Characterization and Storage of Biogas Produced from the Anaerobic Digestion of Cow Dung, Spent Grains/Cow Dung, and Cassava Peels/Rice Husk.

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ABSTRACT

Cow dung, spent grains/cow dung, and cassava peels/rice husk wastes were treated in the digester of volume $0.971m^3$. Each waste was mixed in different ratio, depending on the nature of the waste. Fixed dome plastic biodigester was used and the digestion of waste was undertaken by batch-type anaerobic digestion. The digester operated at mesophilic temperature (20-40^{o}c). Gas chromatography was used to quantify the different component of biogas produced. Volume and pressure of Biogas stored is the cylinders were tabulated. The total viable count determination for bacteria and proximate analysis of the wastes was done.

(Keywords: biogas, chromatography, batch-type, stored, bacteria)

INTRODUCTION

Biogas is produced by anaerobic digestion of biological waste such as cow dung, spent grains/cow dung and cassava peel/rice husk. Biogas is a clean environment friendly fuel. Raw biogas contains about 55-65% methane (CH_4), 30-45% carbon dioxide (CO_2) traces of hydrogen sulfide (H_2S) and fractions of water vapors. (Kapdi, et al., 2004).

The continuing energy crisis has reawakened interest in the anaerobic fermentation of animal and vegetable waste to produce methane. Apart from these economic benefits, biogas plants have provided many indirect social benefits; such as reduction in the drudgery of rural women and children involved in the collection of fuel materials from long distances, reduction disease from cooking in smoking kitchens and an overall improvement in the standard of living. During years 2000-2001 alone, 164 thousand biogas plants were constructed, generated employment to the tune of 5 million man-days. By linking biogas plants to the toile about 160 thousand families in the rural areas and 350 thousand people living in the slums in and around cites have been provided with good sanitation facilities (Kapdi, et al., 2005 and Boodoo, 1977).

There is a great need to make biogas transportable. There is a lot of potential when biogas could be made viable as a transport vehicle fuel like CNG by compressing it and filling into cylinders (Vijay, 2007). This work was therefore taken to identify the various components biogas is made up of, the compression and storage of the biogas into cylinders. A possible relationship between the microbial load and biogas production from the wastes was proposed (Bothi and Sanchez,2007).

EXPERIMENTAL

Materials: The following materials were used, cow dung obtained from Nsukka. Abattoir, spent grains obtained from Ama Brewery in Enugu State, rice husk obtained from Adani Rice Mill in Enugu state and cassava peel obtained from Garri Mill. All these waste were digested in $0.971m^3$ capacity of biodigester. A gas chromatograph was used for gas analysis. Oven, Walkley black Titrimetric method, Meynell method were used to determine the proximate analysis of the waste (Dioha, 2006). Reconstructed gas cylinders, delivery tubes, trough of water, compression and pressure gouge were used to store the biogas into cylinders.

Method: The slurry of cow dung was obtained by diluting it in the ratio of 1:2 (waste: water). 100% percent of cow dung spent grains/cow dung was mixed in the ratio of 1:2. The waste mixed percent was 70:30%. Cassava peels/rice husk was mixed in the ratio of 1:5. The waste mixed percent was 50:50 percent 660kg, 550kg and 420kg of slurry of the wastes respectively were charged into the biodigester. The temperatures of the digesting substrates were measured through the thermometers inserted into the digester through one hole on the Lid.

Cow dung and rice husk added to spent grains and cassava peels acted as an inoculum. In place of nutrient agar, saboround dextrose agar (SDA) was used to determine the total viable count. The set up was left and the gas volume monitored daily for 70days, 61 days and 70 days respectively. The cumulative gas production obtained for the three substrates were 1.510 m^3, 3.839 m^3 and 3.450 m^3 respectively. The curves obtained over the period of observation are presented for the three substrates in Figures 1, 2, 3, 4, 5, and 6.

ANALYSIS

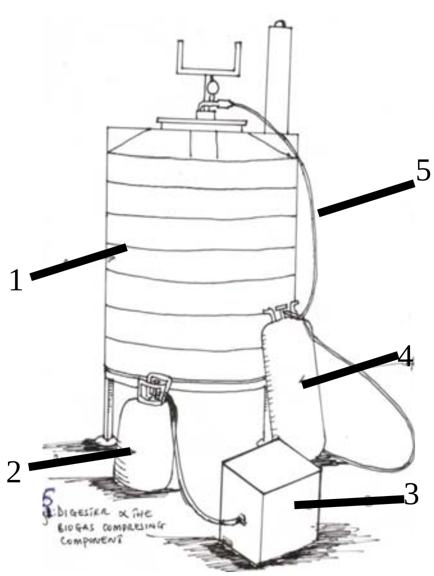
Both the fresh and digested slurry were analyzed for dry matter (DM), Nitrogen, carbon, phosphorous, volatile solid, ash, PH and moisture by standard procedures (Royal, 1971). It was done in the Department of Crop Science Laboratory University of Nigeria Nsukka. The percentage content of these components mentioned above was recorded in Table 1.

Gas production was measured at intervals of about 24 hours by volume displacement, the temperature of the gas being recorded and the volume corrected to a standard temperature of (20^o-40^o C) which is within the mesophillic temperature.

The microbial loads expressed as colony-forming units (cfu) of various waste are shown in Table 2. The biogas generated from the different waste was analyzed using gas chromatography. The result of the biogas composition were recorded in Table 3 or 4 (Vogel, 1978 and Royal, 1971).

A reconstructed gas compressor was used to compress the biogas into gas cylinders (See figure a). A compressor is a mechanical device that increases the pressure of a gas by reducing its volume. Biogas containing mainly methane, could not be stored easily as it does not liquefy under pressure at ambient temperature (critical temperature and pressure required are -85.5C and 47.5 bar, respectively).

Compressing the biogas reduces the storage requirements, concentrates energy of content and increases pressure to the level required overcoming resistance to gas flow. Compression is better in the scrubbed biogas.



1. **Digester**
2. **Gas Cylinder where the Biogas was stored**
3. **Gas Compressor**
4. **Gas Cylinder through which the Biogas was sucked out from the Digester**
5. **Rubber Hose**

Figure A: Digester & the Biogas Compressing Component.

Table 1: Result of Physicochemical Analysis of Cow Dung, Spent Grains/Cow Dung, and Cassava Peels/Rice Husk.

Parameters	Cow dung		Spent grains/cow dung		Cassava peels/rice husk	
	Fresh slurry (%)	Digested slurry (%)	Fresh slurry (%)	Digested slurry (%)	Fresh slurry (%)	Digested slurry (%)
Nitrogen	0.94	2.62	4.35	4.60	0.28	0.91
Carbon content	3.98	5.31	6.49	7.30	5.33	6.62
PH	6.50	7.20	6.50	5.30	5.19	6.62
Ash	3.70	3.50	0.80	0.99	1.00	0.50
Moisture	88.85	84.0	89.60	88.59	93.00	71.75
Phosphorous	0.04	0.37	0.07	4.38mg/100gm	2.27	5.17
Potassium	120ppm	46.80	118ppm	13.43mg/100gm	31.25mg/100gm	52.89mg/100gm
Volatile solid	64.99	74.23	93.20	91.80	86.15	87.06
Total Solid	89.32	84.00	87.86	92.18	97.09	72.70

Table 2: Total Viable Count Determination for Bacteria.

Waste	Mean drop count	Dilution factors	Volume/drop (ml)	Total viable count (cfu/ml)
Cow Dung	18	10^5	0.015	$12x10^6$
Spent Gains/Cow Dung	22	10^4	0.015	$18x10^6$
Cassava Peels/Rice Husk	43	10^4	0.015	$29x10^7$

Table 3: Percentage of the Component of Biogas from Three Different Wastes using Gas Chromatography.

Waste	Carbon dioxide CO_2 (%)	Hydrogen sulphide H_2S (%)	Carbon monoxide CO (%)	Methane and other components
Cow Dung	28.20	0	2.8	63.3
Spent/Cow Dung	20.0	0	4.2	75.8
Cassava/Rice Husk	17.7	0.2	6.5	75.5

Table 4: The mixing, charging the flammable time and total biogas produced.

Waste	Mixing Ratio	Waste mixed (percent)	Flammable time (day)	Retention time (days)	Volume of Biogas stored (m^3)	Total Vol. Biogas produced (m^3)
Cow Dung	1:2	100	4	70	0.76	1.510
Spent/Cow Dung	1:2	70:30	20	61	0.75	3.839
Cassava/Rice Husk	1:5	50:50	30	70	0.76	3.450

RESULTS/DISCUSSION

The result of the cumulative yield in metre cube of the cow dung, spent grains/cow dung and cassava peels/rice husk are drawn in Figure 4 and Table 4. the result indicate that the biogas produced by cow dung became flammable on the 4th day while the biogas from spent grains/cow dung and cassava peels/rice husk became flammable on the 20th and 30th day of digestion spent grains/cow dung, as obtained from the figure produces more volume of biogas (3.839 m^3) for 61 days period of anaerobic digestion. While cow dung produced the smallest volume of 1.510 m^3, but cow dung produced for gas for longer period than spent grains/cow dung. Cow dung being animal waste acted as an inoculum to the plant waste spent grain.

Rice husk acted as a good inoculum because it increases the number of microbes in the cassava peels digestion process. This microbes quickies the digestion and made the biogas generated to be combustible from the 30th day to the end of the digestion. Ezekoye, et al have reported that with out adding an inoculum to spent grains and cassava peels, it takes a longer day before the biogas produced will be combustible.

The analysis of biogas components produced from the three organic wastes show that cow dung has 63.29% CH_4 and less than 28.20%, spent grains/ cow dung has 75.8% of CH_4 and less than 20.0% of CO_2. While cassava peels/rice husk has 75.5% of CH_4 and less than 17.7% of CO_2. This is an indication that the carbon (IV) oxide produced by the three different waste are almost the same in amount.

The result of the physicochemical analysis in table I show that the nitrogen, phosphorous and potassium of the three organic wastes were enhanced after digestion. This implies that the slugged from the three waste could serve as better fertilizers (NPK) after digestion (Chemical, 2006).

Microbial loads expressed as Colony-forming units (cfu) of the various waste are shown in table 2 cassava peels/rice husk has the highest microbial load followed by spent grains/cow dung and cow dung, respectively. The rate of biogas production depends partly on the solids population of the microorganism (AOAC, 1980). Total is an important parameter that affects biogas production. The amount of methane to be produced depends on the quantity of volatile solid that is the amounts of solids present in the waste and their digestibility or degradability (Sarba, 1999).

Figure 1 shows the fluctuation of ambient temperature with retention time for the three different wastes from the graph the ambient temperature falls between (20-35°C). Figure 2 shows charge in daily slurry temperature for the three wastes from the graph the temperature of the inside of the digester was (22-37°C) throughout the period of study.

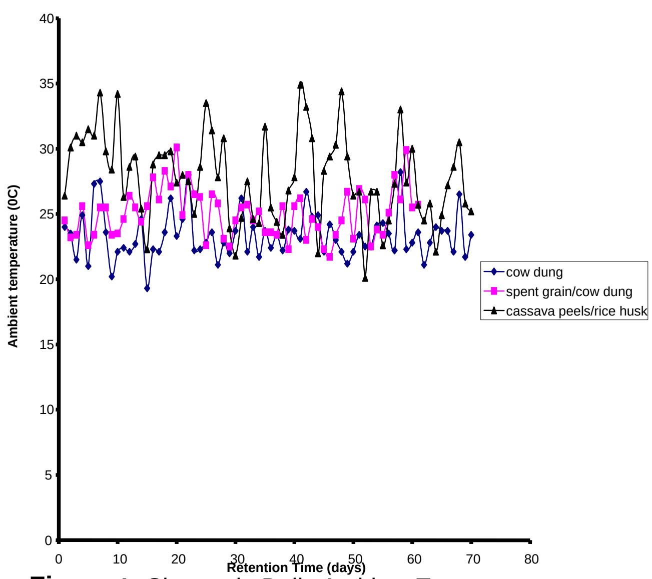


Figure 1: Change in Daily Ambient Temperature.

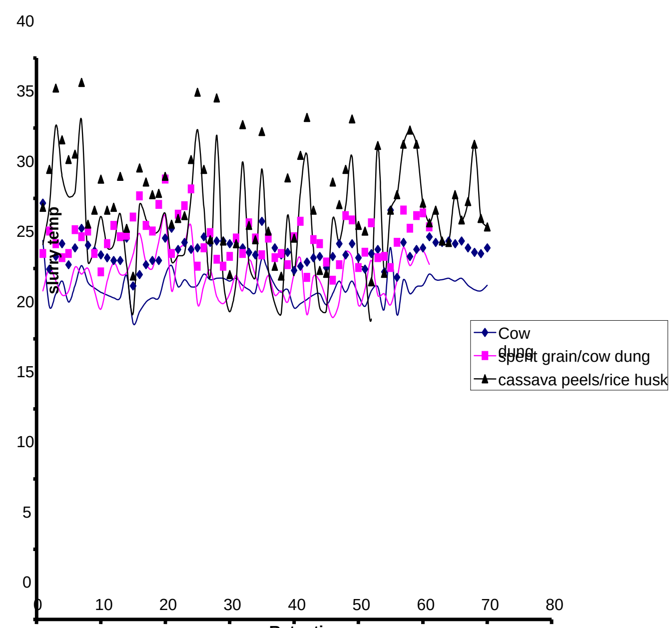


Figure 2: Change in Slurry Temperature (C).

The pH values obtained during the experimental study are presented in Figure 3. From Figure 3, it is observed that the pH of the two seeded samples and one unseeded sample were low and dropped below pH 7.0 within the first 4 weeks. The reason for the low pH values at the beginning of digestion is attributed to the fact that initially the acid forming bacterial will be breaking down the organic matter and producing volatile fatty acids. As a result the general acidity of the digesting material will increase and the pH will fall below neutral.

Figure 5 shows the weekly pressure of the three samples. Cow dung has the highest pressure of 0.43 bars, followed by spent grains/cow dung which has pressure of 0.3 bars and the least is cassava peels/rice husk which has pressure of 0.17 bars (1 bar = 105 Nm^{-2} = 105 Pascal) Figure 6 shows the change in daily volume of gas produced by the three wastes. In Figure 4 the cumulative biogas production shows that as retention time increased, the cumulative biogas equally increased.

The performance of the biogas plant is very satisfactory. The problem of rusting or corrosion, which affects the production of biogas, was solved because a plastic biodigester was used which can withstand high temperatures. All the results collected were for anaerobic digestion.

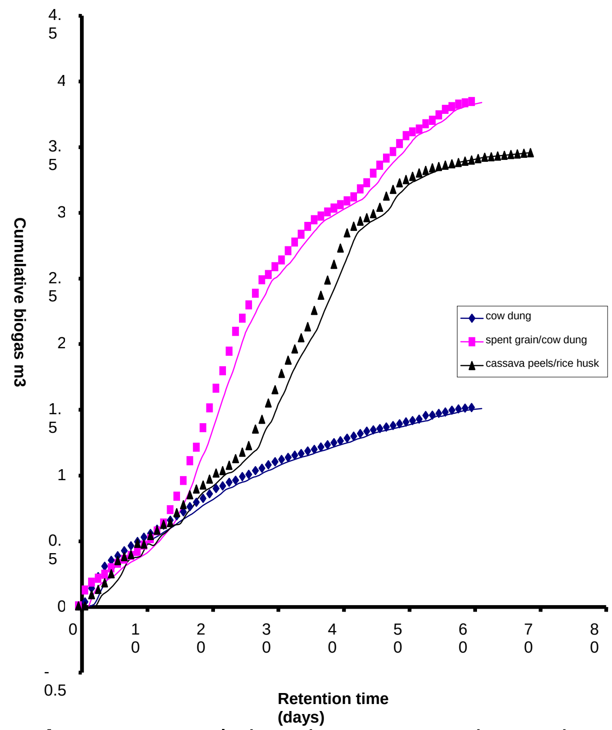


Figure 4: Cumulative Biogas Generation During Fermentation.

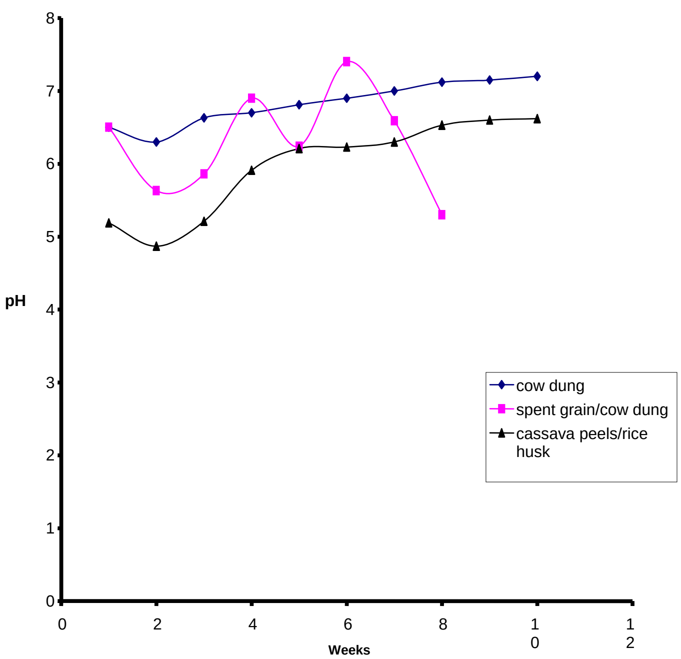


Figure 3: Change in pH During Fermentation.

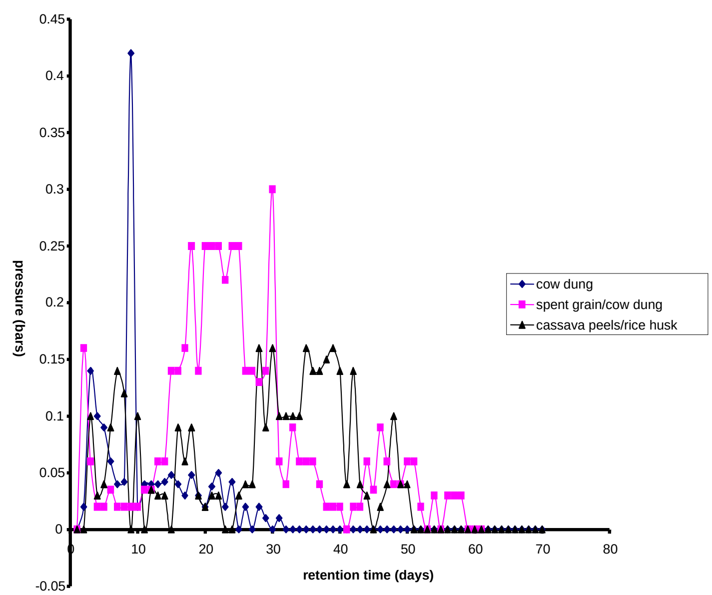


Figure 5: Change in Pressure During Fermentation.

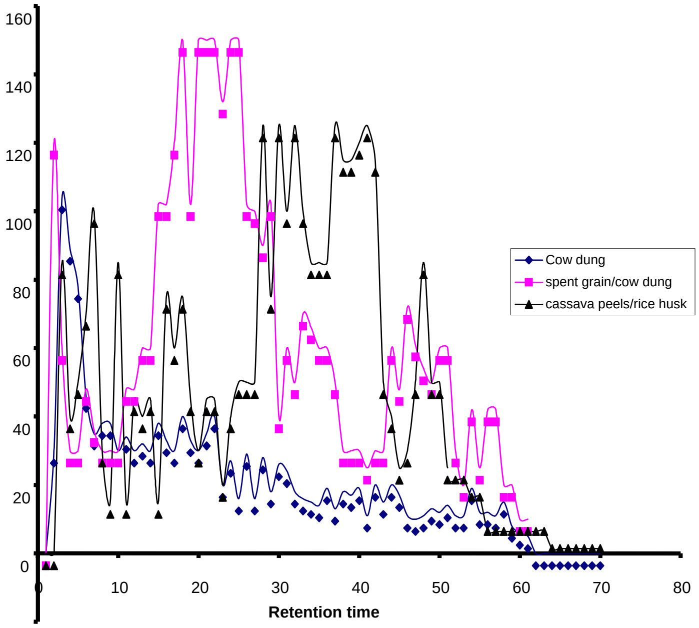


Figure 5: Change in Daily Volume of Gas Produced.

CONCLUSION AND RECOMMENDATIONS

The studies show that cow dung yields biogas faster than spent grains/cow dung and cassava peels/rice husk while spent grains/cow dung produces larger amount of biogas on complete digestion of the three wastes.

Spent grains/cow dung were found to be better fertilizer because of the higher values of N.P.K in both the fresh and digested slurry compared to those of the cow dung and cassava peels/rice husk.Nigeria by virtue of its huge biomass resources has great propects for biogas technology.

It is recommended that spent grains/cow dung should also be used for biogas production. Cow dung waste could be used to seed the spent grains for biogas production at a faster rate. The nature of the organic wastes and other environmental factors were responsible for biogas production.

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