American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-10, Issue-10, pp: 114-118
www.ajer.org
Research Paper Open Access

Biogas Production From Digestion and Co-Digestion of Pig Dung and Poultry Manure

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ABSTRACT
This study is aimed at using a batch-fed anaerobic digester to assess the production of production of biogas from single-substate digestion and co-digestion of Pig Dung (PD) and Poultry Manure (PM) while taking into consideration the pH of the substrates and digestion temperature. Three 50 litres capacity batch fed digesters were utilized in this study. The digesters were loaded using a waste : water mix ratio of 1: 1. The gas was collected and measured using the water displacement method. The daily production of biogas from each waste combinations varied greatly and peaked at different days during the digestion process, with biogas production from single-substrate digestion of PD reaching its peak at the 14th day, single - substrate digestion of PM reaching its peak at the 4th day and co-digestion of PD and PM reaching its peak at the 7th day. The study revealed that single-substrate digestion of PD and PM have great potentials for biogas generation and a co-digestion of these substrates will lead to significant increase in the volume of biogas produced.

KEY WORDS: *batch-fed, single-substrate, co-digestion,mesophilic, biogas*

Date of Submission: 18-10-2021 Date of acceptance: 02-11-2021

I. INTRODUCTION

Increasing energy prices and pressing need to reduce the consumption of fossil fuels has shifted attention to the development of alternative technologies to produce renewable energy (Lungkhimba*et al.*, 2010). According to Azlina and Idris (2009), anaerobic digestion is a decomposition of organic matter in the absence of oxygen to produce biogas and generates odour-free residues rich in nutrients and suitable for agricultural purpose. It produces a large scale of methane and small scales of other by products. Biogas consist mainly of methane, carbon dioxide, nitrogen, oxygen, hydrogen sulphide and traces of other gases such as water vapour (Ward *et al.,* 2008).Commonly used wastes for biogas production include industrial waste and agricultural waste such as animal dungs and energy crops (Thomas *et al.,* 2007).

PD consists of a mixture of excreta, urineand water, and is made up of the liquid fractions which majorly consists of nitrogen compounds, and the solid fraction which is made up ofinorganic phosphorus and organic compounds(Kowalski *et al.*, 2013). PM is a mixture of faeces, wasted feeds and bedding materials (Wilkinson *et al*., 2011; Kim *et al*., 2012). It is characterized by the presence of high levels of protein and amino acids because it contains substantial quantities of nitrogen. Owing to its high nutrient content, PM has been considered to be one of the most valuable animal wastes as organic fertilizer (Ojo, 2017).

Hydraulic retention time in anaerobic digesters varies from 10 to 30 days depending on the temperature (Jenargi, 2002).This study is aimed at using a batch type anaerobic digesterto assess the production of production of biogas from single-substate and co-digestion of pig dung and poultry manure while evaluating some operational parameters (pH and Temperature) that affect the yield of biogas.

II. METHODOLOGY

Digester Capacity

Three 50 litres capacity batch fed digesters were utilized in this study. The digestion chamber was four - fifth of the total volume of the digester while one - fifth of the digester was utilized as the gas chamber. The digesters were equipped with slurry inlet, slurry outlet, gas outlet and pH and temperature check-points. The digestion process was carried out for a retention period of 20 days.

Digestion Feedstocks

The two feedstocks digested and co-digested in this study are PD and PM. Both feedstocks were collected from the animal production and health farm in the Federal University of Technology, Akure (FUTA).

Loading of digesters

The digesters were loaded using a waste : water mix ratio of 1: 1. The digesters were loaded as follows:

- **Digester 1**

100% PD, where 20 kg of PD was mixed with 20 L of water to form slurry.

- **Digester 2**

100% PM, where 20litres of PM was mixed with 20 L of water to form a slurry

- **Digester 3**

50% PD and 50% PM, where 10 kg of PD was mixed with 10 kg of PM and in turn with 20 L water to form slurry.

Experimental set-up

The experimental set-up is shown in Figure 1. The gas was collected and measured using the water displacement method. In this method, water was filled into a measuring cylinder and immersed upside down in a bowl of water, so that no air could escape. Then the gas was channeled into the measuring cylinder using a rubber hose. According to Archimedes' principle, the volume of gas produced is equivalent to the volume of water displaced from the measuring cylinder. The displaced water was collected in the bowl. The volume of water displaced in the water collector was measured daily

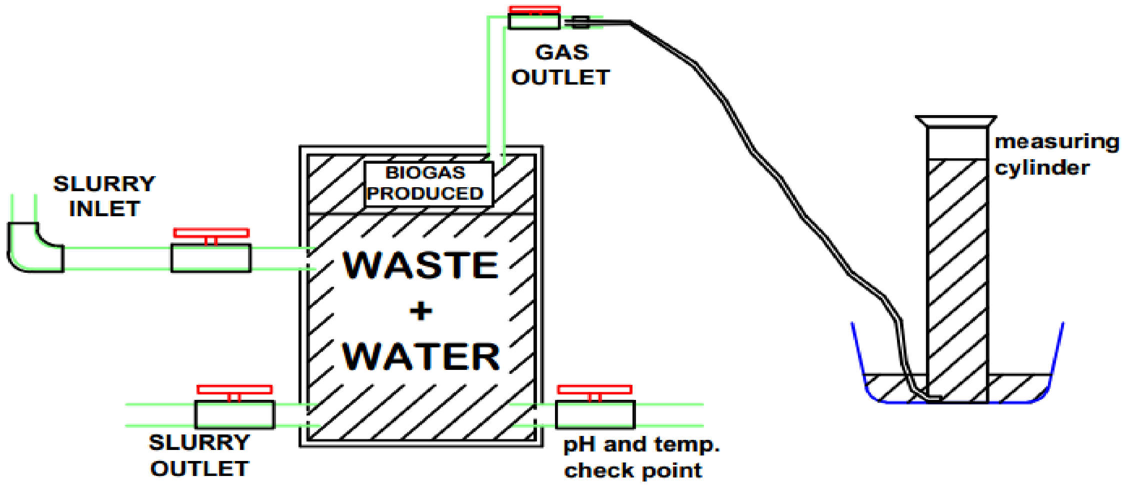

Figure 1:Experimental Set-up

Temperature and pH Detector Outlet

The Temperature and pH outlets provided in the digesters were used for daily temperature and pH measurements.

III. RESULTS AND DISCUSSION

2.1 Biogas Production

Daily production and cumulative production were measured for each digestion process. The results of daily production of biogas for all waste combinations used are presented in Figure 2. Average daily gas produced for the single substrate digestion of PD ranged from 80 ml to 323 ml with the highest volume of gas produced on Day 14. For single substrate digestion of PM, average daily volume of gas produced ranged from 65 ml on Day 7 to 115 ml on day 16. For the co-digestion of PD and PM, average daily gas produced ranged from 83 ml on Day 2 to 528 ml on Day 7.

Biogas production rate and total production are a function of the substrates' organic matter content and biodegradability (Macias-Corral *et al.*, 2008). The daily production of each waste combinations fluctuated repeatedly and peaked at different days during digestion, with the pig dung reaching its peak at the 14th day, poultry waste reaching its peak at the 4th day, pig and poultry waste co-digestion reaching its peak at the 7th day.

The differences in peak periods could be attributed to the differences in organic matter content and the degree of bio-digestibility of the manure mixtures (Ojo, 2017). A comparative analysis of the results revealed that poultry waste produced the highest biogas at the 4th day of the retention period.

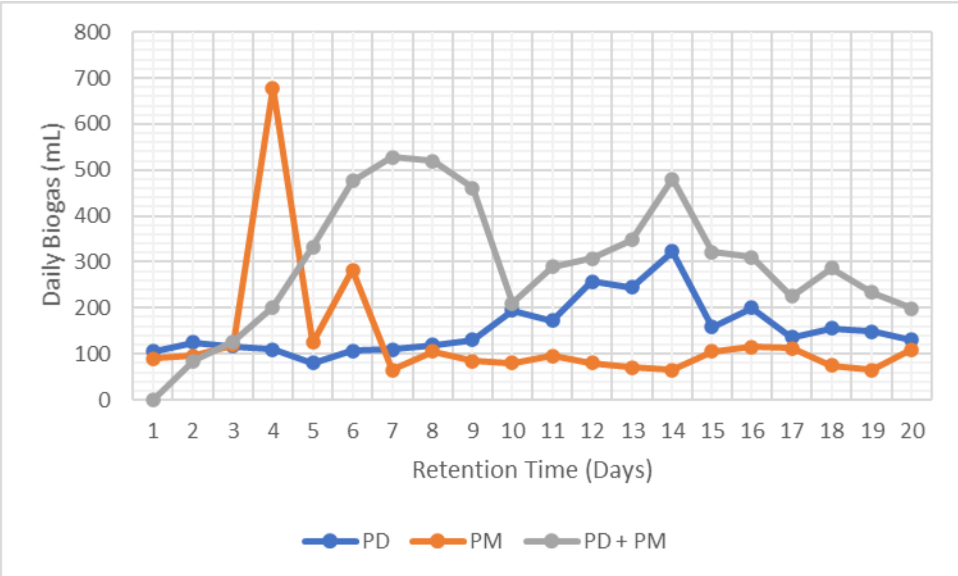

Figure 2: Variation of Daily Biogas Production During Digestion.

2.2 Cumulative Biogas Production

Figure 3 shows the cumulative biogas production with respect to retention time while figure 4 shows the total volume of biogas produced from each digestion process. It could be seen that the co-digestion of PD and PM produced the highest quantity of biogas, while single substrate digestion of PM produced the least quantity of biogas during the experiment.

The single-substate digestion of PD and PM had cumulative biogas yield of 3124 ml and 2616 ml respectively. The peak daily biogas production from PM was higher than that from PD and this could be attributed to high bio-digestibility of PM (Ojo, 2017). On the whole, co-digestion of PD and PM produced the highest cumulative biogas yield of 5940 ml.

Disparities in gas productions from animal manures have been attributed to various factors such as C:N ratio , chemical and physical composition digestibility of lingo cellulosic materials and presence of inhibitors and nutrient composition.

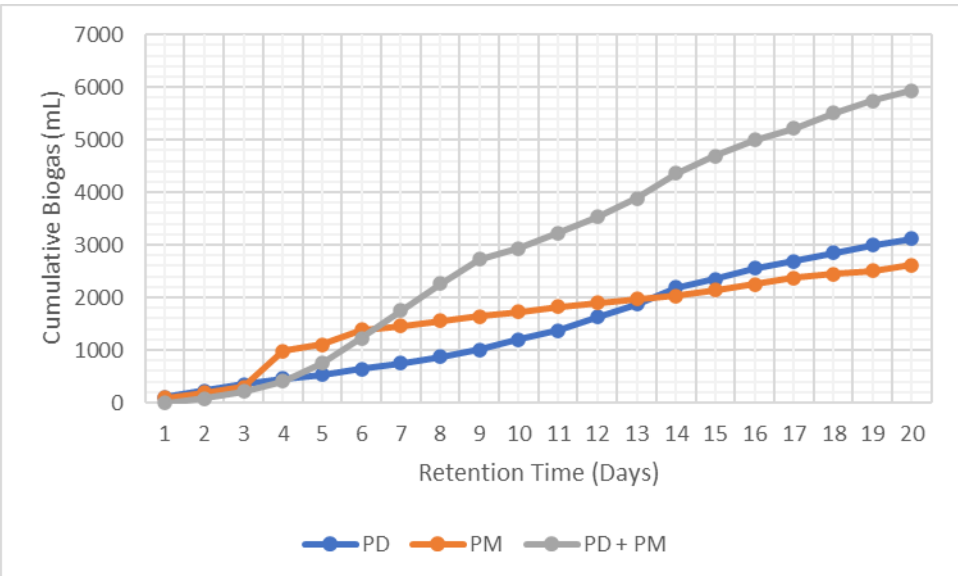

Figure 4: Cumulative Biogas Production with retention time.

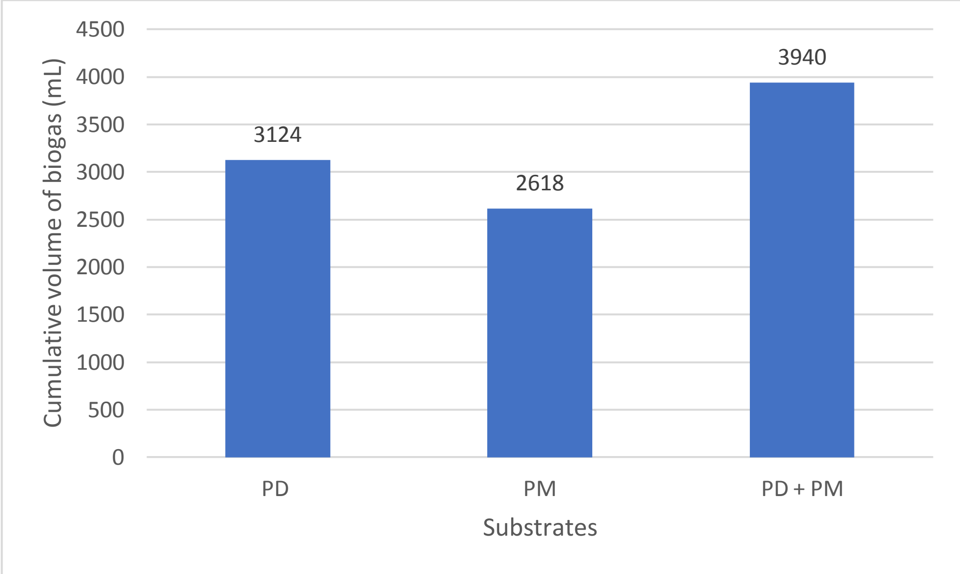

Figure 4: Total volume of biogas produced

2.3 pH Variation

Figure 5 shows the pH variation of the substrates during the course of the experiment. The pH of the substrates during digestion ranged from 4.2 to 7. According to Macias-Corral *et al.* (2008), decrease in pH could be attributed to hydrolysis of the easily degradable fraction of the manures and conversion to volatile fatty acids (VFA), while the increase could be attributed to subsequent transfer and consumption of VFA by methanogenesis. The pH fluctuations were highest in PD and PM single substrate digestion waste and least in the co-digestion process.

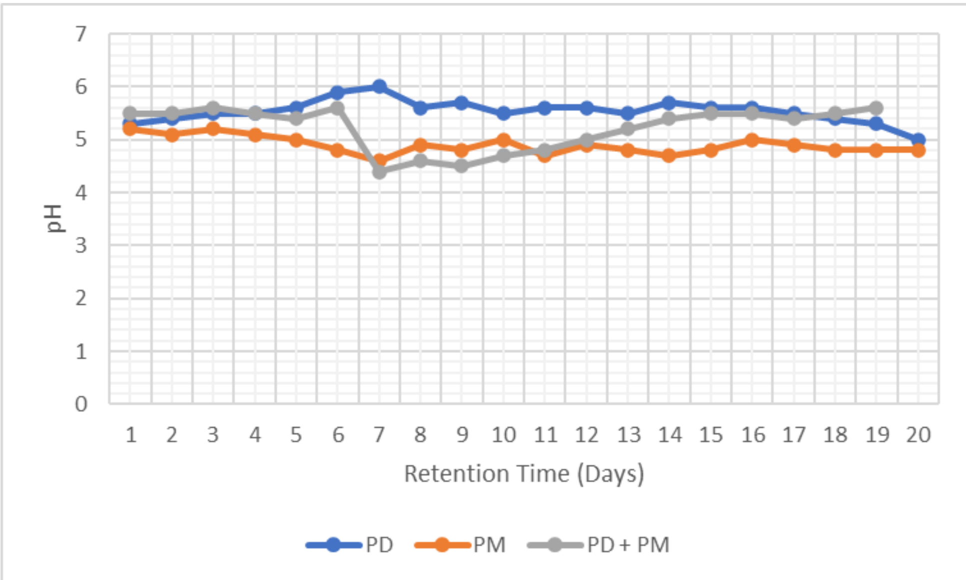

Figure 5: Variation in pH of Slurry During Digestion

2.4 Temperature Variation

The variation of substrate temperature with time, is shown in Figure 6. For single substrate digestion of PD, temperature ranged from 24°C to 28°C while the temperature ranged from 26°C to 29°C for the PM single substrate digestion. The temperature ranged from 25°C to 28°C for the co-digestion of PD and PM. The temperature of the substrates was within the mesophilic range considered optimal for the support of biological-reaction rates. It was observed that single-substrate digestion of PD as well as the co-digestion of PD and PM had lower bio-digester temperatures especially at the beginning of the digestion process and in the long run produced higher volumes of biogas

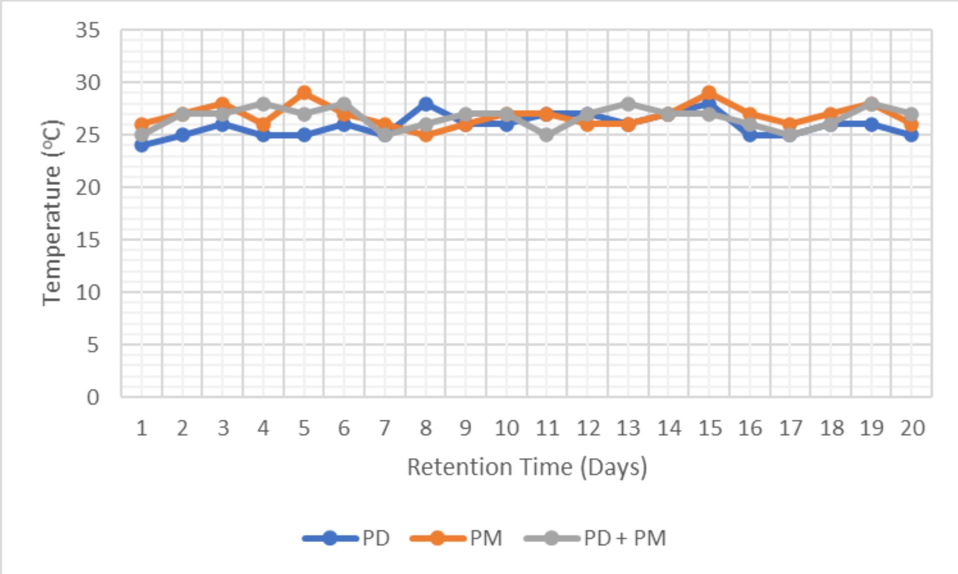

Figure 6: Variation of Substrate Temperature During Digestion.

IV. CONCLUSION

The production of biogas produced from PD and PM was assessed, while evaluating the operational parameters that affect the yield of biogas through single substrate digestion and co-digestion. pH and temperature are two factors that can influence the production of biogas from anaerobic digesters.The study revealed that PD and PM have great potentials for generation. The co-digestion of these waste would further increase the volume of biogas produced. The digestion process took place in the mesophilic temperature range and could be for all the digestion mixes, this temperature range proved to be ideal for biogas anaerobic digestion and co-digestion of both PD and PM. Low pH variation in the co-digested mix could be linked to the increase in cumulative volume of biogas produced. The daily production of biogas from each waste combinations varied greatly and reached its maximum at different days of the digestion process, with biogas production from single-substrate digestion of PD reaching its peak at the 14th day, single -substrate digestion of PM reaching its peak at the 4th day and co-digestion of PD and PM reaching its peak at the 7th day. The co-digestion of PD and PM should be encouraged for improved biogas production.

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Ojo, O. M. "Biogas Production From Digestion and Co-Digestion of Pig Dung and Poultry Manure."*American Journal of Engineering Research (AJER)*, vol. 10(10), 2021, pp. 114-118.