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Comparison of Biogas production from Cow dung and Pig dung under Mesophilic condition.

Aremu, M .O.[1*] and Agarry S. E.

[1]Department of Chemical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

ABSTRACT : *The over-dependence on fossil fuels as primary energy source has led to myriads of problems such as global climatic change, environmental degradation and various human health problems. Moreover, the recent rise in oil and natural gas prices has call for researches towards alternative energy sources. This study therefore investigates the digestion of cow dung and pig dung for biogas production at laboratory scales. The study was carried out through anaerobic fermentation using cow dung and pig dung separately as substrate and fresh cow rumen as source of methanogens. The fermentation medium was prepared with a total solid concentration of 8% fermentation slurry in four separate bio- digesters and fermentation carried out at temperatures between 27 – 35 °C and pH range of 6.2-6.8 for a period of 30 days. The biogas produced during this period was collected by water displacement method and subsequently measured and tested by flame test. The results showed that cow dung in bio-digesters A and B gave a cumulative average biogas volume of 4140 ml (138 ml day^{-1}) while pig dung in bio-digesters C and D gave a cumulative average biogas volume of 4378 ml (145.9 ml day^{-1}) within 30th days of fermentation.*

Keywords: *Biogas, Cow-dung, Pig-dung, Methanogens, Bio-digester, Anaerobic fermentation.*

I INTRODUCTION

Energy is one of the most important factors to global prosperity. The overdependence on fossil fuels as primary energy source has led to global climate change, environmental pollution and degradation, thus leading to human health problems. In the year 2040, the world as predicted will have 9 – 10 billion people and must be provided with energy and materials (Okkerse and Bekkum, 1999). The growth in the world's population has resulted in a surge of energy demand and for far more than two centuries, the world's energy supply has relied heavily on non-renewable crude oil derived from fossil fuels, out of which 90% is estimated as being consumed for energy generation and transportation (Devanesan *et al.*, 2010). This has now led the world to be presently confronted with double crisis of fossil fuel depletion and environmental degradation. These realities have led a boost to the search for renewable and sustainable alternatives to fossil fuels. Moreover, the recent rise in prices of oil and natural gas may drive the current economy toward alternative renewable energy sources. One of these renewable and sustainable alternatives is biogas. Biogas is a readily available energy resource that significantly reduces greenhouse-gas emission compared to the emission of landfill gas to the atmosphere (Murphy *et al.*, 2004). With the increasing size and regional concentrations of confined animal feeding operations (CAFOs), there is growing public concern over potential impact on environmental quality caused by CAFO-generated wastes (Sweeten *et al.*, 1994). In response to this, regulatory agencies are scrutinizing animal waste management practices and revising regulations to reduce environmental impact. CAFOs in Texas produce over 5 million tons (dry) of animal waste annually (Sweeten *et al.*, 1994). Handling these wastes in compliance with stricter environmental regulations can have a significant economic impact on CAFOs. As a result, CAFO operators are evaluating waste management practices that convert wastes into higher value products. One approach to increasing the value of waste is to use it as an energy resource. The amount of waste produced varies with the type of animal, but generally ranges from 60 to 85kg (wet basis) per 1, 000 kg live animal mass per day in intensive production systems. The energy potential of these wastes is given by the volatile solids (organic matter) content, which ranges from 10 to 18% of the total wet waste or 75 to 85% of the dry weight (ASAE, 1997).

Either biological or thermo-chemical conversion methods can be used to obtain energy from animal wastes. Fresh wastes have high moisture content (about 80%), making them unsuitable for most thermo-chemical processes, and their varied composition and high content of lingo-cellulosic material makes them unattractive for fermentation to ethanol or other products. Anaerobic digestion, a biological conversion process, has a number of advantages for waste conversion. Anaerobic digestion is a microbial process that occurs in the absence of oxygen. In the process, a community of microbial species breaks down both complex and simple organic materials, ultimately producing methane and carbon dioxide. Anaerobic digestion also has some advantages from a waste treatment stand point. Although total nitrogen and phosphorus contents are not changed substantially by anaerobic digestion, the effluent is amenable to further treatment for their removal. Also, coliform bacteria, other pathogens, insect eggs and internal parasites are destroyed or reduced to acceptable levels by anaerobic treatment. Temperature has a significant effect on digestion rate with most processes occurring at temperatures in the mesophilic temperature range of 75-100°F, but anaerobic digestion also can be carried out at thermophilic temperatures (125-140°F). It is well-known that the thermophilic is more efficient than the mesophilic in terms of retention time, loading rate, and nominal biogas production but it needs a higher energy input, more expensive technology, and greater sensitivity to operating and environmental variables, which make the process more problematic than mesophilic digestion. Anaerobic digestion is slower than aerobic waste treatment processes, typically requiring retention time of 10-30 days for mesophilic digestion. Biogas yields are in the range of 3-8 SCF/lb VS, and methane content of the biogas usually is 60-70%, with the balance mostly CO_2. Trace amounts of hydrogen sulfide (H_2S), which is both toxic and corrosive, are produced also. According to Shamsul and Naimul Haque (2006), a family of 5-8 members needs 4-6 cattle to run a biogas plant to meet their daily cooking energy requirement. This can help solve the cooking fuel crisis and also, the residual compost generated is a source of organic fertilizer.

II METHODOLOGY

Bio-digester Design: The bio-digester vessels were made of four 25 liters transparent plastic container of diameter 40cm and 30cm length each. The lid of the vessels were drilled in two places with a hot soldering iron, one at the middle for a 0.9 cm diameter rubber hose and another at the side for a 2 cm diameter rubber hose to serve as an inlet for the substrates. The 0.9 cm hose of length 70 cm leads into a 1000 ml mayonnaise bottle through a hole drilled in the lid of the bottle while another hose also of the same diameter but of 20 cm length passes out of the bottle through the same lid into another bottle of the same size. On the side of the container at 2 cm to the base of the vessel, a perforation for a rubber hose of 0.5 cm diameter and length 10 cm was made. This hose was fixed with a clip on the outside to prevent loss of the medium. All perforations were properly sealed with rubber tubes and adhesives to make the whole bio-digester system airtight. The bio-digester was shown in Fig.1 below.

Fig. 1: A newly Constructed Plastic Bio-digester

Materials: The following materials were used for the purpose of this research work: Plastic bio-digester, Mercury-in-glass Thermometer, Weighing balance, pH meter, Connecting tubes, Mortar and pestle, Heater, Bunsen burner, Measuring Cylinders, Beakers, Funnel, Polythene Bag, Cattle Rumen, Cow dung, Pig dung and Water.

Sample Collection: Cow dung was collected from an abattoir (cow slaughter slab) at Kara, Sabo market, Ogbomoso, Nigeria. Pig dung was collected from the piggery unit of faculty of agriculture, Ladoke Akintola

University, Ogbomoso, Nigeria. The cow and pig dung collected was pretreated separately by sun drying and thereafter crushed mechanically using mortar and pestle to ensure homogeneity of the dung and then weighed.

Fermentation slurry: In this study, four 25 liters anaerobic plastic bio-digesters were constructed and labeled A, B, C and D. Each of the bio-digesters was fed with 1.4 kg slurry of fermentation substrates. Bio-digesters A & B were filled with cow dung slurry while C & D were filled with pig dung slurry. The experiment was performed in duplicates for each substrate.

Fermentation slurry was prepared by addition and vigorous mixing of dried cow dung and dried pig dung separately with an equivalent amount of water needed for maximum yield in the ratio 1:1 according to the method of Ituen *et. al.* (2007) (i.e. 100 kg of cow dung to 100 kg of water corresponding to a total solids concentration of 8 - 11 percent by weight in the slurry). Fresh rumen content of a freshly killed cow was retrieved anaerobically and 0.23 kg of the rumen content was measured and used to inoculate the medium in each of the bio-digesters as a source of methanogens. After inoculation, the inlet of the bio-digester (i.e. the 2cm diameter hose) was immediately cotton plugged and blocked with a sticky tape. Initial temperature and pH readings were taken and found to be 27^oC and 6.8 respectively.

Fermentation was allowed for a period of 30 days under mesophilic condition (temperature between 27 and 35°C). The pH of the medium was measured and found to be between 5.8- 6.8 which is within the pH range required for biogas production. During this period the digesters were agitated twice a day (morning and evening) to enable digestion take place in the entire medium. The bio-digesters were covered with black polythene sheets to prevent light penetration which can stimulate algae growth and also to trap the heat that has been absorbed in the day. Leakages in the bio-digester systems were checked by immersing bio-digesters into water-bath to check for air bubbles at intervals to prevent loss of medium and the gases generated.

Data collection

The temperature, pH and volume of gas produced were measured and recorded throughout the fermentation period at intervals of 2 days by releasing the clip on the rubber hose on the lower side of the vessel to let out a small portion of the medium into a beaker. The pH was measured by an electronic pH meter and temperature by mercury in glass thermometer. Volume of gas produced was measured by the volume of water displaced from the first bottle into the second bottle as a result of gas pressure built up inside the first vessel.

III RESULTS AND DISCUSSION

From Figure 2, in the first 4 days there was no evidence of gas production in all the bio-digesters. This may be due to the fact that the inoculums are either in their lag phase or the methanogens undergoing a metamorphic growth process by consuming methane precursors produced from the initial activity as suggested by Lalitha *et al*. (1994); Bal and Dhaghat (2001). It is generally agreed that at the initial stages of the overall process of biogas production, acid forming bacteria produce Volatile Fatty Acids (VFA) resulting in declining pH and diminishing growth of methanogenic bacteria and methanogenes (Vicenta *et al.*, 1984; Cuzin *et al.*, 1992). That is, a low pH value inactivated microorganisms responsible for biogas production. On the 6^{th} day, a low value of biogas was recorded in each of the biodigesters (75 ml, 87 ml, 85 ml and 120 ml for bio-digesters A, B, C and D respectively. The volume of biogas produced was observed to increase steadily until the 18^{th} and 20^{th} day when the readings of each of the bio-digester dropped. This may not be unconnected with the heavy rainfall that occurred on the 17^{th} day which resulted in cold weather generally. The readings of each of the bio-digesters started rising up steadily again and maximum values of 610 ml, 570 ml, 425 ml and 432 ml were recorded for each of the bio-digesters A, B, C and D respectively on the 26^{th} day. After 26^{th} day, the readings of each of the bio-digesters started decreasing progressively on daily basis until the fermentation process was stopped on the 30^{th} day when a decline in gas production was observed. The biogas production was found to be a function of temperature and pH because the temperature and pH readings were found to be fluctuating and the high biogas production values corresponds to increased temperature and pH values. The variation of bacterial counts of the fermentative bacteria and the methanogenic bacteria with pH may also explain the drop in production after the 26^{th} day, after which no appreciable production of biogas occurred but at a reducing rate.

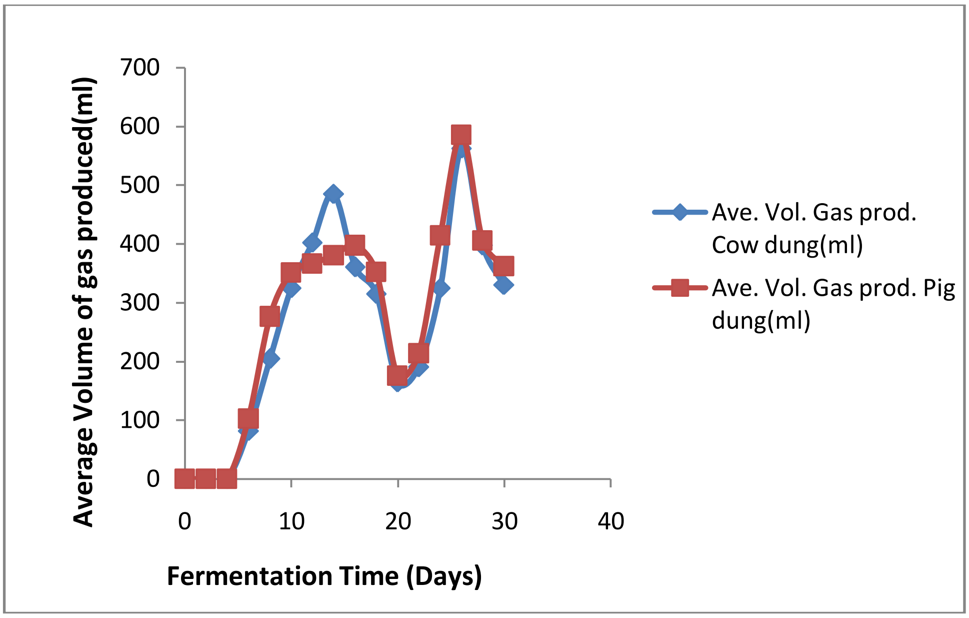

Fig.2: Variation of volume of Biogas produced with Fermentation Time

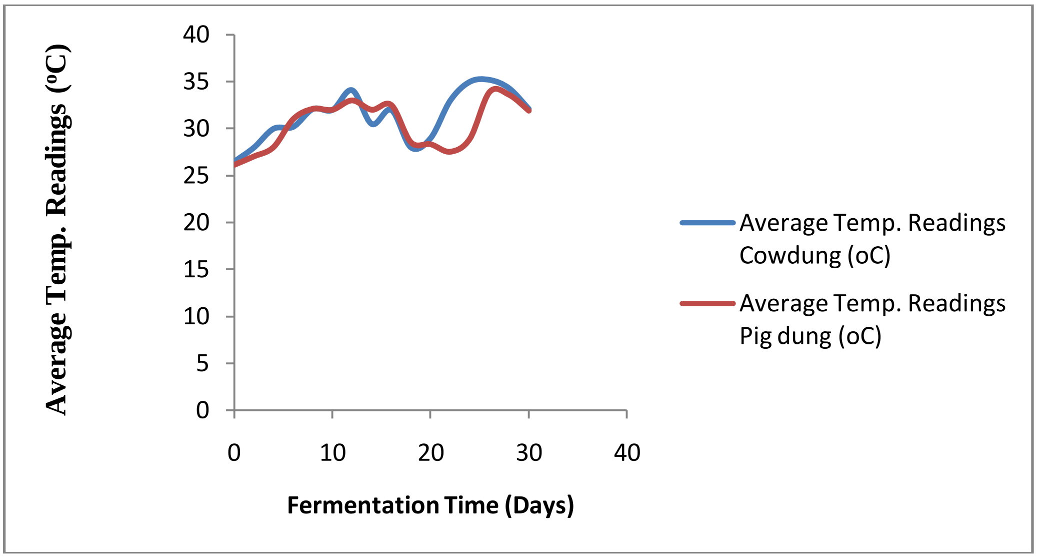

Fig.3: Variation of Temperature with Fermentation Time

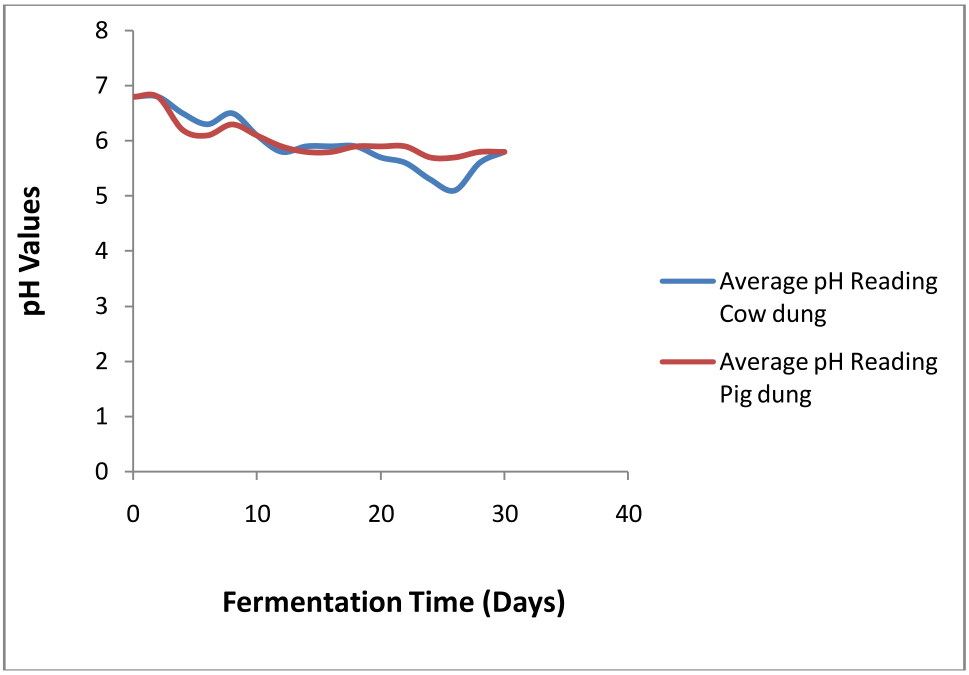

Fig.4: Variation of pH with fermentation Time

Flame Test

To show that biogas was produced, flame test was carried out using the gas produced from the bio-digester A, B, C and D respectively. The pipe connecting the bio- digester and the mayonnaise bottle was cut off and connected to a Bunsen burner and lighted. The test was carried out in a dark room and the gas was found to be flammable but with little flame. This may be due to the presence of impurities such as sand and moisture in the gas.

Fig.5: Flame test for the Biogas produced

IV CONCLUSION

The results of this study clearly showed that biogas can be produced from cow dung and pig dung through fermentation using fresh cow rumen as source of methanogens. The result also reveals the applicability of the locally made bio-digesters as a biogas production model. The remaining slurry in the bio-digester after biogas production was also found to be enriched compost which can be used to improve agricultural soil nutrient and productivity. Animal and plant wastes are abundant especially in rural areas. Studies have shown that biogas can also be produced from plant wastes as a substitute for fossil fuels. The biogas generated from animal wastes (cow dung and pig dung) produces an energy resource that can be purified and stored in gas cylinders and used efficiently for direct heat conversion. The process also creates an excellent residue that retains the fertilizer value of the original waste products. The increasing cost of conventional fuel in urban areas necessitates the exploration of other energy sources. Moreover, the search for alternative energy sources such as biogas should be intensified so that ecological disasters like deforestation, desertification, and erosion can be arrested in our rural areas. The performance of the plastic synthetic bio-digester employed in this study was found to be very satisfactory in the provision of clean fuel and good quality fertilizer.

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