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Assessment of the Level of Biogas Production Using Different Animal Wastes as Substrates

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Abstract:
The use of biogas as a means of satisfying energy demands is a viable alternative to fuel wood which results in the indiscriminate felling of tress. Animal wastes as organic substrates in the production of biogas provide a cheap and eco-friendly method of managing wastes. In this study, three different animal wastes (Cow dung: pH1=7.08, pH2= 7.32; Goats' droppings: pH1=5.49, pH2=5.26; and Chicken droppings: pH1= 5.49, pH2= 5.75) were used as substrates in the production of biogas, and the experiment was carried out at ambient temperature for a hydraulic retention time of three weeks. A set of three laboratory digesters was used in the experimental set up, and the performance of the animal wastes was assessed based on the volume and flammability of the biogas produced. The amount of biogas produced by the animal wastes in decreasing order is as follows; chicken droppings (18.27 Litres), cow dung (12.55 Litres) and goats' droppings (5.11 Litres). The order of flammability of the biogas produced is as follows: cow dung > goats' droppings > chicken droppings. In this study, cow dung produced the biogas of the highest quality and conclusively can be chosen as the best substrate for biogas production.

Keywords: *Assessment, biogas, wastes, substrates*

1. Introduction

In today's energy demanding life style, the need for exploring and exploiting new sources of energy that are renewable and at the same time eco-friendly has become a mandate. The urban sectors in Nigeria have several alternative sources of energy to meet household needs (Abulugbe and Akinbami, 1992). On the other hand, the rural sectors still largely depend on fuel wood for cooking and other household purposes (Danshehu *et al*., 1992). About 80% of the energy demands of rural households in northern Nigeria still come from fuel wood sources as reported by Sokoto Energy Research Centre (SERC, 1991). The remaining 20% is obtained from animal dung and other agricultural residues (Akinbode, 1990). Over dependence on fuel wood has greatly resulted in rampant felling of trees in this already poorly vegetated zone, the result of which is the consequences of desertification and soil erosion (Jatau *et al*., 2001).

2. Materials and Method

2.1. Sample Collection

The animal dung (goat, cow, and chicken dung) used as the substrates in this research were obtained from Samaru village, Zaria. The substrates were sun-dried and ground in to powder using wooden mortar and pestle as described by Jatau *et al*., (2001).

2.2. Experimental Set-up for Biogas Production

A set of three laboratory digesters of 6.5 litres capacity were loaded separately with 880 grams of each substrates and 3.6 litres of water was added to obtained slurries of 1:4, substrates: water ratio. This was then followed by occasional agitation as described by Bajah and Garba (1992). The pH of the slurries was determined using SUNTEX pH meter (SP-701) at the Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria, and the temperature was kept ambient (room temperature). A digestate (Slugde) about 10% of the total volume of each slurry (Christon *et al*., 2002) from a completed biogas plant was added to each digester to serve as the starter culture (Jatau *et al*., 2001). The digesters were then stoppered with rubber bands to prevent leakage and connected via rubber tubing each to a gas collecting jar (1000millilitres measuring cylinder) inverted over a solution of 1% potassium hydroxide. The gas was collected by upward delivery downward displacement of the KOH solution, and the

volume of the gas produced was recorded daily. The digesters were kept at ambient temperature (20-45^{o}C) i.e. operated within the mesophilic range.

2.3. Quantitative and Qualitative Assessment of the Biogas Produced

The parameters used for assessing the performance of the experimental substrates included; time of commencement of gas production, time to reach peak gas production and when production ceased, daily yield of gas and the total volume of gas produced over the period of 21 days called the hydraulic retention time (HRT) of the study (Machido *et al*., 1996). The combustibility of the biogas produced was determined by lightning match flame and passing it over the nozzle of the measuring cylinder in which the gas has been collected and the degree of flammability was recorded.

3. Results

The performance of the three substrates tested for biogas production was based on different parameters as shown in the table of results below;

	Test Substrates		
Parameters	Cow dung	Goat dropping	Chicken droppings
Initial pH	7.08	5.49	5.49
Day production started	2nd	1st	1st
Day flammability started	7th	4th	9th
Flammability test	+++	++	±
Day of peak production	19th	2nd	2nd
Day production ceased	-----	16th	-----
Total gas produced (cm^3)	12,550	5,110	18,270
Final pH	7.32	5.26	5.75

Table 1: Performance of Different Substrates in Biogas Production (HRT= 21 Days)

Key: +++ = Highly flammable, ++ = flammable, ± = flammability fluctuates, --- = No cessation in production for the entire hydraulic retention time.

3.1. Volume of Biogas Produced in cm^3/Day

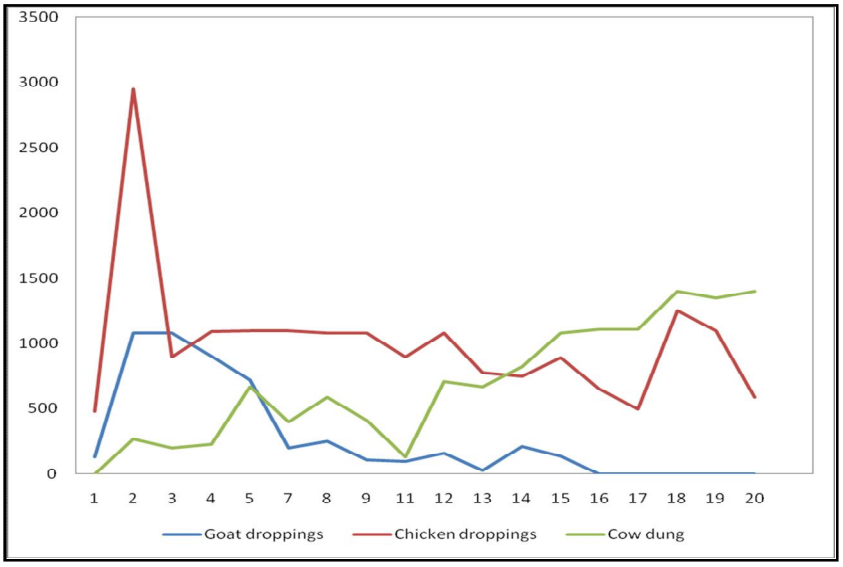

Figure 1: Volume of biogas produced against retention time

Retention Time (days)

4. Discussion

Various factors influence the performance of different substrates in biogas production at varying degrees. Although, the temperature, the loading rate and the HRT were kept constant, therefore, the determinants of the biogas level produced by each substrate were the pH and the nature of the substrate. The initial pH of the goat droppings and chicken droppings slurries were the same but different from that of the cow dung slurries, while at the end of the pre-determined retention time, the pH of each of the digestate (biorest) differs from each other, these could not be unconnected with the nutrient composition of each of substrate that determines the type of metabolism and end product to be generated by the implicated microbial entities (Machido *et al*., 1996). It has however been reported

that about 40-60% of feed consumed by animals eventually ends as manure (Abubakar, 1990). Hence, the major nutrients utilized by the "bottle neck" of methanogenesis (i.e. methanogens) are carbon and nitrogen usually derives from the manure.

The largest volume of biogas obtained was from the chicken droppings having a carbon-nitrogen (C-N) ratio of 5-8:1 as reported by Abubakar, (1990). The C:N ratio was however far from the ideal ratio of 20-30:1 thus, the performance could be attributed to the nutrients contents in this substrate which might include in addition to proteins and vitamins, other macronutrients such as calcium and phosphorus which are also required by the organisms involved in methanogenesis. Although, the chicken droppings had the highest performance regarding the volume of gas produced, but was found to be the least flammable with irregular fluctuations in flammability. This might be attributed to the presence of excess ammonia (incombustible gas) in the biogas produced from abundant uric acid in the droppings by the action of the microorganisms involved.

Cow dung closely followed chicken droppings in terms of the yield. The output was lower than that obtained from chicken droppings but higher than that of goat droppings. Even though, the pH of 7.32 was more close to neutrality, but the yield was not as high as that of the chicken droppings and this might not be unconnected with the relatively inadequate nutrients supply in the feed ((Machido *et al*., 1996) due to their monotonous feeding habit hence, this could only be attributed to the shortage of nutrients in the dung. But interestingly, biogas produced from cow dung was found to have the highest degree of flammability despite the time it took before production started and as well the lower yield. This might be due to high methane content and/or low levels of such incombustible gases as carbon dioxide, oxygen, nitrogen and ammonia as components of the biogas (Jatau *et al*., 2001).

Goat droppings ranked the least in terms of yield but second most flammable, thus, the biogas produced from this substrate was not as high in volume as that obtained from the chicken droppings but more flammable than it, although, it was less flammable than the biogas obtained from cow dung as well as lower volume in comparison to the cow dung.

5. Conclusion

Organic wastes, particularly animal wastes constitute a nuisance to our environment and also a threat to public health, there is therefore a need to search for the beneficial ways of minimizing them without due harm to our environment. In order to alleviate the problems of rural and urban energy requirement, there is a need to explore and exploit other energy sources for man's economic benefits; this is connected to the rapid depletion of fossil fuels. Biogas is a suitable, standard, affordable and sustainable alternative source of renewable energy since the raw materials used are termed as wastes. Moreover, from this research, it could be deduced that a biogas generating plant could be easily constructed at a minimum cost affordable. Conclusively, on the basis of the biogas yield and quality of the gas produced, cow dung was found to be the best substrate for biogas production both domestically and industrially.

6. Recommendation

Based on the low cost of biogas production, as a means of alleviating environmental and public health threats as well as generating a suitable, sustainable and renewable energy source, it can be recommended that government should establish small scale domestic biogas production plant in both rural and urban communities which can promisingly provide the source of energy at a cheaper rate. Also, industrial biogas plants should be set up, which beside providing a reliable source of renewable energy will also alleviate farmers' sufferings by providing a cheap, nutrient-rich and safer bio-fertilizer in order to boost agricultural standards.

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