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Comparative Biogas production by Anaerobic Digestion Using Sugarcane Bagasse, Cow Dung and Chicken Droppings Obtained from Katsina Metropolis as Substrates

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Abstract

The use of energy derived from fossil raw materials as conventional primary source of energy has led to environmental pollution climate changes. The need for other alternative sources such as energy derived from wind, solar and biofuel has become necessary. This research investigated the generation of biogas from three types of wastes: Sugarcane bagasse, Cow dung, and chicken droppings wastes using three different biogas plants. Batch operation was carried out and the daily gas produced from each digester was monitored for the retention period of four weeks at the ambient and slurry temperatures. The digesters were charged differently with these wastes in the ratio of 1:3 wastes to distilled water. The ambient temperature ranges within the retention period were 17-29^{0}C and a slurry temperature range of 19-32^{0}C. The result showed that chicken droppings had the highest cumulative biogas yield of 3228.3cm^3; cow dung had 2816.6cm^3 and sugarcane bagasse had the least cumulative production of 681.4cm^3 within digestion period of 30 days. The qualitative test of the generated gas showed that, cow dung has superior quality for biogas production with the highest methane content of 61.3% over the sugarcane bagasse (57.2%) and chicken droppings (47.6%). The bacterial enumeration for chicken droppings was discovered to have highest count of 28.7 x 10^{5}cfu/g than cow dung and sugarcane bagasse with 21.2 x 10^{5}cfu/g and 2.1 x 10^{5}cfu/g respectively. Cow dung was discovered to have the highest total solid content of 84.74% while sugarcane bagasse had the least (8.67%). The utilization of these waste stockscould bean alternative option for energy source and wastes treatment.

***Keywords**: Sugarcane bagasse; Cow dung; Chicken dropping; Slurry.*

INTRODUCTION

Renewable energy resource is recognized as the easiest, economical and effective solutions to the problems resulting from the use of fossil fuel as conventional energy source. Energy alternative sources especially biofuels can be generated from various hydrocarbon sources and has the tendency of replacing the conventional source of energy. In recent times, scientist involved in biogas technology have focused towards utilizing agro-industrial waste including sugarcane bagasse in renewable energy generation and a number of reports have indicated the use of sugarcane bagasse in ethanol production (Martın *et al.*, 2002).Sugarcane bagasse is one of the major agro-industrial waste obtained from the complete extraction of sugar juice from sugarcane (Pandey *et al.*, 2000). About 50% of sugarcane bagasse is cellulose, 25% lignin, and 25% hemicellulose. Cow dung as a waste has high nitrogen content due to pre-fermentation in stomach and has been observed to be best feed stock for high yield of biogas through the study made over the decades (Ukpai and Nnabuchi, 2012). Chicken droppings is a waste from chickens used as an organic fertilizer especially for soil low in nitrogen, it has the highest amount of nitrogen due to is obtained from monogastric animals that involved pre-fermentation in the stomach. Biogas technology is a waste management technique that eliminates the harmful microorganisms from the environment due to anaerobic treatment processes. Biogas is generated by the breakdown of macromolecules anaerobically (Ozor *et al.*, 2014). It is a flammable gas generated by anaerobic digestion of biogenic wastes (Onwuliri *et al.*, 2013). Biogas is a cheap source of energy renewal due to the feed stock is usually dump wastes. The digester slurry is a good fertilizer. It is claimed that its value as fertilizer could double crop yield.

Biogas when further refined burns as well as liquefied gas, but does not add to global warming like liquefied natural gas (Abdulwaheed, 2015).Thermal decomposition of the ligand and synthesized complexes were studied by thermogravimetric analyses (TG) in order to evaluate their thermal stability and thermal decomposition pathway. Plant materials such as crop residues are more difficult to digest than animal wastes (manures) because of the difficulty in achieving hydrolysis of cellulosic and lignin constituents with attendant acidity in the biogas systems leading to reduction and sometimes cessation of gas flammability / gas production (Stephen *et al.*, 2013), etc. Flammable gas which helps in reducing forestation and desert encroachment is produced through the conversion of this organic matter such as animal and plant wastes into biogas (Onwuliri *et al.*, 2018). The objective of this study was to investigate the biogas production potentials of Cow dung, Cowpea, Cassava Peeling and to compare them. The chemical compositions of biogas mainly are 40-75% methane, 20-40% carbondioxide and traces of water vapor and hydrogen gas among others (Bharathiraja *et al.*, 2018). Substrate composition is important in the anaerobic digestion process. The composition ultimately affects the quality of the digestion residue, both in terms of plant nutrient content and potential contamination. The objectives of this study areto analyze the substrates and compare the biogas generated from sugarcane bagasse, cow dung and chicken droppings wastes by anaerobic digestion.

MATERIALS AND METHODS

Sugarcane bagasse procured from Yan kutungu market and was hydrothermally pretreated; cow dung and chicken droppings were collected from Katsina cattle market and Darma chicken farm respectively all in Katsina metropolis, Katsina state, Nigeria. The samples were subjected to sun treatment for a week and ground with the use of mortar and pestle. The microbial enumeration were determined using and total viable count method adapted by Onwuliri, *et al.*, (2013) respectively. Both fresh and digested samples were analyzed for moisture, ash, protein, fat and carbohydrate content. This was done in the postgraduate laboratory Department of Pure and Industrial Chemistry, Umaru Musa Yaradua University Katsina, Nigeria. Daily volume of biogas produced was collected over water and quantified by measuring the volume of displaced water as adapted by APHA, (2005). Gas analyzer was used to quantify different component of biogas.

Charging of Digesters /Storage of Biogas

The slurry of each digester was prepared by diluting 400g of substrate in to 1.2 litres of water making a ratio of 1:3 irrespective of the moisture content of the substrates, then properly stirred and charged separately into2.5 litres digester. The digesters were moderately daily shaken to enhance contact between the microorganisms and the organic matter. The delivery tube from the digester was connected to the transparent plastic bucket containing water for gas collection and further stored in to bags as suggested by Eze (2000).

RESULTS AND DISCUSSION

The percentage content of moisture, ash, protein, fat, carbohydrates, total solids and volatile solids and the microbial loads were presented in Table 1.The result obtained from the proximate analysis of both fresh and digested substrates indicated that chicken droppings had highest protein, fat and volatile solids and 19.76% crude fibre and carbohydrate content. This is likely associated to pre-fermentation in the stomach that led to the higher nitrogen content from chicken droppings and thus could be a sufficient material for higher generation of biogas. The result of total solids, volatile solids and carbohydrates shows a great methane potential due to the biodegradable fraction exist in the substrates which are in close agreement with the previous values reported by Chen *et al.* (2012) and Stephen *et al.* (2013). Biogas production was delayed in the first week of the production this may likely be associated to the microbial activity. A close examination of result presented in Table 2 indicated that, chicken droppings had the highest cumulative gas yield of 3228.3cm^3/total mass slurry followed by cow dung with 2816.6cm^3/total mass slurry of gas while sugarcane bagasse had the least yield of 681.4cm^3/total mass slurry of gas. Cow dung yielded the highest methane content of 63.1% while chicken droppings had the highest biogas yield but with least methane content of 46.7%.The daily and cumulative biogas production for the three wastes was illustrated in Figure 1 and 2 respectively, which showed that bagasse started production on the second day, reaching peak on the 24thday and yielding 44.3cm^3 of biogas, while cow dung gas production was not started till 3th day after the charging of biogas plant, reaching a peak of 182.6 cm^3 on day 16th. Chicken droppings were the highest in terms of gas production, which started on day one and reaches the peak of 188cm^3 on day 14th(Figure 1).

A cumulative biogas of approximately 6.7 litres of biogas was produced across the digesters after the digestion of 30 days. The daily production of gas was highly dependent on daily slurry temperature which ranged between 22-32^{0}C throughout the digestion period (Figure 3). Biogas production varied from the three waste stocks every day. Biogas generated from digester contained cow dung slurry was favoured in terms of quality with calorific value of 19.2MJ/m^3 than 17.8 MJ/m^3 and 11.6 MJ/m^{3}from digesters contained bagasse and chicken droppings slurry respectively as presented in Table 2.

Table 1: The Physiochemical properties of Fresh and Digested Substrates

Parameters	Bagasse		Cow dung		Chicken droppings	
	Fresh	Digested	Fresh	Digested	Fresh	Digested
Moisture (%)	31.34	25.6	15.26	28.22	22.52	19.5
Ash (%)	4.81	3.4	4	3.38	3.46	12.43
Protein (%)	1.31	1.5	6.13	2.25	24.89	10.01
Fat (%)	3.25	2.26	2.27	1.82	8.03	9.55
Crude fibre (%)	36.16	34.62	43.14	44.3	19.76	23.87
Carbohydrate (%)	23.68	32.57	29.2	20.03	18.34	24.64
Total solids (T.S)	68.67	74.3	84.74	71.78	74.48	80.5
Volatile solids (V.S)	45.24	52.42	54.67	31.4	61.13	56.68

Table 2: Summary of Results for the three waste

Items	Bagasse	Cow dung	Chicken droppings
Total Mass of slurry (kg)	1.6	1.6	1.6
Retention period (Days)	30	30	30
Cumulative Volume of Gas yield (cm^3)	681.4	2816.6	3228.3
Peak Volume of Gas (cm^3)	43.4	182.6	188
Maximum Slurry Temperature (^{0}C)	30.4	30.8	30.8
Maximum ambient Temperature (^{0}C)	29	29	29
Methane content (%)	57.2	63.1	47.6
Total Viable Count (cfu/g)	2.1x10^5	21.2x10^5	28.7x10^5

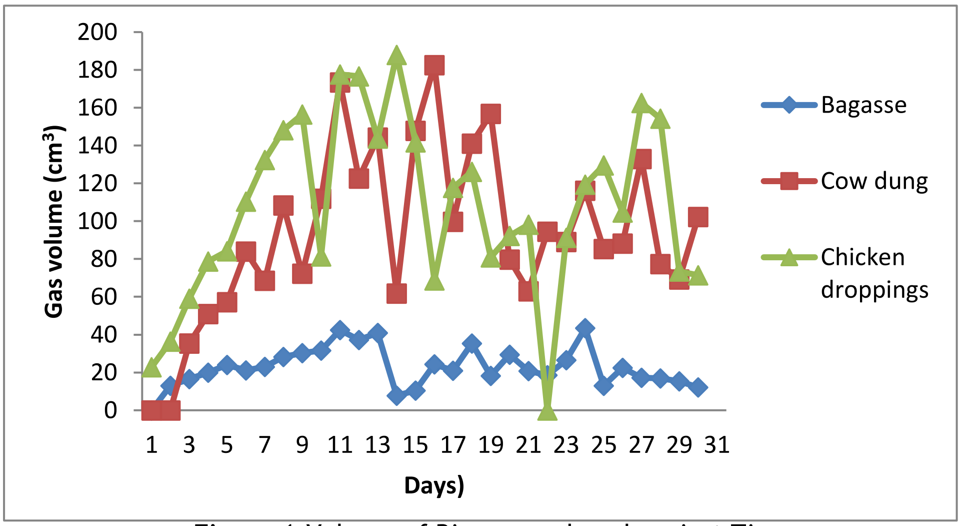

Figure 1: Volume of Biogas produced against Time

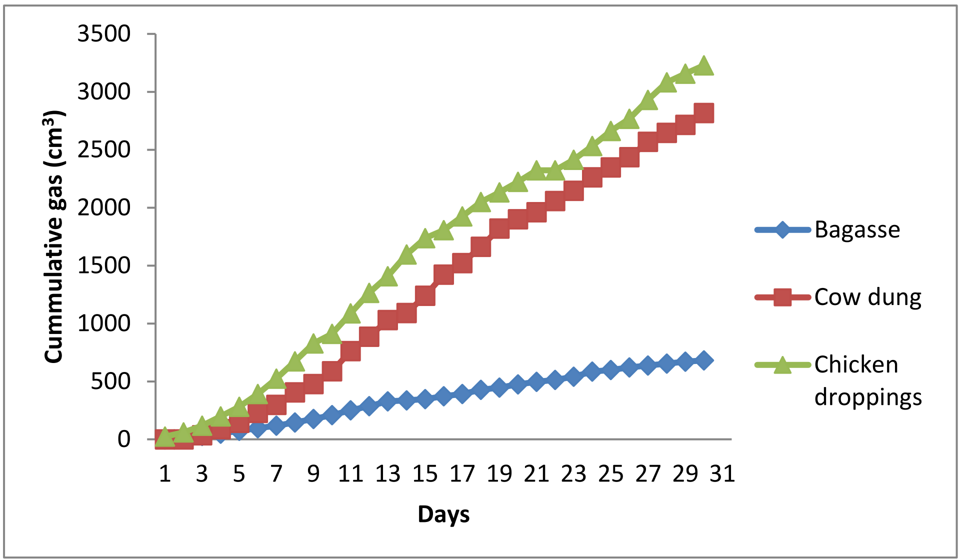

Figure 2: Daily Cumulative Biogas against Time

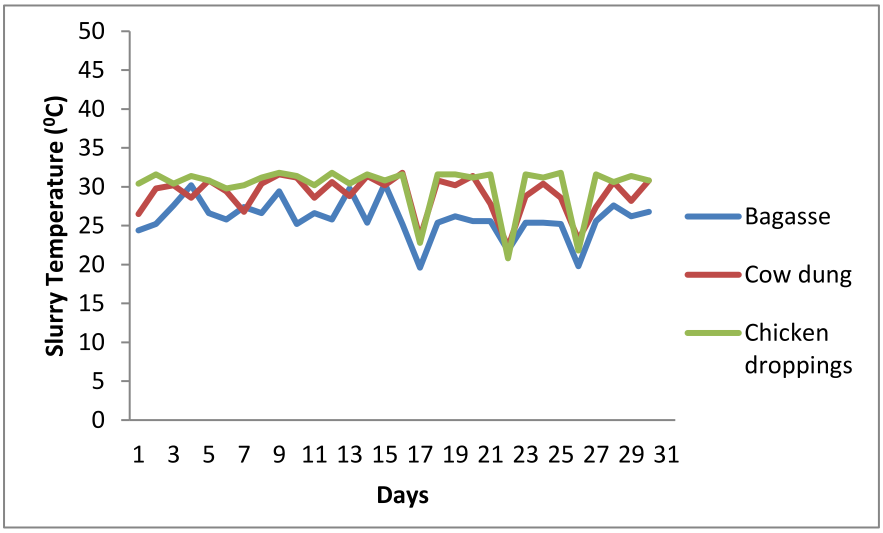

Figure 3: Daily Slurry Temperature against Time

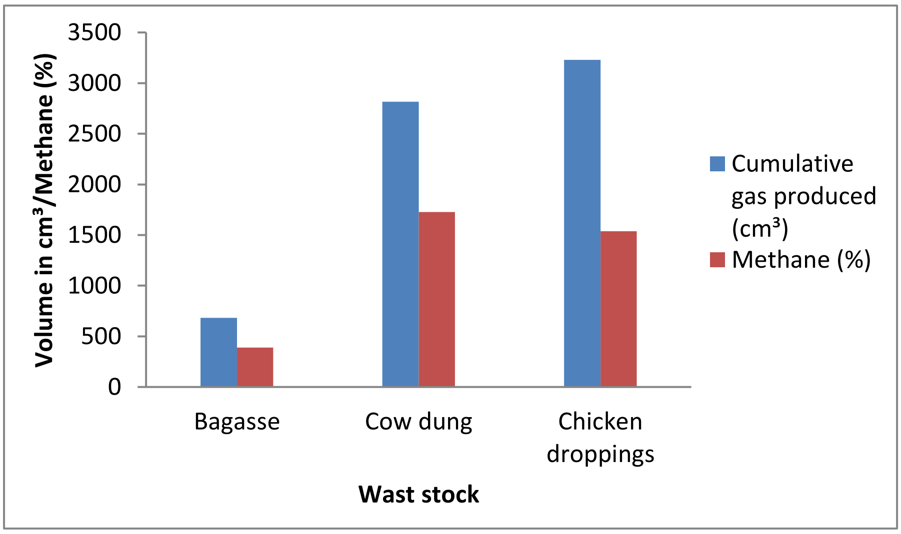

Figure 4: Cumulative gasVs Methane content (%)

CONCLUSION

This study investigated the potentiality of sugarcane bagasse, cow dung and chicken droppings waste in biogas production. The result on the production from sugarcane bagasse, cow dung, and chicken droppings has shown that cow dung might be a best substrate for generation of biogas, its use should be encouraged due to its high volume and quality of gas yields. Chicken droppings were found to be better fertilizer because of the high values of nutrient including protein and fat in both the fresh and digested slurry. It has also been found that changes in temperature and some physiochemical parameters such as total solids volatile solids are among the factors that affected the volume of biogas yield throughout the experiment. The breakdown of the cellulosic waste was achieved through this process by hydrothermal pretreatment of sugarcane bagasse, thus would not provide solutions to energy scarcity alone, would also resolve the problems associated with disposal of biomass by virtue of its large quantity abundantly in Nigeria.

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