IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 3, December 2024

Construction of Biogas Digester and Produce Biogas from Cow Dung and Chicken Droppings as an Alternative Source of Heat to the Existing LPG Gas

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Abstract*: The study analyzed the compositions of cow dung and chicken droppings, revealing that cow dung has a higher proximate composition, containing more organic waste, leading to increased biogas output. Anaerobes break down raw materials through hydrolysis, acidification, and methanization processes. The densities of both materials were found to be different, with cow dung having a larger density than chicken droppings. This results in varying chances of becoming soluble in the digester's contents during fermentation periods. The calorific values of the two raw materials were 7.8 mj/kg for cow dung and 7.9 mj/kg for goat dung. Both materials have a high rate of biogas production and a decent calorific value. The pH values of the slurry for cow dung and chicken droppings were 7.8 and 7.9, respectively. For fermentation and regular gas generation, a pH of 7 to 8.5 is ideal. The modest pH variations between the two substrates might be explained by the type of organic feeds given to animals as ruminants. Gas production was usually started from the 5th day. The pH of the slurry was adjusted to the required value (5-8) by adding 1 N sodium bicarbonate solution. The daily production over 30 days' retention period for the slurry with different pH levels showed that biogas gas production was higher during initial days and decreasing gradually as the day passed. The maximum gas yield was obtained for pH 7 on the 16th day and 8th and 19th in 10 and 20% of cow dung and chicken droppings, followed by 33, 22, and 33, 38 ml for pH 5 on the 25th, 23rd, and 16th, 13th days in 10 and 20% of cow dung and chicken droppings, and 14, 22, and 15, 26.1 cm3 for pH 8 on the 20th, 23rd, and 11th, 18th days in 10 and 20% of cow dung and chicken droppings, respectively*

Keywords: Biogas, Cow dung, Chicken Droppings, Anaerobes Digester, Retention Time and Proximate composition

I. INTRODUCTION

Since the beginning of theindustrial revolution, humanity has relied heavily on fossil fuels as a primary source of energy. Due to finite nature of fossil fuels, prices have steadily risen with the demand as the global population has increased (Singh, 2021).

As we all know, energy plays a significant role in our lives. We use energy for cooking, lightning, drying, and warming (Blengini and Carlo, 2010). For a long time, wood fuel has been the main source of energy, especially in rural African homesteads. However, over reliance on wood fuel has depleted forests and endangered the environment. In addition, smoke inhalation, soot and ash have been found to cause ill health among users of wood fuel (Macharia, 2015). The other alternate source of fuel has been fossil sources such as crude oil,lignite, hard coal, natural gas. These are fossilized remains of dead plant and animals which have been exposed to heat and pressure in the earth crust over hundreds of millions of years. For this reason, fossil fuels are non-renewable resources whose reserves are depleted much faster than new ones are being formed (Olah *et al.,* 2018).

As a result of the increasing costs and the added pressure of climate change, the International Partnership for Energy Efficiency Cooperation (IPEC) is encouraging all nations to consider alternate more cost-effective and ultimately sustainable forms of energy production (IPEC, 2018). This has led to a search for other sources of energy such as wind, solar and biogas. Of all the sources, biogas has been found to be the most suitable for domestic use. This is because it is renewable, simple and cheap to generate (Van Der Wal, 2008).

Biomass resources such as cattle dung, kitchen waste, agriculture wastes and other organic wastes have been one of the main energy sources for the mankind since the dawn of civilization. There is a vast scope to convert these energy sources into biogas. Biogas production is a clean low carbon technology for efficient management and conversion of fermentable organic wastes into clean cheap & versatile fuel and bio/organic manure (Sahu *et al.,* 2020). It has the potential for leveraging sustainable livelihood development as well as tackling local and global land, air and water pollution. Biogas obtained by anaerobic digestion of cattle dung and other loose & leafy organic matters/ biomass wastes can be used as an energy source for various applications namely, cooking, heating, space cooling/ refrigeration, electricity generation and gaseous fuel for vehicular application.

Biogas plants provide three-in-one solution of gaseous fuel generation, organic manure production and wet biomass waste disposal/management (Patel, 2016).

1.1 Problem Statement/Justification:

In Nigerian abattoirs, the disposal of waste (cow dung) is a great problem for community as the waste raises a lot of problems for public health and ecology system. These wastes after some time emit bad odour, create uncongenial and attract hordes of flies which are hazardous to health. The only known use of the waste is as organic manure which only comes during plantationseason.

Beside using the waste as manure, utilizing it through anaerobic digestion is an appropriate technology as it serves two purposes, first it solves disposal problem and second it produces biogas and enrich manure is gotten as a byproduct. Biogas as a fuel can replace the conventional use of kerosene (as it is expensive and have a better use as jet fuel), and firewood (as it has adverse effects on health and the environment) for various purposes, generally cooking or lighting. There is worldwide awakening for protection of environment and safe disposal of wastes that have the potential of causing harm to the environment.

1.2 Justification

The production of biogas as a fuel will help reducing and solving environmental problems such as environmental pollution, greenhouse gases emission, global warming, deforestation etc. The provision of a means to an alternative source of energy to the abattoir community.

1.3 Aim:

The aim of this research is to construct a Biogas Digester and Produce Biogas from Cow dung and Chicken Droppings as an alternative source of heat to the existing LPG gas

1.4 Objectives:

The objective of this work are:

- To source for raw materials (cow dung and chicken droppings)
- To construct a biogas Digester for the production of biogas.
- To develop pilot scale biogas plant (capacity 1 m^3/d biogas) based on lab study.
- To evaluate the performance of developed biogas plant.

II. MATERIALS AND METHOD

2.1 Materials

The materials and equipment are of analytical grade. This includes:Tap water, Sample (Cow dung and Chicken droppings), Hand glove, weighing balance, 500ml measuring cylinder, 1000ml Beaker, 1000 ml Conical Flask, Connecting tube, Retort stand, Rubber tube, Vaseline/grease, Cork, Stirring rod, Iron Metal sheet, Welding electrodes and Pressure Gauge

2.2 Construction of Biogas Digester for the production of biogas.

The design of a digester was based on the amount of organic waste available and the desired biogas production. A suitable metal was chosen for the drum, considering corrosion resistance, strength, and cost. A floating drum was designed for efficient biogas collection according to the measurement in the figures 3.3. A stable support structure was constructed using steel beams, columns, and a concrete foundation. Insulation was applied to the drum for optimal temperature. A biogas collection system was installed, including piping, a gas holder, and a gas outlet. Sensors were installed to monitor temperature and biogas production. The digester was charged, and the process involved maintaining optimal temperature and pH conditions for microorganisms to break down the organic waste. Biogas was collected and sludge was removed regularly. Regular checks and adjustments were made to optimize biogas production. Regular cleaning and inspections were conducted to ensure the digester was in good working condition. The constructed digester is presented in figure 1.

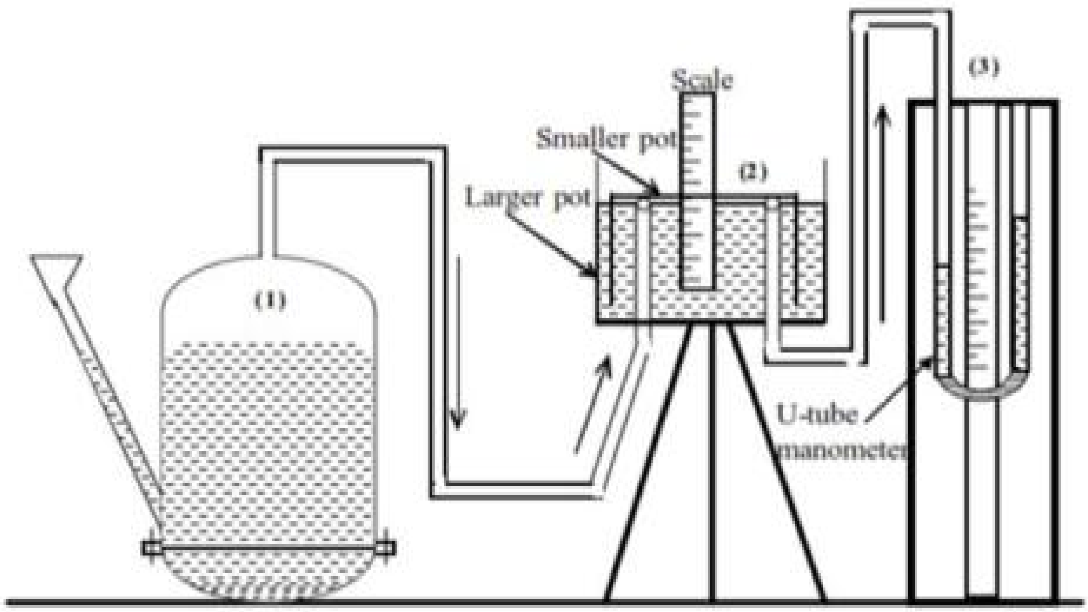

Figure 1: Experimental Set-up

2.3 Feedstock Sample collection

Fresh Cow, Ram & Goat dung and Chicken droppings were collected manually by means of a rubber hand gloves, clean container with cover from the Cattle Ranch of the college of Agricultural Technology, Hussaini Adamu Federal Polytechnic Kazaure. The samples were then brought to the chemistry laboratory. The Cow and Chicken droppings were allowed to get dried under the shade for five days and then grinded by means of mortar and pestle, sieved and re dried for two days.

2.3 Proximate composition of cow dung and chicken droppings used

2.3.1 Moisture content

Ten grams (10g) each of dried cow dung and chicken droppings were separately spread evenly on heating aluminum pan of the mettler LP 16 and LJ 16 moisture analyzer to avoid heat exchange. The LJ 16 moisture analyzer was calibrated from 0-100% according to Pekke et al., (2018) Method.

2.3.2 Total Solids

The percentage (%) total solids were determined using 50grams of cow dung and chicken droppings which were heated in an oven for 12 hrs at 105^oC. After heating, the samples were cooled in a desiccator for 12hrs and weighed to obtain the % TS (Ngulde *et al.,* 2018). **2.3.3 Ash Content**

The samples of total solids obtained above were heated in muffle furnace at 540^oC for 3hrs. The difference in weights obtained after heating to ash and cooling in the desiccators represent the % AC (Ngulde *et al.,* 2018).

2.3.4 Volatile Solids

The percentage (%) volatile solids of cow dung and chicken droppings were obtained from the difference in the weight of ash content and total solids (Ngulde *et al.,* 2018)

2.3.5 Calorific values of Cow and Goat dung

The calorific values of the raw materials were determined using calorimetric method (Zhao et al., 2020).

2.3 Anaerobic Pilot scale biogas plant (capacity 1 m^3/d biogas) based on lab study.

A pilot scale biogas plant was conducted using cow, Ram and goat dung, and chicken droppings

Two sets of slurry, A and B, were made with different pH values (5, 7 and 9) and contained 10 and 20% cow dung and chicken droppings respectively. The slurry made in 100ml of tap water and 1 N sodium bicarbonate solution and hydrochloric acid were used to adjust the pH.

Another set of slurry C was made in 100ml of tap containing cow dung and chicken droppings in 1:1 ratio with pH 7. The mixture were stirred to achieve homogeneity using a glass rod. A rubber delivery tube was connected to a 500ml measuring cylinder filled with the slurry and the gas released was collected using water displacement method. The delivery tube was inserted into the mouth of the conical flask, sealed with adhesive tape to prevent gas leakage. The digesters were kept at ambient temperature for 30 days, and the biogas generated was observed.

2.4 Evaluate the performance of the constructed Biogas plant.

This was accomplished using a 5000 ml biogas machine, which produced biogas using slurry mixes made from 50% cow dung and chicken droppings in a 1:1 ratio. The gas released from the digestion process was collected using the water displacement method. The digester was connected by a rubber delivery tube that transports the gas to a 500ml metal container filled with water. The gas was collected over water and stored in cylinder. Additionally, the burning ability was investigated.

III. RESULT AND DISCUSSION

The result of proximate composition and volume of biogas (cm^3) produced from 10 and 20% cow dung and chicken droppings slurry with pH value of 5, 7 and 9 for 30 days retention time are presented in the figure 2, 3, 4, 5 and 6 respectively.

The study reveals that cow dung and chicken droppings have different proximate compositions, with cow dung having a higher proximate composition containing more organic waste, leading to increased biogas output (figure 2). Anaerobes break down raw materials through hydrolysis, acidification, and methanization, which are similar procedures used in producing biogas. The densities of chicken droppings and cow dung are 515 kg/m3 and 510 kg/m3, respectively, resulting in varying chances of soluble slurry in digesters during fermentation periods. The digestion periods for both raw materials vary due to differences in densities, moisture content, and total solids (figure 2).

The calorific values of cow dung and goat dung are 7.8 mj/kg and 7.9 mj/kg, respectively, indicating high biogas production rates and decent calorific values. The pH values of the slurry for cow dung and chicken droppings are 7.8 and 7.9, respectively (figure 1), which is ideal for fermentation and gas generation. The modest pH variations between the two substrates may be due to the type of organic feeds given to animals as ruminants. Overall, the study provides valuable insights into the potential of cow dung and chicken droppings for biogas production.

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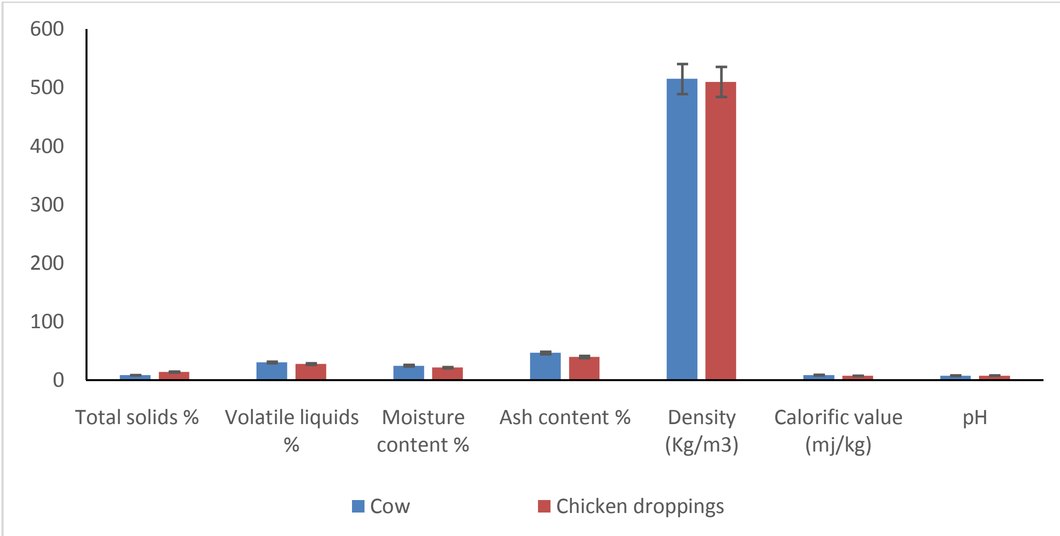

Figure 2: Results of Proximate composition of cow dung and chicken droppings used

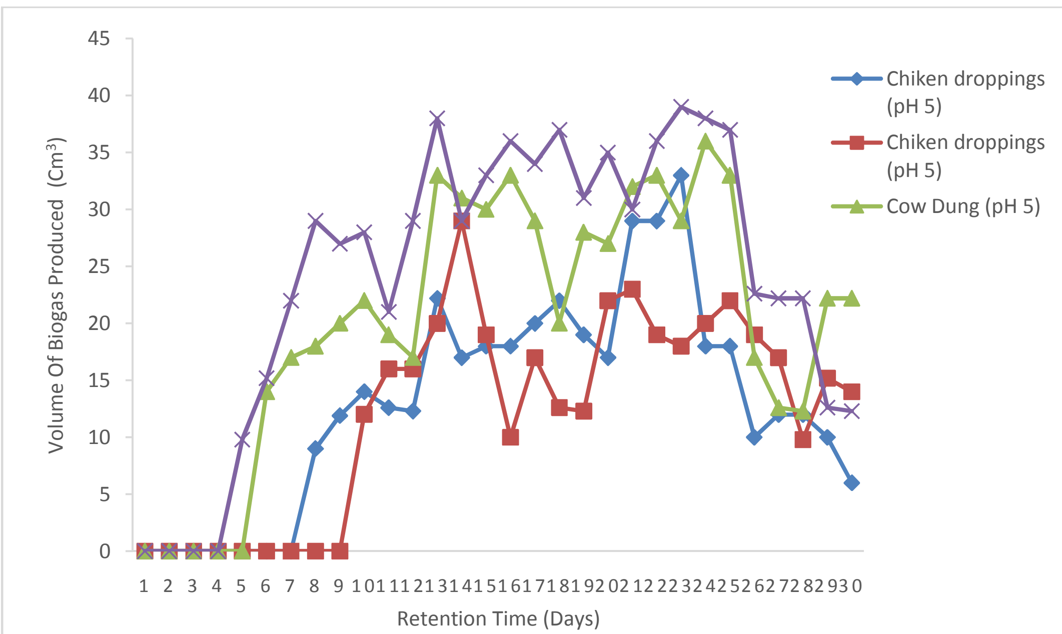

Figure 3 Biogas produce by 10% and 20 % slurry of pH 5 by slurries of cow dung and Chicken Droppings

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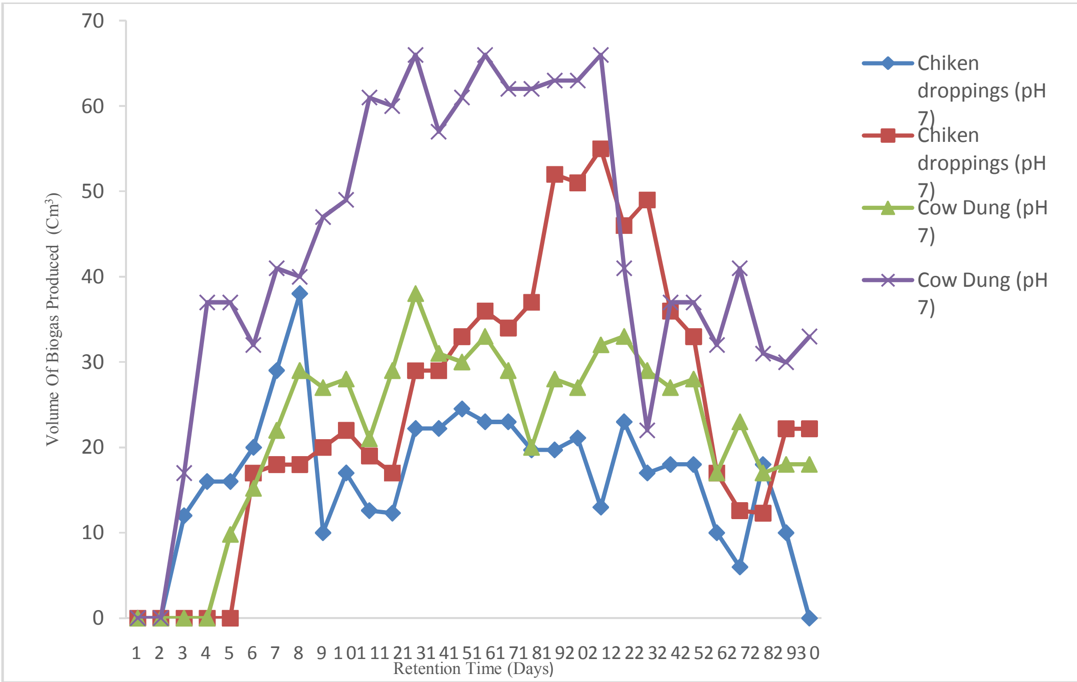

Figure 4 Biogas produce by 10% and 20 % slurry of pH 7 by slurries of cow dung and Chicken Droppings

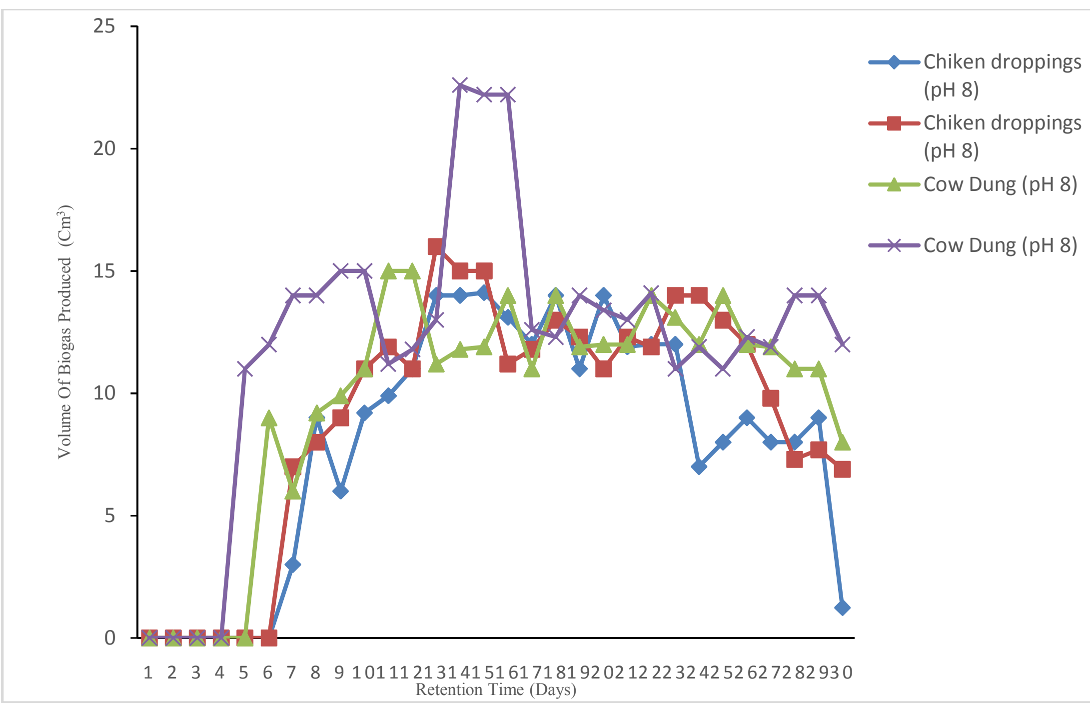

Figure 5 Biogas produce by 10% and 20 % slurry of pH 8 by slurries of cow dung and Chicken Droppings

The characteristics effect of pH of slurry on biogas production are given in figure 3, 4 and 5 The pH was adjusted to 5-8 by adding 1 N sodium bicarbonate solution. The biogas production was higher during the initial days and decreased gradually over the day. The maximum gas yield was obtained for pH 7 on the 16th and 8th days in cow dung and

DOI: 10.48175/IJARSCT-22871

chicken droppings, followed by pH 5 on the 25th, 23rd, and 16th days, and pH 8 on the 20th, 23rd, and 11th, 18th days. Compared to pH 7, pH 7 and pH 8 produced lower biogas production and degradation efficiency. The results indicate that the pH of the slurry significantly affects biogas production, as it affects the activity of bacteria in destroying organic matter into biogas. A low pH in the digester inhibits the activity of microorganisms involved in the digestion process, particularly methanogenic bacteria. The maximum biogas yield was found to be higher for pH 7 biogas production. Similar trend was observed by Budiyono et al. (2013)

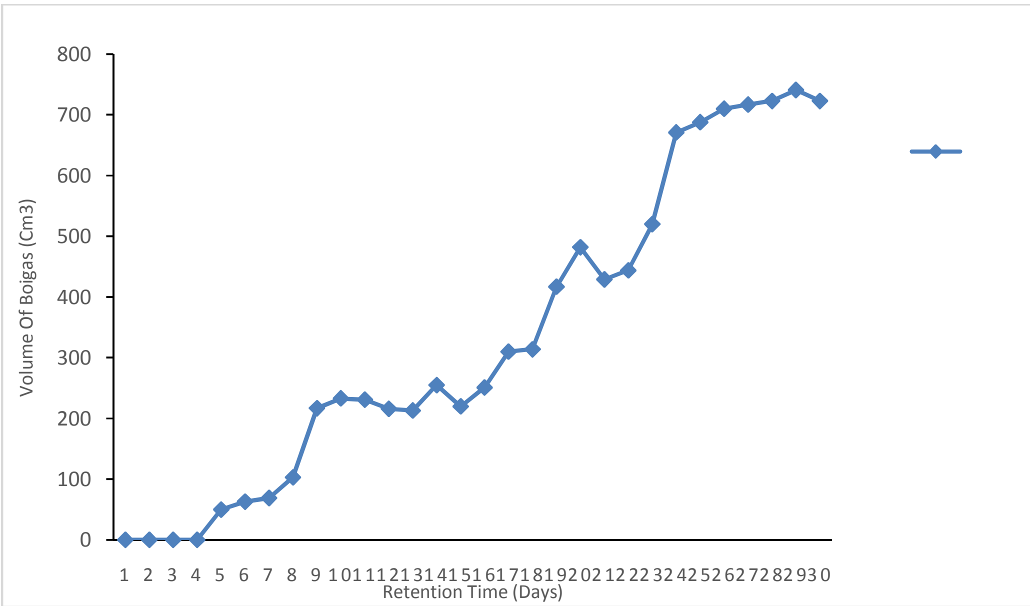

Figure 6: The result of performance of the developed biogas digester

The result of performance of the constructed biogas digester is presented in figure 6.In a formulation of 50% 1:1 cow dung and chicken droppings slurry, biogas production started on the fifth day and reached 50, which is consistent with earlier work that was reported (Fouda, 2021). Therefore, the relatively high biogas production could be attributed to the digester's optimal C/N ratio, which was achieved by a balanced mixture of cow dung and chicken droppings that contains bacteria necessary to start the anaerobic digestion process (Todhanakasem et al., 2020). This follows a general trend of gas production in batch mode due to the microbial activities of met.

This is in line with the overall trend of gas generation in batch mode as a result of met's microbiological activity. Since many peaks were seen throughout digestion, it is not possible to say that the gas output from the three digesters in this investigation followed a linear trajectory. As the temperature fluctuated, so did the daily gas output. Therefore, temperature variations can be blamed for the biogas production's non-linear trajectory.

Low temperatures brought on by the season's weather conditions were the study's main constraint since this suggests that greater temperatures might result in bigger amounts of biogas.

IV. CONCLUSION

In conclusion, the production of biogas from digestion of cow dung and chicken is feasible using fabricated biogas digesters that are affordable, locally available, and require little skill for setup and operation.

The study investigates the potential of cow dung and chicken droppings for biogas production. It reveals that cow dung has a higher proximate composition containing more organic waste, leading to increased biogas output. Anaerobes break down raw materials through hydrolysis, acidification, and methanization, similar procedures used in producing biogas. The densities of chicken droppings and cow dung are 515 kg/m3 and 510 kg/m3, respectively, resulting in varying chances of soluble slurry in digesters during fermentation periods. The calorific values of cow dung and goat dung are 7.8 mj/kg and 7.9 mj/kg, respectively, indicating high biogas production rates and decent calorific values. The pH values of the slurry for cow dung and chicken droppings are 7.8 and 7.9, respectively, which are ideal for fermentation and gas generation.

The study also provides insights into the characteristics effect of the pH of the slurry on biogas production. The biogas production was higher during the initial days and decreased gradually over the day. The maximum gas yield was obtained for pH 7 on the 16th and 8th days in cow dung and chicken droppings, followed by pH 5 on the 25th, 23rd, and 16th days, and pH 8 on the 20th, 23rd, and 11th, 18th days. Compared to pH 7, pH 7 and pH 8 produced lower biogas production and degradation efficiency.

V. RECOMMENDATIONS

It is, however, recommended that further studies should be carried out to determine the feasibility of producing biogas from other waste materials within our means to supplement energy for daily used.

VI. ACKNOWLEDGEMENT

The researcher sincerely thanks Almighty Allah for giving him the capacity and allowing him to conduct this study. The management of Hussaini Adamu Federal Polytechnic, Kazaure is highly appreciated for providing the conducive environment for the study. Special appreciation goes to the Tertiary Education Trust Fund (TETFund for providing the financial support to conduct the research.

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