Generation of Methane Gas from Poultry Brooding House.

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ABSTRACT

This study focused on the incorporation of biogas scrubbing accessories on a 0.1m3 biodigester with the primary aim of assessing the volume of methane gas that would be recovered from poultry brooding wastes through biogas scrubbing. Results obtained show that a significant volume of methane gas was recovered from each of the substrates after 2 weeks of anaerobic digestion. However, poultry wastes generated more gas than poultry droppings within a Hydraulic Retention Time (HRT) of 14 days.

(Keywords: poultry farm-wastes, poultry droppings, biogas, anaerobic digestion, microbial population, biodigester, biogas scrubbing, caloric value, carbon-reducing technology, desulphurization)

INTRODUCTION

Production of biogas through anaerobic digestion is a relatively carbon-reducing technology that can be implemented at the household, commercial, or village scale. It allows for the controlled management of large amount of animal dung and plant residues and the safe production of gas for cooking, lighting or power generation. In addition, its by-product provides an extremely valuable agricultural fertilizer.

The calorific value of biogas varies from 4800-900Kcal/m^3 while pure methane has a calorific value of 9100Kcal/m^3 at 15.5^{o}C and 1 atmosphere (FAO, 1981). In terms of energy equivalent, 1.33-1.87 and 1.5-2.1m^3 of biogas is equivalent to 1 liter of gasoline and diesel, respectively (Basker, 2001). Biogas that has been scrubbed off of other gases leaving behind methane as the most predominant gas can be used as fuel in stationary and mobile engines to supply motive power, drive machinery such as threshers, grinders etc. or generate electricity. It can be used in both spark and compression (diesel) engines. The spark ignition engine is easily modified to run on biogas by using a gas carburetor. Scrubbing off other gas components from biogas to get almost pure methane gas is technically essential because the hydrogen sulphide in biogas is corrosive and particularly harmful to internal combustion engines. The only practical way of removing the hydrogen sulphide on a small scale is by desulphurization, using ferrous substances (Plevin and David, 2004).

The presence of carbon dioxide (CO_2) in biogas is unsatisfactory if it is to be used for automobiles. Carbon dioxide lowers the power out put from the engines, takes up space in the storage cylinder and it can cause problem of freezing at valves and metering points. All or most of the CO_2 therefore, must be removed from the raw biogas if it must be used as fuel for vehicles and compressed into high-pressure cylinders carried by vehicles.

The simplest and most effective method of removing the CO_2 is by washing the biogas with water under pressure. This process can be conveniently integrated with compression, using a 3 or 4 stage compressor and can be easily automated. This method of scrubbing the biogas is capable of producing 100% pure methane from raw biogas. The scrubber also removes all corrosive sulphides (Kapdi, et al., 2003).

A solution of sodium hydroxide and iron fillings can be used to isolate CO_2 and H_2S from biogas, respectively. Isolation of methane gas from the other gas components that constitute biogas in environmentally friendly manner, results to cheaper and clean energy for both electricity generation and fuel for powering automobiles. The major aim of this study is therefore, to evaluate the various factors that affect methane isolation from biogas generated from poultry brooding wastes.

MATERIALS AND METHODS

The constructed biomass digester (Figure 1) was evaluated using poultry droppings and a mixture of poultry droppings and feathers (herein referred as poultry manure). The poultry droppings were carefully picked from the top of the wire gauze at a poultry farm in Animal Science Department, University of Nigeria, Nsukka whereas the poultry manure was collected from the same farm as total daily wastes normally raked from the farm every morning. The two separate wastes samples were mixed water at the ratio of 3:1 (i.e. water to wastes). The wastes were used in charging the biodigester at batch basis; starting from poultry droppings. After loading the digester with the wastes and water, it was subjected to anaerobic digestion after making the entire system airtight. The digestion was carried out on a batch basis; each at average daily ambient temperature of 32°C.

Methods of Analysis

The digesting slurries were collected through the outlet of the biodigester and used for the expected routine analysis. Total solids and ammonia nitrogen of the digesting slurries were carried Meynell's method (1982). The rate of biogas generation was measured by downward displacement of water in a calibrated and transparent jerry can. The pH was measured using a Jeanway 300 meter. The ambient temperature was monitored with a thermometer while Frazier and Wolfe (1976) method was used to estimate the microbial population in the organic residues. The nitrogen content was measured by Kyjeldahl analysis as described by Pearson (1976) while ash was by the AOAC (1990) method. Moisture content was determined by hot oven method as described by Meynell (1982) while carbon content was determined by Tinsley and Noiwakowski (1959) method at National Centre for Energy Research and Development, UNN Lab.

RESULTS AND DISCUSSION

The results of the proximate composition of the 2 bio–wastes used for biogas production show that they differ in their proximate compositions. The result reveals that poultry farm wastes (PFW) have more potential to generate biogas than poultry droppings. The higher moisture content of PFW could be explained by the fact that part of the composition is "urine" (liquid component of feces) and water spill from drinking trough and watering can, at point of feeding the birds.

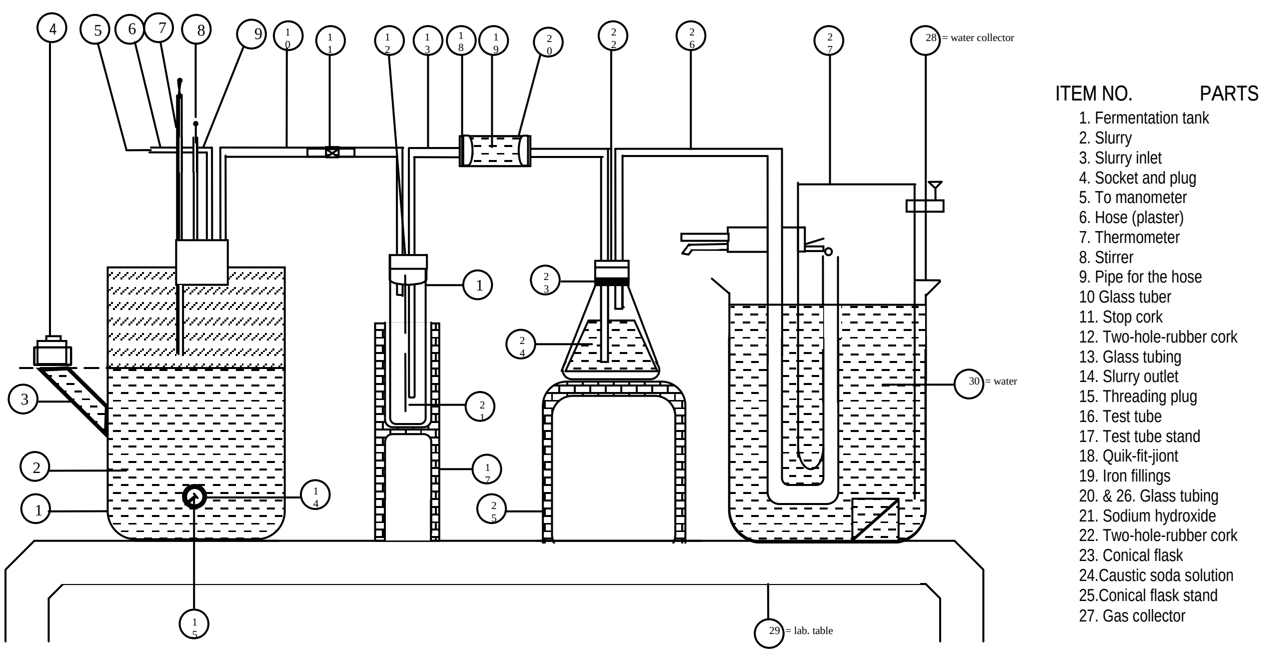

Figure 1: Digester Assembly with Gas Scrubbing Accessories.

This similarly explains why TS in poultry droppings are higher than that of PFW. The relatively higher nitrogen content in PFW is attributed to the fact that poultry excrete urine and feces together (Fernando and Dangogo, 1986). The higher carbonnacous materials in poultry wastes is attributed to cellulosic, hemicellulosic materials, pectins, lignin, and plant wax associated with the beddings that contain saw dusts etc.

A consortium of micro-organisms ranging from coliform to fungi and bacteria at different concentrations were observed on various growth media (Table 2) . However, the most numerous and persistent micro organisms observed were on poultry wastes. These micro organisms catalyze the three main stages of sludge digestion to produce biogas. The result of the total solids of the wastes during fermentation (Table 3) indicates a steady decrease as fermentation progressed. However, poultry droppings showed higher values of Total solids during the fermentation period.

It has been earlier reported by Moustafa and Belyea (1990) that concentrations higher than 8.2%, total solids resulted in fast decline in the rate of methane gas generation. In the present study this value was exceeded at the beginning of fermentation (within the first 6 days) when the fermentation was at the hydrolytic stage. In Figure 6, at that period, there was also a low gas generation, therefore, this result gives further backing to that of Moustafa and Belyea. High substrate concentration inhibits the growth and metabolic activity of the methanogens (Mc Neil, 2000).

Results of pH of the digesting medium are presented in Figure 4. Initially both fermenting media showed a shift from acidity towards alkalinity within the 8th and 10th day of fermentation before the started declining. The adduced reason for the initial low pH values, that is the high acidic digesting media is due to the activities of the acid forming bacteria that were degrading the organic matter resulting to the liberation of volatile fatty acids that consequently lowered the pH below neutral within the first 6 days. However, as the pH rose above neutral, the acid formers were displaced later by the methanogens to produce methane. The maximum pH obtained during the research period was 6.8 from poultry wastes. This pH value has been reported to be within the range for gas production by and Blanchard and Grills (1987) who noted that pH values between 6.6 and 7.6 are suitable for optimum biogas generation while pH below 6.2 and 7.6 results to acute toxicity and impairment of biogas production. Figure 5 is a presentation of the result on effect of fermentation on ammonium nitrogen of the wastes.

Table 1: Proximate Composition of Wastes.

Analysis	Poultry droppings	Poultry wastes
Moisture content (%)	63.00	77.23
Total solids (% slurry)	22.66	15.60
Volatile solids (% dry wt basis)	86.17	80.42
Ash (% dry wt basis)	6.3	21.60
Nitrogen content (% Dry wt basis)	6.50	8.24
Carbon content (% Dry wt basis)	44.30	53.4

Table 2: Population of Micro Organisms in the Wastes.

Growth Media	Type of Organism	No. of Micro-organisms per g dry wt	
		Poultry droppings	Poultry wastes
Nutrient agar	Bacteria	4.3×10^4	5.0×10^7
Potato Dextrose agar	Fungi	3.0×10^7	2.1×10^5
Glycerol agar	Actinomycetes	1.3×10^4	1.0×10^7
Lactose broth	Coliform	4.8×10^4	5.1×10^4
Fuller's & Norman water cellulose dextrin agar	Cellulolytic organism	5.5×10^5	4.6×10^3

This trend could be explained by the simple fact that poultry droppings are known to contain more ammonia nitrogen than poultry waste (Wang, 2003). However, both poultry droppings waste exhibited a steady rise in ammonia nitrogen concentration of the digesting slurry during the experimental period but none exceeded 0.7ppm ammonia nitrogen. This level of ammonia nitrogen did not result to ammonia toxicity which inhibits methanogenesis since gas production was still going on even on the last day of fermentation The results of the methane gas generated during the period is presented in Figure 6.

The two bio-wastes produced appreciable quantity of gas during fermentation; however, poultry wastes produced more gas than poultry droppings. This result supports the earlier result obtained by Plevin and David (2004), Meynell, (1982) and El-Mashad, (2004) who observed that proper combination of nitrogenous and carbonaceous materials favors methanogenesis.

The feed particles and saw dust used in the poultry brooding/raising house contain high concentrations of carbon while the chicken droppings have high level of nitrogen. This is the possible explanation why more gas was got from poultry manure. Poultry wastes commenced gas production on the 4th day whereas both attained their maximum gas generation on the 10th day. The corresponding pH value for poultry wastes is 6.88 which is still very suitable for biogas generation while that of the poultry droppings at the same period is about 6.6 (see Figure 3). Both wastes have high potentials for biogas production.

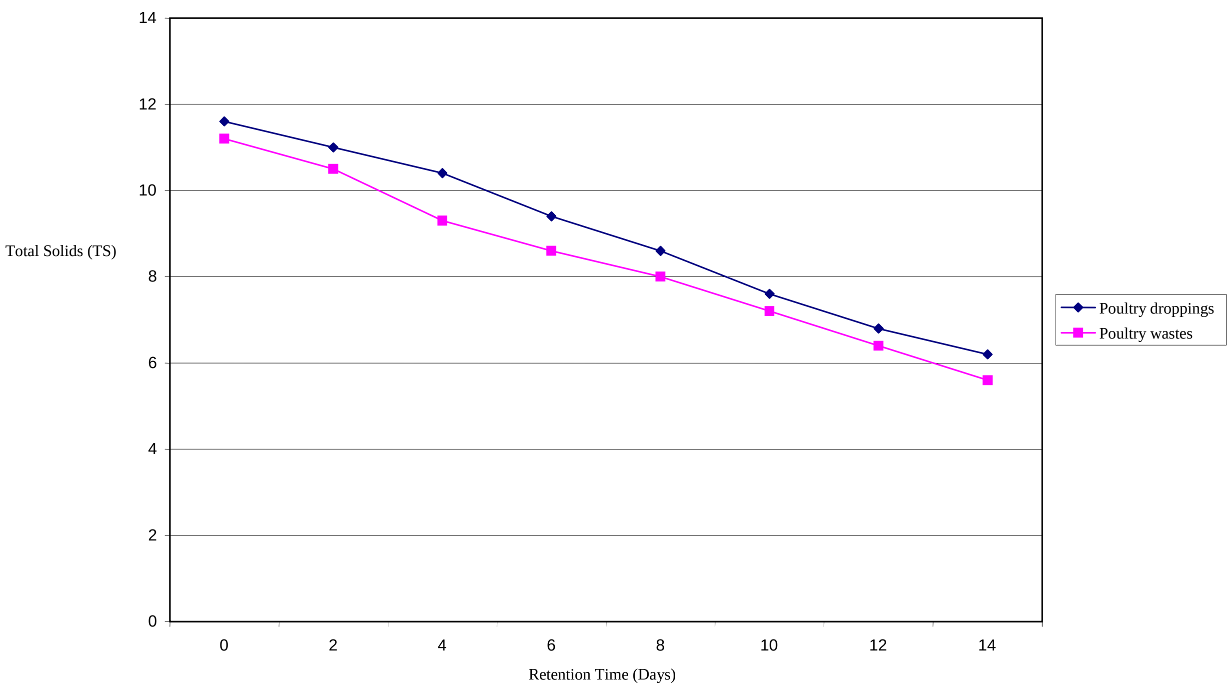

Figure 2: Effect of Retention Time on the Total Solids (Ts) of the Feedstock.

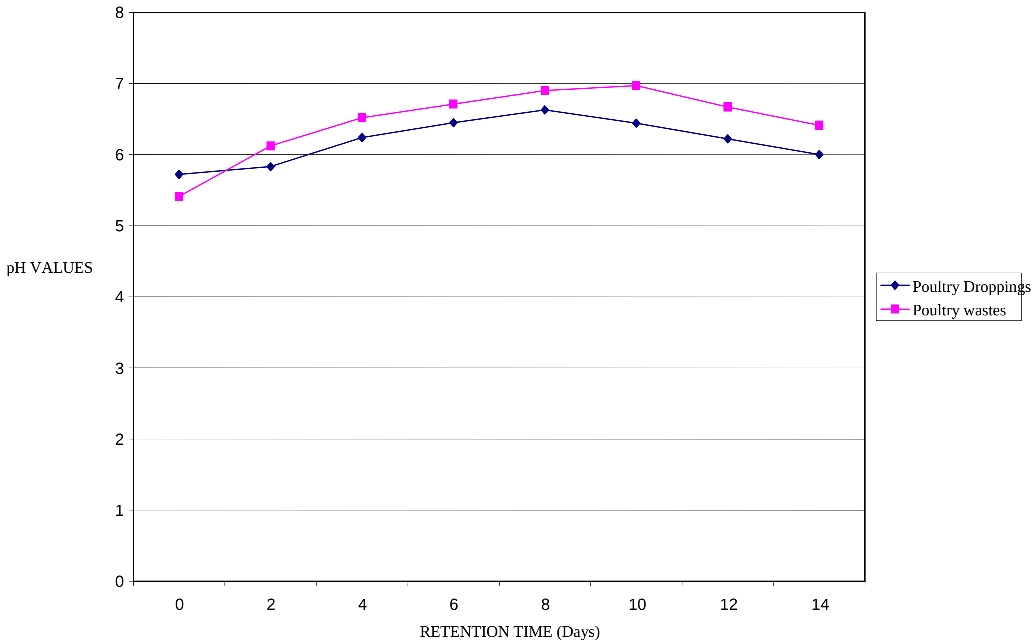

Figure 3: Effects of Retention Time on the pH of the Waste.

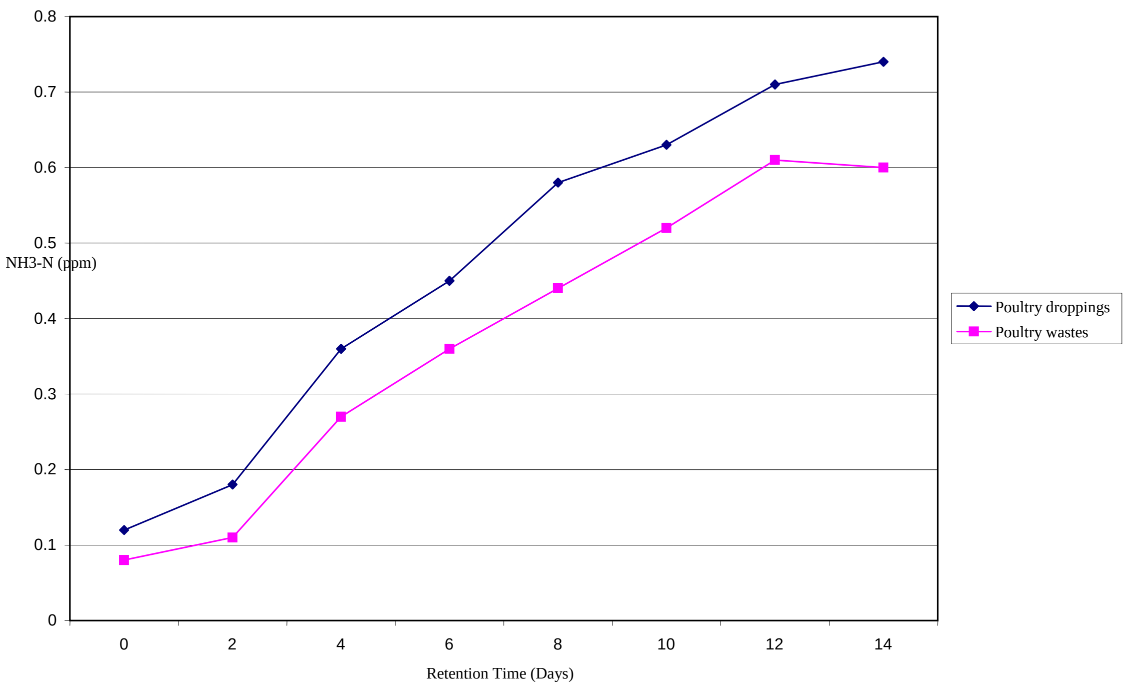

Figure 4: Effect of Retention Time on the NH_3-N of the Feedstock.

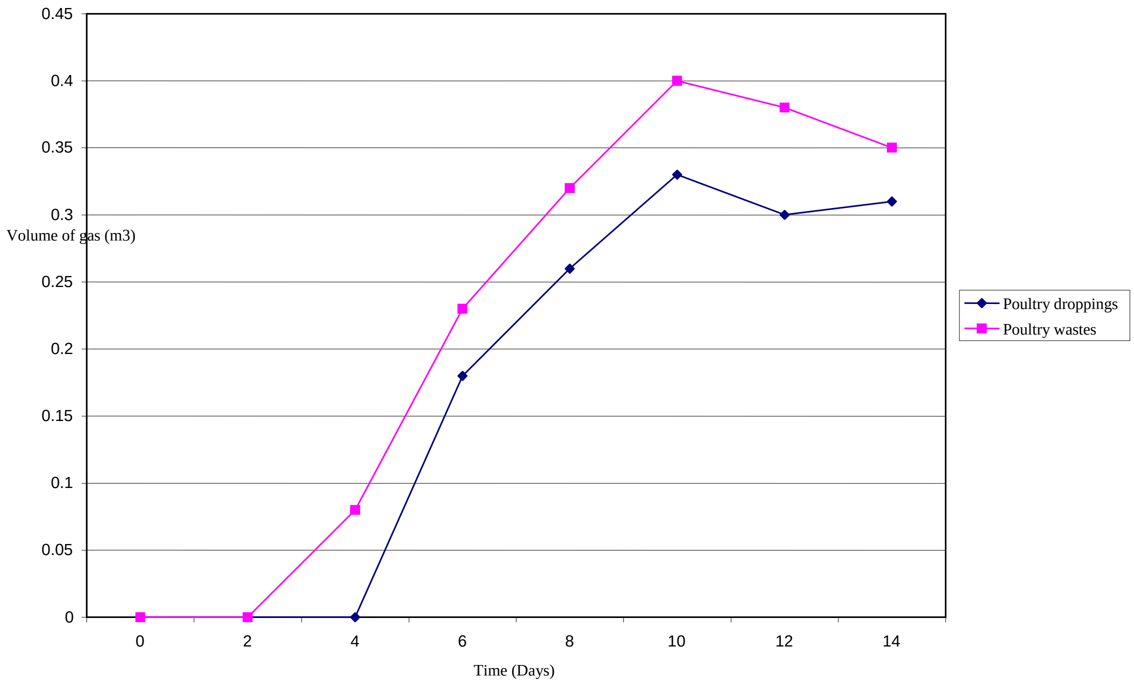

Figure 5: Methane Production of the Feedstock.

CONCLUSION

Results obtained from this study show that even though poultry droppings, poultry beddings and feed particles have the potentials to produce biogas through anaerobic digestion, a combination of all the wastes from poultry brooding house, gives a higher yield of biogas. This result is hinged on the proper carbon to nitrogen balance that ensues when wastes associated with nitrogenous matter like poultry feaces and urine are combined with those noted for their high carbon contents such as saw dust and feed particles. The results of some of the major indices of anaerobic fermentation stability of digesting slurry such as pH, ammonia nitrogen, Total solids, total gas generated, did not show any sign of gas production inhibition. The volume of methane gas produced in the two organic wastes was noted to have maintained the same trend like that of biogas and that is an empirical evidence that the gas scrubbing assembly used was very efficient and reliable.

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