER'S FEEDSTOCK

Animal wastes are generally used as feedstock in biogas plants and their potential for biogas production has been presented by Nagamani & Ramasamy (1996) and Fantozi &

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Buratti (2009). Though, there are many millions of chickens, goats, sheep and cattle in Nigeria presenting potential but untapped sources of feedstock for biomass digesters, the unavailability of these substrates in some parts of the country may be a major hindrance in biogas digesters development and operation. Many other substrates have been explored with the aim of increasing biogas production and yield (Mursec et al, 2009). Food waste as biodegradable substrates for biogas production has been investigated (Kubaská et al, 2010)

Food waste (garbage) as source of biogas has been used for biogas production, the two most important parameters in the selection of particular plant feed stocks are the economic considerations and the yield of methane for fermentation of that specific feedstock (Nagamani & Ramasamy, 1996). Methane yield from fresh-water aquatics, forage grasses, roots and tubers, and marine species was investigated and the highest yield was obtained from root crops followed by forage grasses, and fresh-water aquatics while Marine species yielded the lowest yield of methane (Nagamani & Ramasamy, 1996).

Though, biodigester feedstock is a major determinant of the yield of biogas, there are many other factors affecting the production of biogas such as; design of digester, inoculums, nature of substrate, pH, temperature, loading rate, hydraulic retention time (HRT), C : N ratio, volatile fatty acids (VFA), etc.

3. EXPERIMENTAL METHODS

3.1. Equipment/Apparatus

Constructed Digester, Weighing Balance, Vacuum Pump, Rubber Tube, Plastic Funnel, Bucket, Digester Bottle, Gas Collector Bottle, Calibrated Bottle, Beaker, Glass Rod, and Measuring Cylinder.

3.2. Materials (Raw Materials Used)

Waste Tomatoes, Waste Fluted Pumpkin Leaves, Chicken manure, Sheep manure, Cow Dung, Water, and Bacterial Sludge.

3.3. Experimental Details; Water displacement method was used; the set-up for this method is shown in Figure 1. The feed to the digester was prepared by mixing 100 g of substrate with 100 ml of water and adding 20 ml of inoculums. The mixture was fed into the biodigester bottle and connected to the gas collector bottle filled with water and it was then connected to a graduated container.

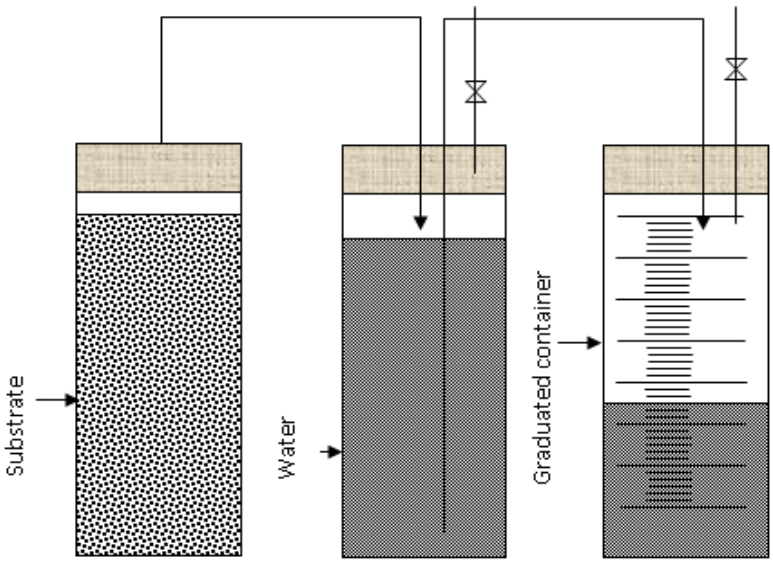

Figure 1: Experimental set up for water displacement method

The biogas produced was determined by noting the quantity of water displaced from the gas collector into the graduated container. The biogas production was recorded daily at an interval of 24 hours for a period of 22 days.

3.4. Analysis of the biogas; The gas produced was analyzed at Warri Refining and Petrochemical company ltd (WRPC) quality control laboratory (LPG and Gases) using Gas Chromatograph ASXL-FID. Also the COD of the substrate was determined using ASTM D1252-95.

4. RESULTS AND DISCUSSIONS

4.1. Results; The cumulative volume in milliliters of biogas produced was recorded daily and tabulated for the five substrates as shown in Table 1. the result was also presented graphically in Figure 1. Table 2 shows the result for the analysis of the biogas.

Table 1: Results for Biogas produced using Water Displacement Method

Days	Cumulative Volume of Biogas (ml)				
	Tomatoes Waste	Fluted Pumpkin Leaves Waste	Chicken Dropings	Sheep Manure	Cow Dung
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	10	0
5	0	10	0	20	0
6	0	10	0	40	0
7	0	20	10	60	0
8	10	40	20	80	10
9	20	40	40	100	20
10	40	60	50	110	30
11	40	80	60	120	40
12	60	100	70	140	60
13	80	110	80	140	80
14	100	120	100	160	100
15	110	130	120	170	120
16	120	140	130	180	140
17	130	150	140	190	150
18	140	160	140	200	160
19	150	160	150	210	170
20	160	170	160	220	180
21	160	170	170	230	190
22	170	180	170	240	200

Table 2: Results for analysis of the biogas using Gas Chromatography

S/N	Component	Mole %
1	Methane	65.34
2	Carbon dioxide	22.81
3	Water	Trace
4	Nitrogen	3.39
5	Hydrogen	7.49
6	Carbon monoxide	Trace
7	Oxygen	0.95

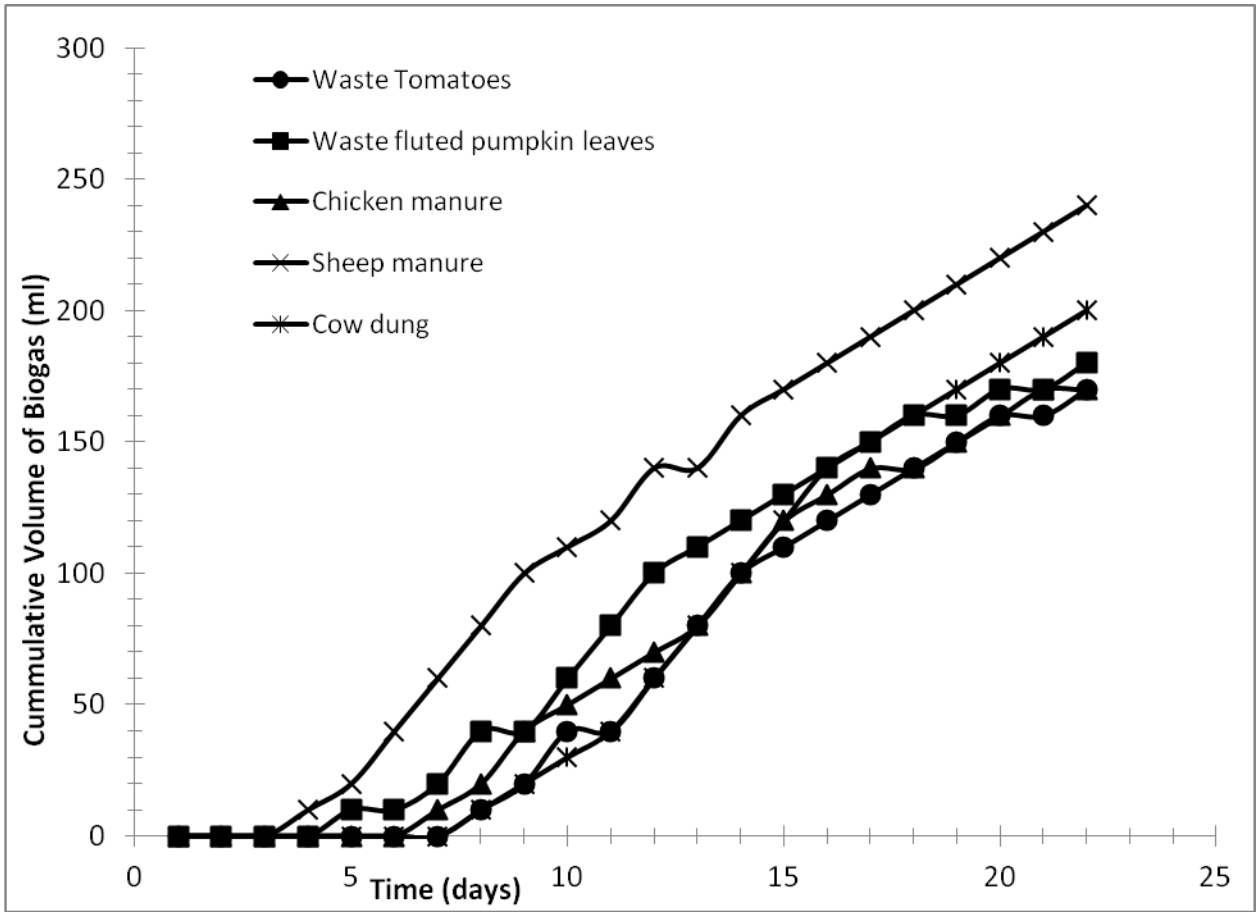

Figure 1: Plots of cumulative biogas produced against time.

4.2. DISCUSSION OF RESULTS

The results were plotted in Figure 1, and these show that biogas production was noticed on the fourth day for sheep manure and that of waste Fluted Pumpkin Leaves was noticed on the 5th day. The highest cumulative yield of biogas was from sheep manure followed by that of cow dung. Based on available literature, there are many factors that affect the yield of biogas (pH, substrate/product inhibition, poisoning etc) these factors were not taken into consideration in this work but will be dealt with in an on-going work.

CONCLUSIONS

The effect of substrate on yield of biogas was investigated and the results show that sheep dung gave the highest cumulative volume of biogas per 100 g of the substrate of 240 ml followed by cow dung 200 ml and the least being waste tomatoes and chicken manure with cumulative volume of 170 ml each.

Analysis of the biogas produced indicated that the average content of methane is 65.34%; other components present are carbon dioxide, nitrogen, hydrogen, oxygen and water. Hydrogen sulfide was not detected.

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