SUSTAINABLE MANAGEMENT OF COW DUNG FROM SLAUGHTER HOUSES

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Abstract

Large amount of cattle dung are generated daily from slaughter houses which are not only of environmental concern due to methane emission but also present a significant health risk if not adequately managed. In this study, cow dung obtained from slaughter house was anaerobically digested and its composition evaluated.8 kg of the collected cow dung was mixed with water using a mechanical stirrer set at a speed of 150 rpm to form slurry before pouring it into a laboratory scale digester affixed with stirrer, inlet and outlet ports and temperature detector. The set up was left for 3days for microbial activation to take place, before daily stirring. Average weekly temperature of the slurry inside the digester tank was observed. Biogas produced was collected in a rubber tube and trapped with activated charcoal dissolved in 500 ml of carbon disulphide (CS_2) for 120 minutes in an open air. The liquid filtrate was then analysed using a Gas Chromatography. The optimum temperature was observed at 36.5 ^{O}C. The digestion temperature variation was between 0.5 to 2 ^{O}C. Methane bacteria worked best in the temperature ranges between 34 and 37 ^{O}C. After the liquefaction process, 30 cm^3 of biogas was generated. Out of which, methane occupied 25.002 cm^3 (83.34 %), carbon dioxide 4.467 cm^3 (14.89 %), nitrogen 0.468cm^3 (1.56 %) while carbon monoxide generated was 0.063 cm^3 (0.21 %). The result clearly show that methane has the highest yield, the energy contained in methane can be used as domestic gas.Cow dung is an excellent substrate for biogas production in anaerobic digesters instead of indiscriminate disposal. Bio-digestion of cow dung is a viable and sustainable solution to the problem of waste pollution, disposal, control and management.

Keywords: Cow dung, Waste management, Animal waste, Biogas, Bio-digestion

INTRODUCTION

The amount of cow dung generated from rearing of cattle is rapidly increasing over time due to increased agricultural activities (high demand for meat, milk, hides) as a result of population explosion. Indiscriminate disposal of cattle dung from slaughterhouses are not only of environmental concern due to methane emission but also present a significant health risk, increases the risk of water pollution as well as air contamination. Indiscriminate disposal of cow dung also constitutes a nuisance to the environment as well as an eyesore to the public. Livestock waste management in many parts of the world especially Africa is a big challenge (Adeshiyan *et al*., 2010; Oyeleke *et al*., 2003) due to lack of proper management strategy and policy implementation and enforcement (Coker *et al*., 2008). Large volumes of cow dung generated from feed lot farming is on the increase, most of which are disposed indiscriminately into land or applied to the land without treatment (Budiyono *et al.*, 2011; Kaygusuz and Kaygysuz, 2002). These large quantities of animal waste requires adequate management.

Animal wastes are abundant all over the world with Nigeria producing about 227,500 tons of fresh waste each day, about 1kg of fresh animal waste can produce about 0.03 m^3 of gas per day (Baki, 2004). Report has it that an average cow produces about 13.2 litres of urine daily and about 29.5 kg of dung/faeces per day that is about 908 kg annually (Cow in and out, retrieved on April 15th 2016 from https://fergusonfoundation.org/). It has theoretically be proven that Nigeria can produce 6.8 million m^3 of biogas daily, which in terms of energy is equivalent to 3.9 million liters of petroleum. The energy contained in methane produced by about 12 cows daily would be sufficient to provide an average household with its domestic gas (Yohaness, 2010). Globally, ruminant livestock produce approximately 80 million tons of methane annually (EPA, 2009). Cattle can produce 250-500 litre of methane per day (Johnson, 1995). One cubic meter methane has the energy content of 9.97 kWh. Cow dung generation over time has been identified as the largest source of methane emission. Methane emission from ruminants is not only of environmental concern but also present a significant health risk (Roonal, 2015; Broucek, 2014; Pierre *et al*., 2013) if not managed appropriately.

Cow dung from slaughterhouses, farms and homes has very great potential for the generation of biogas which can serve as alternative source of energy (Budaraga *et al*., 2016; Ojolo *et al.*, 2007). Cow dung is an excellent substrate for biogas production in anaerobic digesters (Salam *et al*., 2015). A major significant of bio-digestion of cow dung is that it provides a viable solution to the problem of waste pollution, disposal, control and management.

Biogas holds the greatest promise as a cheap household energy source because it is renewable, simple to generate, convenient to use, and cheap; other benefits are highlighted in Table 1. However, its potential generation from cow dung is still under-exploited in Nigeria.

Table 1: Benefit of Proper Management of Cow Dung

Benefit of biogas production from cow dung
Provides an ideal working and living place, clean slaughter houses and animal farms
Proper use of cattle dung for odour control
Solution to difficulty in getting conventional energy sources as well as their high costs
Economic benefits (saves time and energy)
Provides fertilizer and nutrients of higher nutrient value
Fast, easy and comfortable cooking
Health benefits (clean kitchen, no smoke-borne diseases, proper management of dung)
Environmental benefits (saving of forest, clean surrounding etc.)

Source: Adopted from Ghimire (2007)

Biogas is a combination of gases produced during anaerobic decomposition of organic materials mainly from anaerobic decomposition of livestock wastes (dung, urine and food waste or feeds). The main gaseous by-product is methane (CH_4), with relatively less carbon dioxide (CO_2), ammonia (NH_3) and hydrogen sulphide (H_2S). Ordinarily, these materials decompose in open-air (aerobic) conditions with carbon dioxide (CO_2) and water (H_2O) as the main by-products, and with limited amounts of other gases. The composition of the gases depends on the chemical composition of the substrate. Biogas from livestock wastes burns well when the methane content is greater than 70% (karanja and Kiruiro, 2003).

Most research had focused on the use of cow dung with additives. Cow dung blended with water hyacinth had been used to produce biogas (Sugumaran *et al*., 2014; Momoh and Nwaogazie 2008), blends of cow dung and fowl dung had been digested to produce biogas in a research work by Ukpabi *et al.,* 2017, here, result showed that biogas production was higher from cow dung slurry followed by the blend and lastly from the fowl slurry. Volume of biogas produced depend on several factors as substrate material, process, temperature among others. Rabah *et al*., (2010) reported that biogas from manure including cow dung represents a huge potential for reduction in global greenhouse gas emissions. Therefore, in this study, cow dung obtained from slaughterhouse was anaerobically digested and its composition evaluated for potential utilization and sustainable management strategy.

MATERIALS AND METHOD

Experimental Set Up

The digestion tank employed for the cow dung digestion is as shown in Plate 1. The laboratory scale digester with stirrer, inlet and outlet ports also has a temperature detector. A 9 mm diameter rubber hose connects the digester to a rubber tube which stores the biogas generated from the digestion process. Open and close valve was attached to both ends of the digester and the rubber tube to control the movement of the gas. Stirrer was properly fixed, tightened and adequately located in order to reach every nooks and corner of the digester to have a good and homogeneous paste and thermometer was adequately attached for temperature measurement.

The bolts and nuts of the digester tank were checked and properly lubricated; digestion tank was washed, cleaned and sundried before use. Poly filler was applied to all welded joints to seal all joints in order to ensure that the digester was airtight to avoid leakages. The experiment was set up outside the Civil Engineering laboratory, LAUTECH, Ogbomoso. Safety precautions were observed throughout the experimental process.

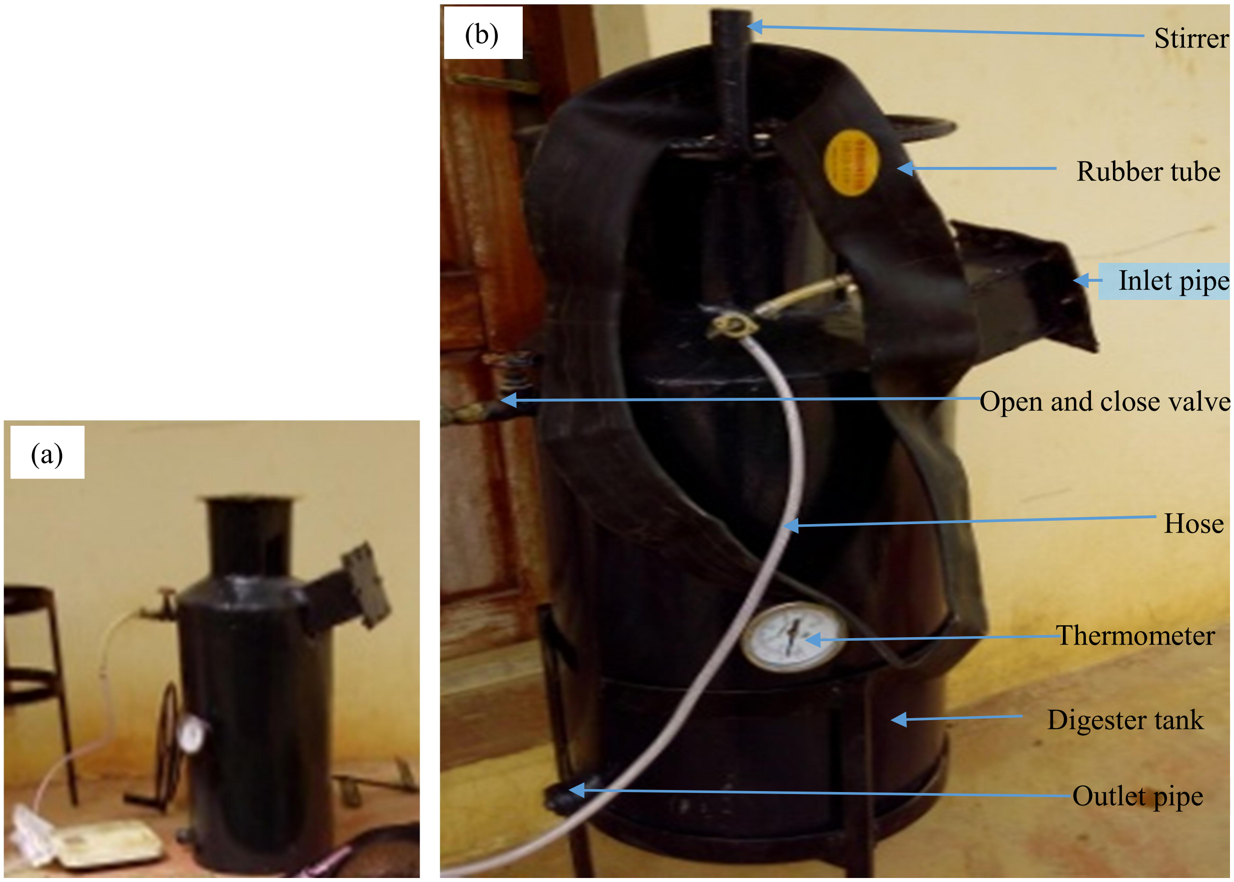

Plate 1: (a) Digestion Tank (b) Experimental Make-up

Collection of Cow Dung and Substrate Preparation

Cow dung was collected fresh after slaughtering the cows at the Central Ogbomoso Slaughterhouse. It was then transported to the Water Resources and Environmental laboratory of the Department of Civil Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, for experimental study.

8 kg of the collected cow dung was mixed to attain a uniform paste. Equal weight of the freshly mixed cow dung and water were mixed with a mechanical stirrer set at a speed of 150 rpm to form slurry (Abubakar and Ismail, 2012). The slurry was poured into the airtight digester through the inlet pipe.

The set up was left for 3 days for microbial activation to take place, after which, daily stirring was carried out to aid homogenization process, keep the temperature steady, provide better contact between microorganism and to prevent the formation of scum on the surface which could prevent the release of the biogas. The slurry was retained in the tank for 6 weeks. Meanwhile, daily temperature was taken, from which the average weekly temperature of the slurry inside the digester tank was recorded.

Gas Collection and Estimation

The biogas from the anaerobic digestion was collected through a rubber hose into a small rubber tube. A non-return valve was used to prevent the biogas from returning into the digester. The quantity of biogas produced was estimated using the equation below:

Weight of biogas produced (B_w) = W_2 -W_1

Where; W_1 = weight of the rubber tube before filling with biogas

W_2 = weight of the rubber tube after filling with biogas

Liquefaction of the Biogas Produced

The biogas collected in the tube was trapped with the use of activated charcoal due to its excellent adsorption property and ability to attract constituent or matter to its self. The activated charcoal was dissolved in 500 ml of carbon disulphide (CS_2) for 120 minutes. This was carried out in an open environment to avoid any unprecedented accident such as fire outbreak, due to the volatility of the carbon disulphide (CS_2). The liquid filtrate generated was poured into a tube and prepared for analysis. The filtrate sample generated was taken to Chemical Engineering Laboratory, University of Ilorin for analysis using a Gas Chromatography in other to determine the constituent and percentage composition of the biogas produced.

RESULT AND DISCUSSIONS

Average Temperature from Anaerobic Process

Figure 1 shows the average weekly temperature observed from the anaerobic digestion, starting from the first week the digester was loaded. Observation shows that the temperature continued to increase from the first to the second week and reaches maximum temperature in the 3rd week with an optimum temperature of 36.5 ^{O}C. After the 3rd week, the temperature started to drop and continued to the 6th week with average temperature ranging from 33.0 ^{O}C – 36.0 ^{O}C. This temperature variations affects the production of biogas. Report by karanja and Kiruiro (2003) shows that maximum gas production usually occur at 35-40 ^{O}C, or between 30 – 40 ^{O}C. Mesophilic methane bacteria operate best within 20 - 40 ^{O}C. Gas production declines as temperature drops and ceases at around a temperature of 10 ^{O}C.

Anaerobic breakdown of waste often occurs at temperatures between 0 ^{O}C and 68 ^{O}C, while the action of the digesting bacteria usually decreases below 16 ^{O}C. Temperatures between 32 – 35 ^{O}C has proven to be the most efficient for stable and continuous production of methane from most report. Biogas produced outside this range will have a higher percentage of carbon dioxide and other gases than within this range.

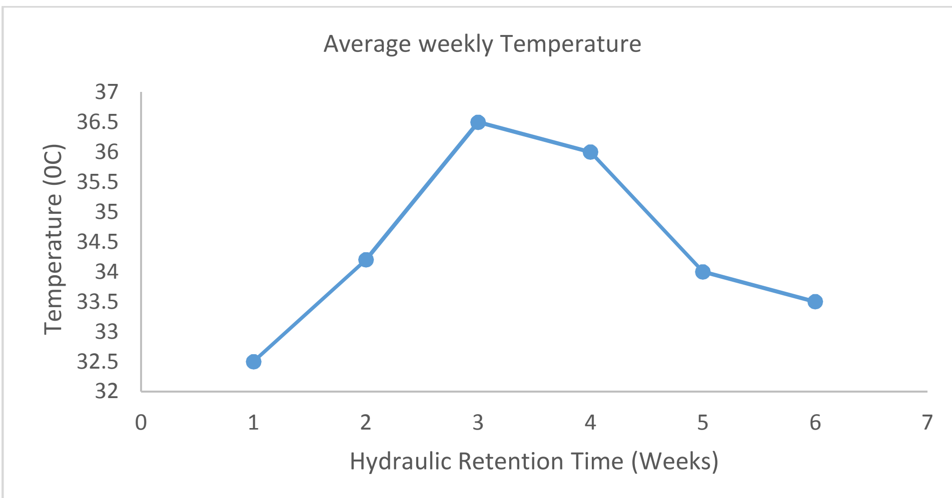

Figure 1: Average Temperature Observed

Constituent of Biogas Produced

Table 2 shows the composition and volume of biogas produced. The biogas produced yielded 83.34 % of methane (CH_4), 14.89 % of carbon dioxide (CO_2), 1.56 % of nitrogen (N) and 0.21 % of carbon monoxide (CO). Results indicated that methane has the highest yield. The absence of oxygen in the composition of biogas produced is similar to the work of Budiyono *et al.,* 2011 where oxygen was also absent, though cow dung and rumen fluid were used as substrate.

The high percentage of methane (CH_4) generated (83.34 %) represent the main source of energy. For comparison, Dasin *et al.,* (2014) digested 2 kg of cow dung with fresh human excreta, mixed with water hyacinth and urine in a batch system, and obtained 85 % of methane (CH_4), 13.011 % of carbon dioxide (CO_2), 1.596 % of nitrogen (N) and 0.048 % of carbon monoxide (CO). The work of Dasin *et al.,* (2014) yielded almost the same amount of methane, slight variation can be attributed to other waste added to the cow dung to form the substrate. It is often reported that percentage yield of the various by-product of biogas depends on type of substrate used and its chemical constituent. For instance, Khan *et al.,* 2013 used water hyacinth as a substrate for biogas production for 40 days and obtain 39 cm^3 of biogas, similarly, poultry waste was used as substrate for 36 days which produced 79 cm^3 of biogas while cow dung and rumen fluid used as substrate yielded 46 cm^3 of biogas. For this study, 30 cm^3 of biogas was generated after 40 days. The yield and composition of the biogas and the volume of methane generated depended on the substrate type and materials used.

After the process of liquidation the volume of biogas produced was 30 cm^3 from which 25.00 cm^3 of Methane (CH_4), 4.467 cm^3 of Carbon dioxide (CO_2), 0.468 of Nitrogen (N), and 0.063 cm^3 of Carbon monoxide (CO) were generated. In a similar case, cow dung was digested in a 10 L anaerobic digester at a temperature of 25 ^{0}C to 30 ^{0}C at uncontrolled pH for a period of 3 weeks by Ozor *et al.*, (2014) which produces about 23 cm^3 of biogas on the 22nd day.

Table 1: Composition and Constituent of Biogas Produced

Constituent of biogas	Average percentage of composition (%)	Volume produced (cm^3)
Methane (CH_4)	83.34	25.002
Carbon dioxide ($C0_2$)	14.89	4.467
Nitrogen (N)	1.56	0.468
Carbon monoxide (CO)	0.21	0.063
Total	**100**	**30**

CONCLUSION AND RECOMMENDATION

Biogas was produced from a substrate of cow dung with water only without any additive. Anaerobic digestion of the cow dung took place at any temperature between 10 and 40 ^{O}C. The value of 36.5 ^{O}C was taken as optimum. The rate of biogas formation was very slow below 20 ^{O}C. The digestion temperature variation was between 0.5 to 2 ^{O}C. Methane bacteria work best in the temperature ranges between 34 and 37 ^{O}C. After the liquefaction process (conversion of the biogas to liquid form), 30 cm^3 of biogas was generated. Out of the 30cm^3, methane occupies 25.002 cm^3, 4.467cm^3 of carbon dioxide, 0.468cm^3 of nitrogen while carbon monoxide occupies 0.063cm^3. Cow manure is an excellent substrate for biogas production in anaerobic digesters. The biomass generated after digestion can be used both as animal feed and to improve soil fertility.

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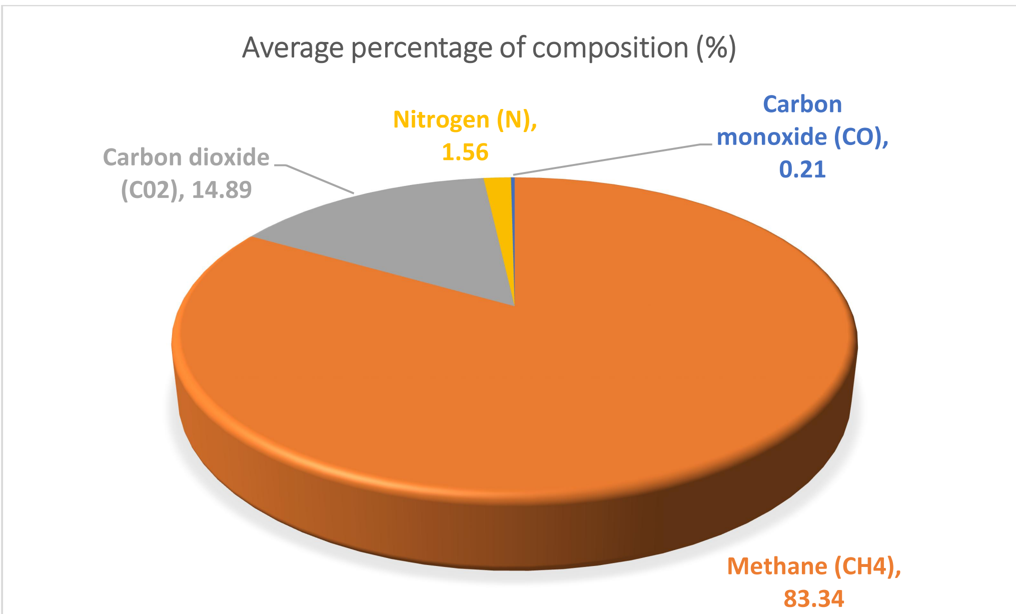
Appendix



Constituents of Biogas Produced in Percentage