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PRODUCTION OF BIOGAS FROM CO-DIGESTION OF COW DUNG, CHICKEN DROPPING AND COW RUMEN WASTES

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ABSTRACT

The increased use of fossil fuels for energy consumption has caused environmental problems both locally and globally. This study investigates the anaerobic digestion in the production of biogas, a renewable energy from the digestion and co-digestion of three different types of biodegradable wastes available in Katsina (cow dung, chicken droppings and cow rumen waste) as an alternative for fossil fuels for energy consumption. This was carried out using a 25 Litres capacity plastic keg, constructed to investigate the anaerobic digestion in generating biogas. The experiment was batch operated and the digester was charged with 10 kg of each waste was mixed with 10 kg (10L) of water and loaded into six different batch type biogas plants. Biogas production was measured for a period of 15 days and at an average temperature of 37^0C. The average biogas production from poultry droppings, cow dung, cow rumen wastes, mixture of cow dung/cow rumen wastes, cow dung/chicken droppings and cow rumen wastes/chicken droppings was found to be 210 cm^3/kg, 160 cm^3/kg, and 520 cm^3/kg, 375cm^3/kg, 470 cm^3/kg, 390cm^3/kg, respectively. During the digestion period, the volume of biogas production and the changes in pH indicate that the pH decreases as the retention period increases. The study recommends that biogas is not just a renewable energy source but also an appropriate way of managing waste, having potential to replace fossil fuel.

Keywords: biodegradable wastes, cow dung, cow rumen wastes, retention period

INTRODUCTION

In our today's world where the demand for energy is growing by the day, the need for exploring and exploiting new sources of energy which are renewable as well as environmental friendly cannot be overemphasized (Ezekoye *et al*. 2006). Biogas technology offers an attractive platform to utilize certain categories of biomass for meeting rural energy needs if it is properly harnessed. In our rural areas, various cellulosic biomass material such as cattle dung, poultry droppings, rumen wastes and agricultural waste are available which can be utilized in the production of biogas.

The rate at which our environment is being exposed to global warming, ozone layer depletion and desert encroachment as a result of human interference, cutting down trees for energy needs and cooking in developing world is alarming. Over 80% of energy consumption for cooking in developing world rely on fuel wood and charcoal on a daily basis (Garba, 2009). Apart from CO_2 released to the environment, the use of fuel wood is causing desertification and other ecological degradation (Karekezi, 2002).

Inadequate supply of energy also restricts socio-economic activities, hence limits economic growth and adversely affect the quality of life. In Nigeria fuels like coal, oil, gas, and electricity are not sufficiently available and therefore people mostly depend on fuel wood for cooking purposes. This has brought the depletion of our forest and therefore increased fuel wood price which imposes economic and social hardship on the people (Ezekoye *et al.* 2006).

Deforestation and waste management are problem that increasingly threatening a lot of masses in Nigeria, most of the part depends on fuel wood and charcoal for fuel supply which requires cutting of forest deforestation leads to decrease the fertility of land. Use of wastes dung, firewood as energy is harmful for health of the masses due to the smoke arising from them causing air pollution. The need for ecofriendly substitute for energy is necessary. The aim of this research was to investigate the possibility of biogas production from a mixture of raw material (cow dung, chicken waste and cow rumen waste) using a laboratory scale digester.

Biogas is made from anaerobic digestion of agricultural and animal wastes. The gas is about 20% lighter than air and has an ignition temperature in the range of $650^o c$ to $750^o c$. It is odorless, colorless and burns with a brilliant blue flame similar to that of liquefied natural gas. Its caloric value is about $20MJ / m^3$ and burns with about 55% efficiency in a conventional biogas stove (Ziana Ziauddin and Rajesh, 2015). The gas is a mixture of methane, carbon dioxide, hydrogen, nitrogen, hydrogen sulphide and water vapor. Biogas is a useful substitute for firewood, petrol, diesel and electricity depending on the nature of the task and its availability. Biogas can be used to power vehicles. Biogas has no particulate emissions and generates one-fifth as much nitrous oxide as diesel (Amigun *et al*. 2007).

Katsina State is greatly blessed with cow dung, poultry droppings and rumen wastes from abattoirs. These coupled with tremendous agricultural wastes provide higher prospects for biogas generation and utilization but has not yet been exploited.

MATERIALS AND METHOD

Materials

Materials consist in this study are digester (25-liter capacity gallon), Bucket (30L), Bucket (13L), 1 inch pipe, angle elbows, ¾ PVC pipe, wielding rod, Thermometer (-10 to 110^oC), Digital pH meter, toilet papers, gum, tape meter, hand gloves. The major raw materials used for the production of the biogas in the bio-digester are cow dung, food waste, chicken droppings, cow rumen wastes and distilled water**.**

Methods

The solid wastes used in this study were collected from various parts of Katsina state of Nigeria. Cow dung was collected freshly from a cattle farm at Yan-turaku market, Poultry droppings were collected from a Poultry farm (Darma house) and Cow rumen wastes were collected freshly from central Abattoir of Katsina Metropolis.

A total of six batch experiments were performed and monitored twice a day for optimum biogas production as shown in Plate 1. The bio-digesters containing substrates of cow dung, poultry droppings and cow rumen wastes and co-digestion of the wastes were labeled as:

1. Digester 1 (D_1) had 10kg of cow-dung mixed with 10liters of water.
2. Digester 2 (D_2) had 10kg of cow rumen wastes mixed with 10liters of water.
3. Digester 3 (D_3) had 10kg of poultry droppings mixed with 8liters of water.
4. Digester 4 (D_4) had (5kg each) mixture of cow-dung and cow rumen wastes mixed with 10liters of water.
5. Digester 5 (D_5) had (5kg each) mixture of poultry droppings and cow-dung mixed with 10liters of water.
6. Digester 6 (D_6) had (5kg each) mixture of chicken droppings and cow rumens wastes 10liters of water.
7.

Plate 1: Experimental Setup

This was then loaded to about 3/4 of the bio-digester volume to provide enough room for expansion. The bio-digesters were each subjected to periodic shaking to ensure thorough mixing of the digester content while maintaining intimate contact between the microorganisms and substrate and to enhance complete digestion of substrate. The volume of biogas yield was measured and recorded on a daily basis at 12:00noon and 3.00pm and the average biogas was obtained. The experiment was monitored for 15 days.

RESULTS AND DISCUSSIONS

Six batch digesters were initially setup with a retention time of 15 days and observed concurrently. These were to investigate optimum gas yield from different composition of the locally available as well as easily obtainable animal wastes consisting of cow dung, chicken droppings and slaughtered cow rumen wastes. Results obtained are shown below.

Effect of pH from Batch Digesters

The result from figure 1 shows the pH values of the slurry observed during the period of the experiments from different compositions of the wastes fed in to six different batch type digesters. The initial pH at the start of the experiment, it's variation with time up to the experimental retention period of 15days which was the final pH was observed for each feedstock. Each showed a significant difference, with the pH values of the slurry before the experiment having higher values than that of the slurry after the experiment. It could be observed that generally the pH value ranged between 6.8 – 7.5 at the start of the experiment it then decreased to a range of 6.6 to 7.2 which was at the middle or on the 8^{th} day of the experimental retention time. Finally, on the last day it dropped to a range of 6.1 – 5.4. This is in consonance with the work of Oladeji *et al.* (2016). For optimal performance of the microbes, the pH with in the digester should be kept in the range of 6.8 - 8.0. The pH value below or above this interval may restrain the process in the reactor since micro-organisms and their enzymes are sensitive to pH deviation (Yadvika *et al*. 2004) and the pH of the microbes with in the Digester fall between the range. It was reported that at an appropriate pH of 7, there is balance in the population of the acidogens and methanogens, such that an equal amount of the acid intermediates produced during the digestion process is converted to biogas (Ukpai *et al*. 2012). If the methanogens are not present in suitable number or are inhibited by unfavorable conditions such as low pH, they will not use the acids as rapidly as they are produced. However, it could be observed that digester D_5 (pH 7.5-6.1) and digester D_3 (pH7-6) possessed more favorable pH condition as is more clearly shown in Figure 4.1b. Any of these substrates could therefore be used as input to the constructed fixed dome digester.

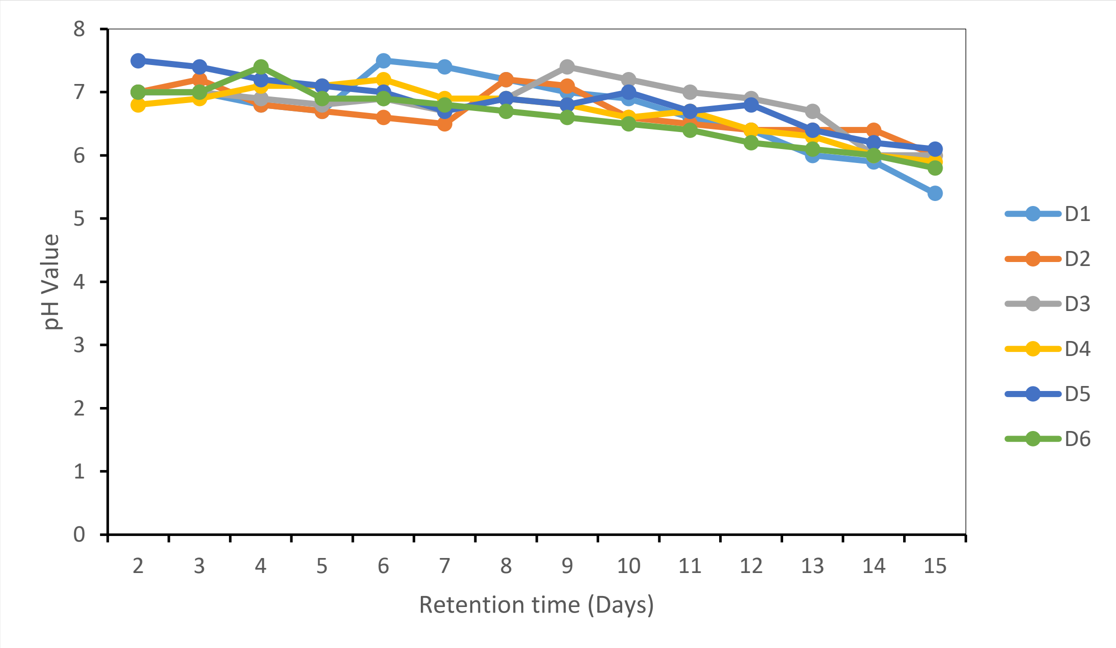

Figure 1 Variation of pH with Time from all the Six Batch Digesters

Effect of Temperature

Temperature has been observed by most biogas researchers to be quite critical for anaerobic digestion, since methane – producing bacteria operate most efficiently at temperatures 30ºC - 40ºC or 50ºC - 60ºC, (Ilori *et al*. 2007). For this study, the digesters were operated under a mesophilic (34ºC – 39ºC) temperature condition as shown in figure 2. It is similar to the temperature reported by Ukpai, (2012). The ambient temperature was above 30ºC in which this experiment was carried out, it could have contributed to the development of methanogens and consequently high methane production.

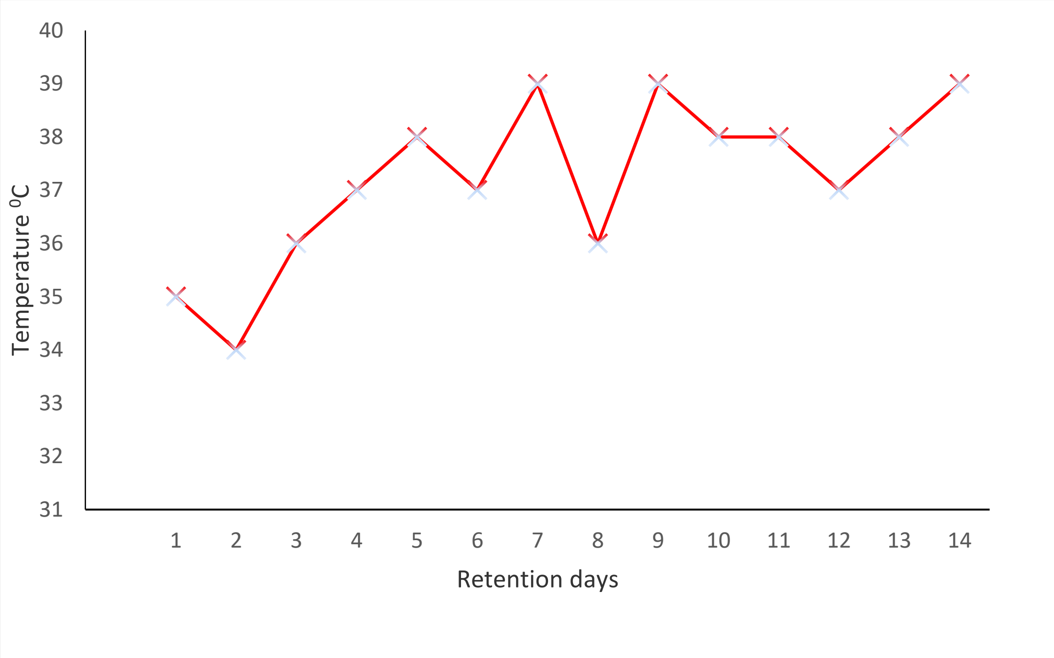

Figure 2 Variation of Temperature with 15 days Retention Time

Effect of Substrates Comparison on Biogas Yield

Figure 3 shows the cumulative Biogas production from different fermentable materials, the total Biogas production from 10 kg of cow dung is 210 cm^3. This means that 210 cm^3/kg of biogas is produced from cow dung. The total Biogas production from poultry waste was almost thrice (520 cm^3) to that of cow dung. This gives 520 cm^3/kg of biogas production from chicken waste. And total biogas production from cow rumen wastes is 160 cm^3 which is equivalent to 160 cm^3/kg. This means that less amount of chicken waste is needed for the same amount of biogas production in comparison to cow dung and cow rumen wastes. The biogas production was different for different substrates because the bacteria responsible for the breakdown of substrate were different. Cow dung can have a continuous supply of substrate from animals on a daily basis. This is one reason that the use of mixture of cow dung and chicken droppings can be recommended for the long term use. For large farms where there is continuous process of rearing poultry, biogas production by this method would be the best as continuous organic loading of reactors would make available adequate biogas for lighting, cooking and other uses.

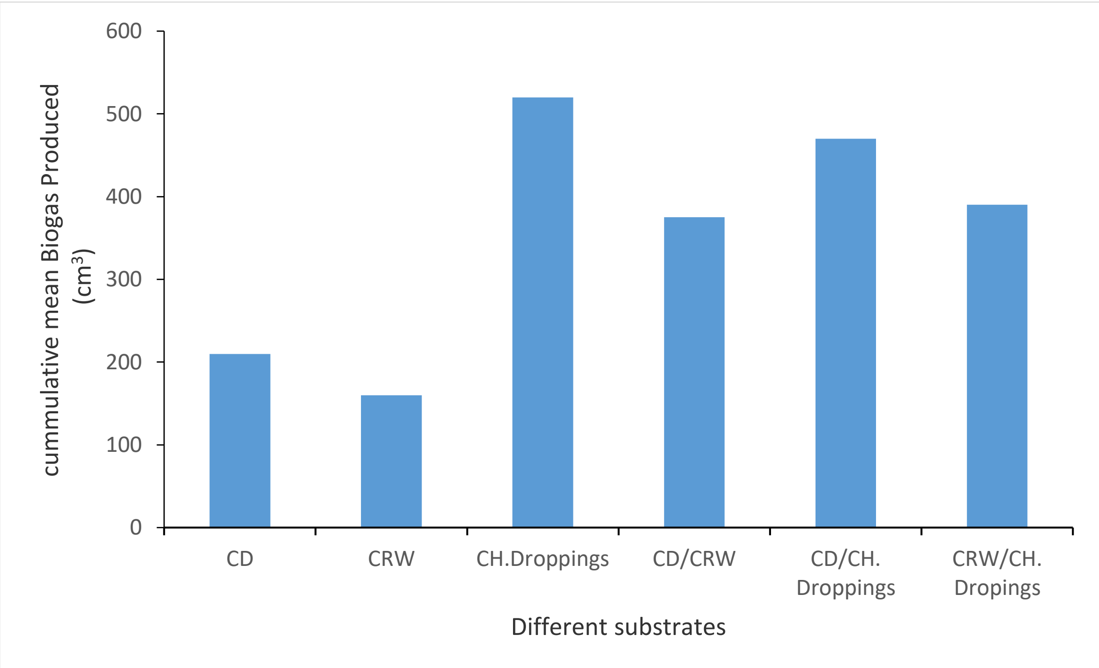

Figure 3 Cumulative mean Biogas Production (cm^3) from Different Waste products.
Key CD = Cow-Dung, CRW = Cow Rumen Wastes, CH. Droppings = Chicken Droppings.

CONCLUSION

The study on the production of biogas from the digestion of cow dung, chicken droppings, cow rumen waste, and from the co-digestion of cow dung, chicken dropping, and cow rumen waste has shown that biogas can be produced from these wastes through anaerobic digestion for biogas generation. These wastes are always available in our environment and can be used as a source of fuel if managed properly. The study revealed further that chicken droppings as animal waste has great potentials for generation of biogas if only one type of waste is to be used and co-digestion of cow dung with chicken dropping if co- digestion is to be used. The utilization should be encouraged due to high volume of biogas yields.

Moreover, it has been found that temperature variation and pH are some of the factors that affected the volume yield of biogas production and the temperature ranges also signifies a mesophilic thermal stage of biogas production (34^oC – 39^oC). Finally, it was observed that the pH decreases as the retention period increases hence the decrease in the pH explains the gradually change of stage of the production of biogas, from hydrolysis to acidogenesis in which the slurry become acidic and form substrate after which it produces biogas.

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