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Comparative Analysis of Biogas Yield Potential from Cow Dung, Poultry Dropping and Pig Dung

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ABSTRACT

Waste management is inadequate and ineffective in many urban and rural areas in Nigeria. The poor management of animal waste in Nigeria is a source of concern to the society. Besides, Nigeria's increasing population has contributed greatly to sustained demands for energy source that is renewable and readily available. At presence, the major means of energy generation in Nigeria is from fossil and wood fuels which have huge negative effect on our environment especially the ozone layer depletion. The biogas technology can help to solve part of Nigeria energy problem, thus this research work that is focused on the comparative analysis of three different samples of animal manure. 30 kg of each samples of animal manure (cow dung, poultry dropping and pig dung) were digested differently in a biogas digester made with mild steel and with a capacity of 0.05m3. The experiment was allowed for complete hydraulic retention. Mesophilic temperature, pH readings, pressure build up and biogas yield were parameters used for evaluation. The results obtained showed that pressure build up in each case were almost the same. Besides, the experiment was subjected to the same mesophilic temperature range. However, biogas yield was higher with cow dung, followed by poultry dropping and pig dung. Besides, there was a variation in pH reading from acidic, to alkaline and neutral. Moreover, each of the samples possess shorter hydraulic retention time, therefore they can served as a seeding agent for biogas yield.

Keywords: *Biogas yield, cow dung, poultry dropping, pig dung*

INTRODUCTION

Waste is defined as left over or already used item waiting for reuse or disposal (Titus and Anim, 2014). The volume of wastes generated is largely dependent mainly on the population in any given area and the consumption pattern of the inhabitants of such area (Orhorhoro *et al.*, 2017b). Solid wastes are generated and dump indiscriminately in Nigeria due to poor implementation of standards, thus causing environmental and public health hazards (Orhorhoro *et al.*, 2017b). Nigeria generates more than 32 million tons of solid waste annually, out of which only 20-30% is collected and disposed in an open dump site (Owamah *et al.*, 2015). Different researchers have reported that organic waste fraction of solid waste generated in Nigeria has the highest percentage which is over fifty percent (Owamah *et al.*, 2015; Orhorhoro *et al.*, 2017b). Unfortunately, this portion of generated solid waste has not been properly enhanced for biogas production (Orhorhoroet *al.*, 2017c). Besides, reckless disposal of solid waste has led to blockage of sewers and drainage networks, and choking of water bodies. Most of the wastes are generated by households and in some cases, by local industries, artisans and traders which litter the immediate surroundings. Improper collection and disposal of solid wastes is leading to an environmental catastrophe as the country currently lack adequate budgetary provisions for the implementation of integrated waste management programs across the states .

The anaerobic digestion (AD) process is a green technology involving the generation of methane rich biogas via the biological degradation of available biomass from organic waste food waste and animal manure (Orhorhoro *et al.*, 2016c). It is an efficient process for treatment and utilization of organic waste because it has proven to be a promising method for waste reduction and energy recycling (Orhorhoro *et al.*, 2017a). The AD process is widely adopted by Germany, Sweden, China, USA, and Denmark, which have implemented rigorous waste disposal legislation. Since 2000, annual power generation from digester projects in USA has increased almost 25- fold from 14 million kilowatt-hours (KWh) to an estimated 331 million kWh per year (Garfi *et al.*, 2011).

Biogas composition typically ranges from 55-70% vol CH_4, 30-45% vol CO_2, and 0-1.5% vol H_2S, and is saturated with water (Schomaker *et al.*, 2000; Orhorhoro *et al.*, 2018). This can be an acceptable substitute of natural gas that is composed of 85% CH_4, with CO_2, N_2 and C_2H_6 making up the rest (Schomaker *et al.*, 2000; Ebunilo *et al.*, 2016b). Biogas is a product of bio-methanation process when fermentable organic materials such as cattle dung, kitchen waste, poultry droppings, night soil wastes, agricultural wastes etc. are subjected to anaerobic digestion in the presence of methanogenic bacteria and absence of oxygen (Bande, 2004; Orhorhoro *et al.*, 2016b; Orhorhoro *et al.*, 2017c). Among the various types of the renewable sources, biogas is a potential fuel, which can be produced through an anaerobic digestion of organic material, such as biomass, municipal waste and sewage (Authayanun *et al.*, 2013; Ebunilo *et al.*, 2015b). The high concentration of methane makes biogas an attractive fuel and its use solves an emission problem since methane (as a greenhouse gas) is several times more harmful than CO_2 (Niesner *et al.*, 2013). Removing of carbon dioxide (CO_2) increases the heating value and leads to a consistent gas quality, similar to natural gas. Hydrogen sulphide is present in small quantities in the biogas; the presence of H_2S usually prohibits the direct use of these gases because of its toxic properties, the formation of SO_2 upon combustion (acid rain), and the problems it (usually) gives in downstream processing. Beside, H_2S is frequently encountered in the field of odour monitoring because of its high odorous power (Zaouak et al., 2012). The type and the amount of pollutants depend upon the biogas source and determine which cleaning and upgrading techniques are the most suitable for gas purification (Ebunilo *et al.*, 2016c; Orhorhoro *et al.*, 2017d). With the potential of solid waste from animal manure, with the adoption of biogas technology, part of Nigeria energy problem can be solved, thus this research work.

MATERIALS AND METHODS

Materials

The materials used in this research are as follow: water, cow dung, pig dung, poultry dropping, 0.05m^3 mild steel anaerobic digestion plant, pressure gauge, pH meter and mercury in glass thermometer

pH Meter

An electronic pH meter was used to monitor the pH of the digested slurry. The probe (glass electrode) is dipped into the sample of the slurry inside the digester after each evacuation. The other part of the probe is connected to the electronic pH meter.

Thermometer

The mercury in glass thermometer is connected to the anaerobic digester plant. It was used to measure the slurry temperature.

Anaerobic Digestion Plant

The anaerobic digestion plant was constructed from a mild steel material. It has a total capacity of 0.05m^3 and it was fabricated using a mild steel material. The inlet valve for charging of slurry, thermometer for taking the temperature of the slurry, pressure gauge for taking the gas pressure, outlet valve for discharge of slurry, valve for biogas evacuation and stirrer for continuous stirring of slurry were all connected to the digester.

Method

Collection of Substrate

The cow dung, pig dung, poultry dropping was collected from local farm in Nigeria on a daily basis. A basket was used for the collection and it was sorted and properly weighed using a weighing balance.

Preparation and Charging of Substrate

Foreign materials were removed from the collected substrate samples and a grinding machine was used to further decrease the sizes of the substrate. According to Orhorhoro *et al.*, (2017C), the finer the particles size, the shorter the hydraulic retention time (HRT). Besides, it leads to an improved biogas yields. Therefore, for an optimum biogas yields, bio-waste grinding machine is required. During the preparation of the substrates used, same measured masses of pig dung (30kg), poultry dropping (30kg), and cow dung (30kg) were digested differently with same water volume in ratio of 2 (substrate) to 1 (water) as recommended by Ebunilo *et al.* (2015a). The temperature and pH were monitored using mercury in glass thermometer and electronic pH meter respectively.

Due to maintenance and technical know-how, a single fixed dome batch anaerobic digestion plant was used for the digestion of the substrate samples. Charging was carried out separately with AD1 for cow dung, AD2 for poultry dropping, and AD3 for pig dung. Each of the AD was subjected to complete hydraulic retention time (HRT) under the same condition of mesophylic temperature and pH.

RESULTS AND DISCUSSION

The quantity of biogas yield was evaluated at an interval of two (2) days after indication of blue via flame test. It was observed that it took 14 days for proper biogas yield (blue flame) and this agree with the research work of Ebunilo *et al*. (2016a). The biogas produced was evacuated into a mild steel biogas storage bottle. This was done for each sample which comprised of cow dung, pig dung, and poultry dropping.

The performance analysis of pressure build up for each of the sample is depicted in Figure 1. The pressure at each evacuation showed that pressure was higher for cow dung, closely followed by poultry dropping and pig dung was least. However, in each sample, the different in pressure build up was minimal.

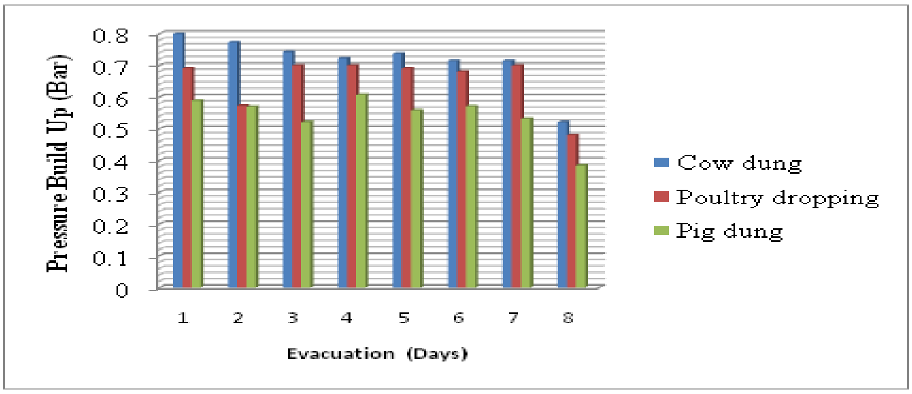

Figure1. *Comparative analyses of pressure build up*

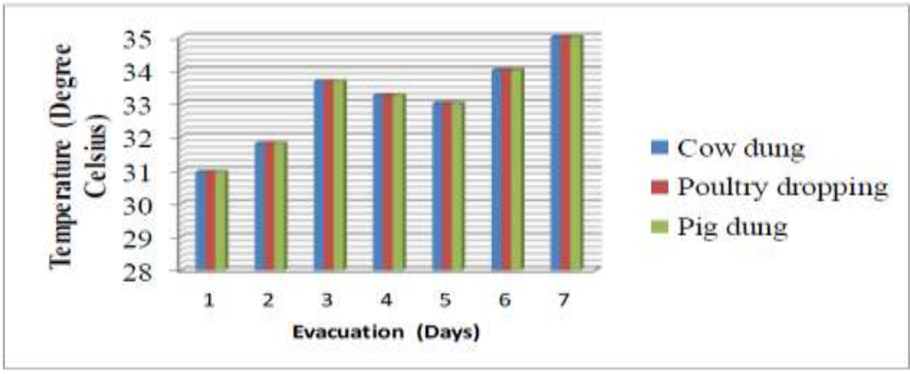

Figure2. *Comparative analyses of temperature*

The high pressure value obtained with cow dung in comparison to the other substrate samples (pig dung and poultry dropping) was an indication of better biogas yield. According to Orhorhoro *et al.* (2016b), improved in pressure build up in the anaerobic digester was an indication of better microbial activities taking place in the anaerobic digestion plant that favored methanogenesis stage on the other hand, thus improved biogas yield.

Besides, higher value of pressure build up in the anaerobic digester is a function of a better slurry temperature across each of the sample as shown in Figure 2. It was observed that the research work was carried out at a mesophilic temperature range (Ebunilo *et al.*, 2016a). Nevertheless, in each of the sample, mesophilic temperature ranges of 28^{o}C-35^{o}C were used. In general, the higher the mesophilic temperature inside the digester, the less time required for complete digestion of substrate (i.e. more production of biogas) since more methanogenic bacteria are working upon substrate and also more destruction for diseases causing microbes. Ebunilo *et al.* (2016a) reported 36^{o}C-37^{o}C as optimum mesophilic temperature for optimum biogas yield. Moreover, the temperature inside the digester should be stable, since the methanogenic bacteria are highly sensitive toward changes and variations of temperature inside the digester especially at high temperature ranges where the productivity of the biogas dropped significantly, while it drops gradually at low temperature range (Orhorhoro and Erameh, 2019).

A sudden or fast temperature changes reduces the production of biogas or might stop its production, so temperature monitoring is essential especially for biogas plants work at high and low temperature range (Orhorhoro and Erameh, 2019).

The results of flame test evaluation for the three samples are shown in Table 1.

Table1. *Comparative analysis of flame test*

Flame Test			
Hydraulic retention time (days)	**Cow dung**	**Poultry dropping**	**Pig dung**
1	No gas	No gas	No gas
2	No gas	No gas	No gas
3	No gas	No gas	No gas
4	No gas	No gas	No gas
5	No gas	No gas	No gas
6	No gas	No gas	No gas
7	No gas	Yellow flame	No gas
8	No gas	Yellow flame	No gas
9	Yellow flame	Yellow flame	No gas
10	Yellow flame	Yellow flame	Yellow flame
11	Yellow flame	Yellow flame	Yellow flame
12	Yellow flame	Yellow flame	Yellow flame
13	Yellow flame	Yellow flame	Yellow flame
14	Blue flame	Blue flame	Blue flame
15	Blue flame	Blue flame	Blue flame
16	Blue flame	Blue flame	Blue flame
17	Blue flame	Blue flame	Blue flame
18	Blue flame	Blue flame	Blue flame
19	Blue flame		Blue flame
20	Blue flame		Blue flame
21			Blue flame
22			Blue flame

From the results analysis, indication of biogas production started earlier with poultry dropping (day 7), followed by cow dung (day 9) and pig dung (day 10) took longer time. Besides proper methane production which is the indication of blue flame (Ebunilo *et al.* 2016a) started earlier with poultry dropping, followed by cow dung and ended with pig dung. The shorter hydraulic retention time observed was as a result of quick decomposition of the samples used. This simply showed that either of the samples can be used as a seeding agent. Ebunilo et al. (2016b) reported similar results for cow dung and water leaf. Comparative analysis of biogas yield is shown in Figure 3. From the results obtained, cow dung has a better biogas yield when compared to poultry dropping and pig dung.

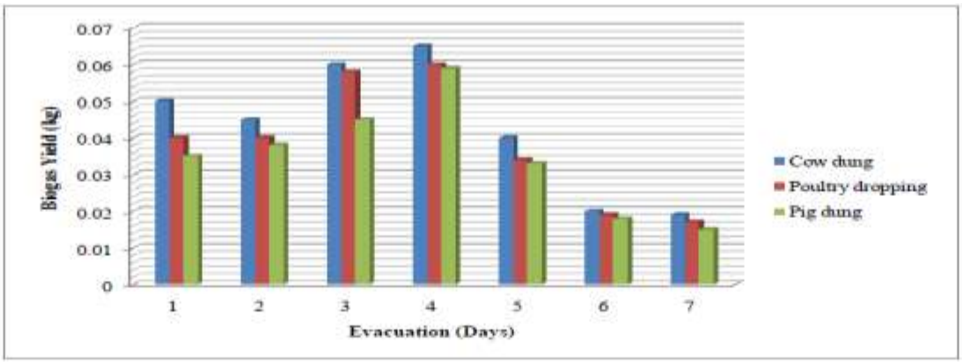

Figure3. *Comparative analyse of biogas yield*

The results of pH readings evaluation of cow dung, poultry dropping and cow dung is shown in Figure 4. For each of the samples, at the early stage of the process, it was weak acidic which is an indication of hydrolysis stage as reported by Orhorhoro and Erameh (2019). However, with prolong decomposition; it appeared to be alkaline medium before a neutral range that favoured optimum biogas yield was obtained. These results go in line with the research work of Orhorhoro and Erameh (2019).

Conclusion

In this research work, comparative analysis of three different samples of animal manure was evaluated and compared. The results of the analysis show that for a period of this research work, cow dung has a shorter hydraulic time, closely followed by poultry dropping with pig dung coming last. Also, analysis was equally carried out to evaluate temperature and pH readings as a process and operation parameters. It was observed that mesophilic temperature range has effect on biogas yield from animal manure. Besides, variations in pH reading from acidic, to alkaline and neutral were recorded.

However, each of the samples possess shorter hydraulic retention time, therefore they can served as a seeding agent for biogas yield.

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