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Studies on Biogas Generation and Heat Efficiency from Cow dung and Poultry waste

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Abstract

The study was carried out to produce biogas from cow dung and poultry wastes. The study was also carried out to determine the heat efficiency of each of the biogas produced. Nineteen litre bio-digesters and gas collection systems were fabricated using locally available materials. The respective organic materials used for the feed stock were collected locally. The slurry was prepared from each of the wastes by mixing with five litres of clean water. Water dispenser bottles were used to digest slurries of cow dung and poultry wastes. The wastes were digested and analyzed in accordance with standard methods. The physico-chemical parameters and gas yields were monitored daily. The average digester temperatures during the study were within the mesophillic range (24-37°C) which is best for methanogens. The pH values were within the optimal range 7.0 and 7.5. The total gas yields were 826m1 and 286.3m1 for cow dung and poultry wastes. A domestic heating test was carried out for the two substrates digested using the biogas produced to raise 1 litre of water to boiling point (100°C). The time expended was recorded in minutes as follows- 7.42 mins,7.46mins for cow dung and poultry wastes using a stop watch. The experimental procedure lasted for 14 days. The study revealed that cow dung had the highest heat efficiency and cooking rate while Poultry wastes had the lowest heat efficiency.

Keywords: Cow dung, Poultry wastes, Bio-digester, Slurry, Heat efficiency, Biogas

INTRODUCTION

The global demand for energy is rapidly increasing, and about 88% of the demand solely depends on fossil fuel till today (Wieland, 2010). The demand for energy will increase progressively throughout this recent century. Similarly, greenhouse gas (GHG) emissions from use of fossil fuels have posed one of the most severe environmental threats to mankind. There is a globally demand to reduce the emission of GHG to stem the impact of climate change and global warming. Africa and indeed Nigeria is yet to meets its energy challenges despite of a having a huge oil and gas reserves. Many rural communities are not connected to the national grid. Reliance on renewable energy sources will reduce the harm of fossil fuel to the environment (Parawira, 2009). Biogas has significant advantages as a major energy-efficient and environmentally beneficial technology. Biogas technology can use locally available and cheap resources to produce energy where it is wanted. In rural areas, biogas can meet needed energy for cooking, heating, drying, food processing and preservation. Biogas technology leaves a lasting imprint of GRG reduction while meeting our energy needs in a sustainable manner.

As animal husbandry become increasingly practiced, waste management becomes a greater problem facing mankind. Agro waste can be fed into anaerobic bio-digester in which some bacteria acts to decompose the wastes to yield biogas. Biogas is flammable and can provide heat and generate power in combustible engines. Cow dung is a preferred feedstock for biogas production (Joy and Idris 2014; Mookherjee *et al*., 2017). Decomposing organic matter kept in warm, air-tight environment releases biogas. An anaerobic digester partially converts organic wastes to heat energy (Mshandete and Parawira, 2009). Therefore, cow dung can be employed as a means of energy supply for livestock farmers all year round. In order to increase organic materials to obtain a higher biogas yield, cow dung is digested with some additional co-substrates such as lemon grass, rice husk and maize cob (Tajidin *et al.,* 2012).

Poultry wastes are made up of feaces, litter, feed, dead chicks, broken eggs and feathers. The 2013 data from the Nigerian Federal Ministry of Agriculture and Rural Development that there about 266 million unit of layers and broiler chicks and approximately 15 million tons of manure were created every year. In the absence of thorough treatment, these wastes may rise to toxic level causing several health risks by creating an unfriendly environment for harmful microorganisms, insects, environmental air pollution resulting from offensive odour, and forms methane gas thereby resulting to greenhouse effect. Biogas can be derived from poultry wastes and these can assist in boosting energy supply (Eze, 1995; Igboro, 2011; Mshandete and Parawira, 2009).The main aim of this study was to demonstrate a working biogas system using two feedstock.

MATERIALS AND METHODS

Site Description

This research experimental set up was situated in the University of Port Harcourt premises with ambient environmental temperature, free from contamination that may pose a threat to the actualization of this work. However, in an isolated open space. This was done as a precautionary approach to safety against gas explosions (Schniitz, 2007).

Research Design

This work was conducted in a single phase on small scale in a 10 litre plastic water container. The research design used was completely randomized. Two different types of organic wastes were used. Each of the wastes was replicated four times. The population (n) is the total number of individual samples in the experiment. Two types of organic wastes were sampled and each was replicated four times. In total 16 bio digesters containing the samples were used to carry out this research.

Sample and Sampling Techniques

The wastes were collected using a 20 litre paint bucket with an air-tight lid to reduce evaporation, exposure to flies and the resultant unpleasant smell. The buckets were kept at various locations where the required wastes were readily available for collection. The wastes were mixed homogenously by using a grinder and water mixed in a particular ratio to obtain the slurry. The slurry was poured into two different plastic cylinders using a funnel. The containers were locked air tight for a period of 14 days.

Fresh cow dung was collected from the Faculty of Agriculture demonstration farm mini cattle ranch. The fresh cow dung was mixed homogenously with water at the ratio of 1kg to 1 of water to make the slurry. The cow dung was made up of food residues, undigested forage some fibrous food substances.

Poultry wastes were collected from Faculty of Agriculture poultry house refuse dump site. Poultry wastes were provided from the routine sanitation process of the poultry house. This contained fecal matter, food droppings, feathers and urine. The wastes were sieved to remove unwanted solid contaminants and mixed thoroughly with water to obtain a homogenous mixture. Cow dung was collected fresh so as to reduce the ammonia evaporation upon drying; this was also applicable to poultry waste.

Two types of organic wastes were used with four replicates for each. The organic wastes were used to remove impurities, blended or ground to achieve a homogenous mixture. The homogenous mixture was mixed with water in the ratio of 1kg litre of water to prepare slurry with each of the different organic wastes (Lay *et al*., 1997).

Experimental Setup

Eight separate 1 9litre transparent water containers (plastic dispenser water bottles) were washed, sterilized and used as the anaerobic bio digesters, 1 inch PVC pipe of 15cm length was connected at the opening of each container. A plastic valve was fixed at the top end of the PVC pipe to regulate gas flow and a rubber gas hose of 0.5m length was connected to the plastic valve from which the gas burner was fed. 200ml silicon gum was used in all the constructions to prevent any possible leakage. The slurry prepared was poured into the various digesters using a Funnel to prevent wastage. The systems were kept air-tight for a period of 14 days.

Generation of Biogas

The two substrates; cow dung and poultry wastes used for the experiments were initially tested using separate plastic containers with the vent covered tightly with a balloon for 7 days. The slurries prepared were poured differently into the bio digesters. The substrates yielded gas as the balloons were slightly inflated, the gases were not measured.

The environmental temperature was measured using a mercury-in-glass thermometer. The gases produced were passed through a rubber hose to the adjusted burner to determine the flammability and cooking rate of each of the gases.

Cooking rate (Cr) = Weight of substance (Kg) (Sasse 1988)

Time taken to boil (in minutes

The time taken by the heat produced from the biogas to raise the temperature of 1 litre of water 100°C was also (heat efficiency) measured using a stop watch. The temperature of the heated water was determined by inserting a mercury-in-glass degree Celsius (°C) thermometer into the water. The daily pH values were measured using Reli-on electronic pH meter for a period of 14 days. A gas meter was connected to the rubber hose the valve was opened to allow gas flow and the volume of gas produced was measured using the gas meter.

Data Analysis

Data obtained were analyzed using Analysis of Variance (ANOVA) and descriptive statistics using SPSS software program 2012 IBM version.

RESULTS

The two sets of the substrates yielded gas in the digesters. The gases produced had odour similar to that of bad eggs. The gases burned with blue flame and left no soot underneath the stainless kettle containing the heated water. The experimental results obtained during the monitoring period were analyzed by statistical method.

The mean daily temperature in the digester and temperatures of the four substrates digested are presented in Table 1. The temperature in the digesters ranged between 30.4°C and 32°C, with digester containing cow dung having the highest of 32°C, while that containing poultry wastes had the lowest. Figure 1 shows temperature fluctuations across the digesters. Cow dung had the highest temperature fluctuations ranging from 27°C to 36°C. The temperatures in the digesters containing poultry wastes fluctuated uniformly throughout the test period. Poultry wastes had its peak temperatures on day 5.

Table 1: average daily digester and ambient temperature of the two substrates digested

Substrates	Average digester temperature (°C)	Ambient temperature
Cow dung	32	28
Poultry waste	31.4	28

Figure 1 shows the pH values of the two substrates digested for a period of 14 days. Cow dung digesters maintained a neutral pH range throughout the retention period. The poultry wastes substrates maintained a slightly neutral balance from days 1 to 10. The pH values dropped as the retention time elapsed. Water was added and the pH rose on day 9 and remained neutral up to day 10. The two substrates digested had their pH decrease as the retention time increased.

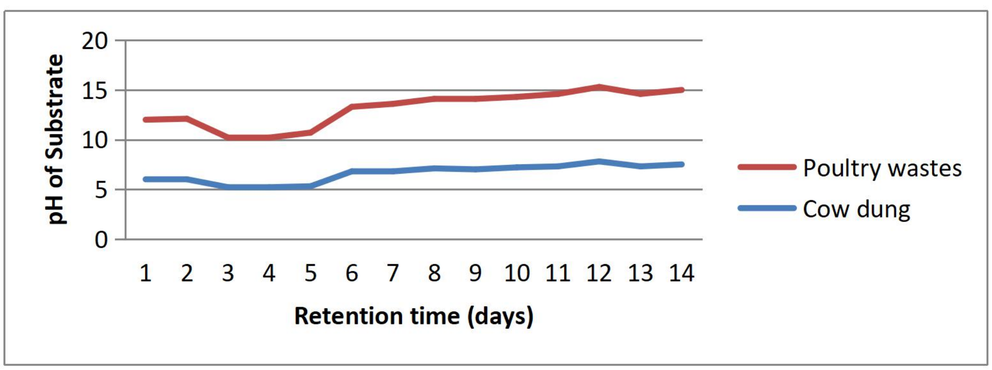

Figure 1: Daily pH changes for the two substrates digested

The summary of heat efficiency and cooking rate for the biogas produced are presented in Table 2. The gases produced were subjected to combustion using an adjusted biogas burner. The efficiency ranged from 445 seconds (7.42 minutes) to 488 seconds (7.46 minutes). Biogas produced by cow dung had the highest heat efficiency (445 seconds) while the lowest was from was produced by poultry wastes (488 seconds). The cooking rate of the substrates digested ranged from 0. 0048L/min to 0.0055L/min. From the results (Table 2), it is shown that cow dung the highest heat efficiency and cooking rate while Poultry wastes had the lowest heat efficiency.

Table 2: Summary of heat efficiency and cooking rate for biogas from two substrates

Substrates	Time (seconds)	Time (minutes)	Cooking rate (kg/min)
Cow dung	445	7.42	0.0055
Poultry waste	448	7.46	0.0048

The comparisons of the daily gas yield of the four substrates digested are presented on figure 3. The highest gas yield occurred in the cow dung digesters (90m1) whereas; the digesters containing poultry wastes produced the lowest volume of biogas (34.825m1). The gases produced by the two substrates digested had their start off on days 1 and 2, the daily gas yield across the digesters decreased as the retention time elapsed. Poultry wastes maintained slight uniform gas yield while Cow dung fluctuated throughout the retention period.

Figure 2 shows steady increase in gas yield with slight fluctuations for poultry wastes from days 1 to 7. There was a sharp fall between days 8 and 9 (19ml). The daily gas yield from the poultry wastes digesters ranged from 3.9ml to 35ml, the highest to lowest values respectively. The highest gas yield occurred on day 12, while the lowest yield occurred on day 1. Gas yield decreased as retention time increased.

Biogas yield from cow dung bio digesters is presented in Figure 5. The gas yield from cow dung ranged from 18ml to 106ml. The highest gas yield by cow dung was l06ml observed on day 12 while the lowest gas yield was 18ml occurring on days 1, 2 and 8 respectively. Gas yield increased slightly from day 2 and maintained uniform yield of 3 8ml between days 3 and 4. There was a rapid increase in gas yield between days 4 and 5, the fluctuations occurred till day 7 with a sharp fall in gas yield. Water was added on day 8 to neutralize the pH, this triggered a continuous rise in yield between days 9 to 12. Gas yield started to decrease from days 13 to 14 as the retention time elapsed.

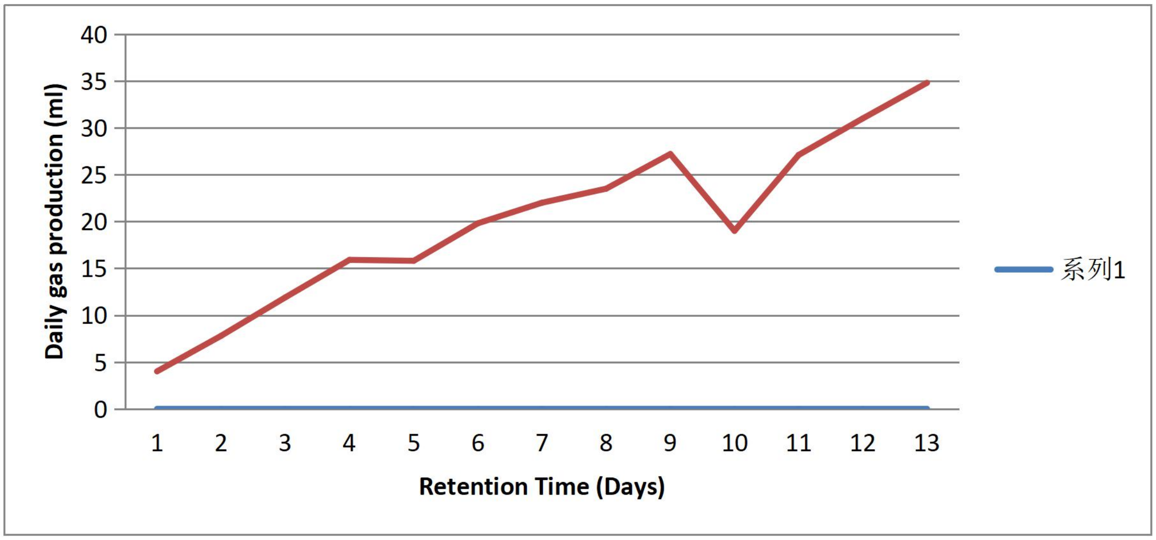

Figure 2: Daily gas yield in poultry waste digester

DISCUSSION

The temperatures fluctuated optimally between 26°C — 37°C which confirms the mesophillic temperature range and this means that it is possible to install digesters that will operate within this range in our rural communities. This agrees with the findings of previous studies (Verma, 2002) which suggested that methanogens thrive best in mesophillic temperature range.The average temperatures for the two substrates observed at the point of observation within the digester and the ambient temperatures were also observed on the course of the experiments. The average ambient temperatures measured on the course of the study was 28°C whereas the temperatures in the various digesters for the two substrates digested measured 32 °C for cow dung and 31.4 °C for poultry wastes.

The pH dropped as the process was ongoing. The methanogens produces fatty acids and they utilize these fatty acids which in turn slow down the reaction in the digesters. In cow dung and poultry wastes digesters, there was a high increase in pH to 7.8 which implied that the digestate was basic and methanogens activates on high pH medium. This is in scontrast with the work of

Ayu and Aryati (2010) who suggested that low pH of the digestate increases as the process is in progress.The pH values fluctuated significantly ($P < 0.05$) in the bio digesters.

There was increased gas yield from the digester containing poultry wastes slurry starting from day 1 with slight fluctuations on days 5. 6 and 7, which could be as a result of microbial activity but the yield increased. There was a sharp fall in gas yield on day 10 which was suspected to be increased acidity in the digesters, after which gas production rose up to 35ml. Gas yield fluctuated significantly ($P <0.05$) in the bio digesters over the observation period. This also confirms the activities of the methanogens thriving best between pH levels ranging 7 to 8. It can be implied that gas production in bio digesters is sensitive to every slight variation in pH levels. Gas yield ceased on day 14 as the pH of the digesters fell below 7. This confirm the findings of Karki, (2005) that suggested the sensitivity of methanogenic bacteria to pH that methanogenes do not thrive below a pH value of 6.0.

The methane contents of the organic matter digested were within the ranges suggested by literature. Cow dung had the highest methane content both in quality and quantity and hence higher heat efficiency. The monitoring of the digesters indicated that all substrates worked satisfactorily with respect to their technical performance. According to Sasse (1988), Cow dung has the highest methane content and followed by poultry droppings 65.9% and 61.71% respectively .Cow dung from a cattle ranch contains, food from both the large and the small intestine mixed with a bit of forages and other organic matter hence contains higher organic wastes which can account or the high methane content compared to other substrates. The methane content of poultry wastes on the other hand can be attributed to the nature of organic wastes present in the substrate which is also a function of the type of feed the birds were exposed to Sasse (1988).

Conclusively, the study showed that Cow dung possess the highest methane content which makes it a highly inflammable biogas source with increased heating heat efficiency and cooking rate (Cr). The heat efficiency of the two organic wastes was evaluated using the heat produced from the biogas adjusted burner to heat 1liter of water (1.07kg) to boiling point (100°C). The heat efficiency for cow dung was 445 seconds while poultry wastes was 448seconds and their cooking rates were 055kg/min and 0.0048 kg/mm, respectively. The outcome of this comparative study supported other previous studies on biogas production.

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