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Assessment of Biogas Production from mixtures of Poultry Waste and Cow Dung

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Abstract

The increase price of cooking gas and high rate of deforestation (firewood) has led to search for an alternative source for cooking. This study was carried out to produce biogas from cow dung and poultry waste as well as the respective co-digestion of cow dung and poultry dung as alternative fuel for cooking. Four-liters digester and gas collection system were designed and fabricated using locally available materials. The digesters were used to digest cow dung and poultry dung respectively as a single substrate as well as to digest cow dung and poultry dung respectively. The respective materials were collected locally. They were fermented, digested and analyzed in accordance with standard methods for the single substrate. The total volume of gas produced was recorded for different mixtures of cow and poultry waste. The total volume of gas produced ranged from 222 cm^3 (20g cow dung plus 60g poultry waste) to 258cm^3 (80g cow dung plus 0g poultry). *The result shows that cow dung produces more gas than the poultry waste. Therefore, it is recommended that biogas factories or*

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industries should be established that make use of the abundant animal waste. This will reduce the over-dependence on other forms of energy.

Keywords: Biogas Production, Cow dung, Poultry waste, Co-Digestion, Digester.

INTRODUCTION

Biogas produced from anaerobic digestion has received considerable attention in recent years and the worldwide biogas boom will continue in the coming years (Jianbo *et al*., 2010). This is due to the increasing concerns over energy depletion and environmental problems triggered by fossil fuels (Huayong *et al*., 2016). Biogas is an environmentally advantageous energy source which is mostly comprised of methane (60%) and carbon dioxide (35–40%). Moreover, biogas contains a low quantity of other gasses such as ammonia (NH_3), hydrogen sulfide (H_2S), hydrogen (H_2), oxygen (O_2), nitrogen (N_2) and carbon monoxide (CO). (Cu *et al.,* 2012). Biogas is the gas evolved from a process known as anaerobic digestion (AD). Anaerobic Digestion is known as the degradation of organic compounds to simple substances by microorganisms which live as dystrophy under the lack of oxygen with releasing biogas (Colemenar, 2005). Anaerobic Digestion has been found as a biological process for the transformation of waste materials to energy sources through the treatment of various organic waste such as municipal solid waste, food waste, industrial waste, sewage sludge, animal manure and agricultural residue (Nguyen, 2010). AD of organic waste offers some advantages including the reduction of odor release, decrease of pathogens and low requirement for organic sludge (Amon *et al*., 2007). Furthermore, the treated organic waste (digestate) is used as an organic fertilizer for arable land instead of mineral fertilizer as well as an organic substrate for green house cultivation (Chew *et al*., 2016). Anaerobic digestion (AD) with concomitant biogas production is an environmentally attractive technology for the treatment of organic waste. Biogas provides environmental benefits with regard to waste treatment, pollution reduction, the production of CO_2 (neutral renewable energy) and the improvement of agricultural practices through the recycling of plant nutrients (Dimitriades, 2008). Also, biogas can be burnt to produce heat, or combusted in gas engines for electricity generation, and after purification it can be used in any application for which fossil fuel natural gas is utilized today (Etelka *et al*., 2013). The use of agricultural waste as a major component of renewable energy is suitable for improving energy security and decreasing environmental disruption caused by carbon emissions. (Mähnert and Linke 2009). Cow dung and poultry waste are among the top two animal's wastes in northern part of the country and account for 80.5% of the total output and 40.6%, respectively Tong Zhang *et al.,* (2013). Production of waste materials is an undeniable part of human society. The wastes are produced by several sectors including industries, forestry, agriculture and municipalities (Amon, 2007). The accumulation of waste and the "throw-away philosophy" result in several environmental problems, health issues and safety hazards, and prevent sustainable development in terms of resource recovery and recycling of waste materials (Mahnert and linke 2009). A perspective aimed at promoting greater sustainable development and resource recovery has influenced solid waste management practices, and is gradually becoming implemented through policy guidelines at national levels in a number of industrialized and even developing countries. (Mohammad *et al*., 2008).

So many researches have been done to determine biogas production by animal waste. A comparative study of biogas production from cow dung, cow pea and cassava peeling using 45 liters biogas digester was carried out, by Ukpai and Nnabuchi (2012). and the result obtained from the gas production showed that cowpea produced the highest methane content of 76.2%, followed by cow dung 67.9% content and cassava peeling has the least methane content of 51.4%. The cow dung had the highest cumulative biogas yield of 124.3 L/total mass of slurry (TMS) while cow pea had 87.5 L/TMS and cassava peeling with lowest cumulative biogas yield of 87.1 L/TMS within this retention period. Another studies on biogas production from fruits and vegetable waste, was carried out, by Sagagi *et al.*, (2009). The results obtained shows that difference in the production of biogas to a large extent depends on the nature of the substrate. All the substrates used appeared to be good materials for biogas production and their spent slurries can be used as a source of plant nutrients. The aim of this study was to assess biogas production from mixtures of poultry waste and cow dung. The objectives of the study are to design and construct a biogas digester that will operate under existing weather; to utilize biogas digester of cow dung and poultry dung for maximum energy production through digestion of each; to established the technical performance of anaerobic digestion of cow dung and poultry dung as well as the co-digestion respectively as biomass feed materials.

MATERIALS AND METHODS

Sampling Procedure

The basic raw materials used for this work are cow dung and poultry dung. Cow dung was obtained from Muhirab Cow Farm Sararai, Dutse Local Government of Jigawa State. Poultry waste was obtained from M.I.D Poultry Farm Dutse, Jigawa State, Nigeria. The cows are normally fed on green postures, while the poultry are fed with combination of cereals. The cow dung and poultry waste were grounded into powder separately known as substrate, the substrate was weighted on a manual weighing balance (Mettler Toledo). Four litre gallons were added as digester and 500cm^3 measuring cylinder as gas collectors. Rubber hose pipe was used to connect the gallon to the measuring cylinder. Grease was used as sealant against any leakage from both joints.

SAMPLING PREPARATION

Initially eighty grams (80g) of cow dung, zero gram (0g) of poultry were mixed with three hundred centimeters cube 300cm^3 of water i.e. in the ratio of (1:3w/v) in a beaker known as slurry. The prepared slurry was then transferred to gallons and biogas production observed for (70g) of cow dung and (10g) of poultry dung. The other mixtures of substrates are shown in Table 1.

Table: 1. Sampling Technique

Sample Code	Cow Dung (g)	Poultry Dung (g)
A	80	0
B	70	10
C	60	20
D	50	30
E	40	40
F	30	50
G	20	60
H	10	70
I	0	80

The gallons (digester) were shook twice daily in order to aid fermentation before taking the reading at 02:00pm daily. The room temperature and volume of gas produced were recorded on daily basics at 02:00pm each day for the period of ten (10) days. Gas produced was noticed by down word displacement of the water by the biogas in the inverted measuring cylinder as shown in the Figure 1

RESULTS AND DISCUSSION

Table 2. Volume of Gas Produced for First Five Setups

Day	Temp.	A (cm^3)	B (cm^3)	C (cm^3)	D (cm^3)	E (cm^3)
1	30	21	21	20	18	20
2	29	23	24	23	20	22
3	34	26	28	28	22	25
4	34	34	28	27	23	25
5	31	31	26	25	30	29
6	33	28	24	27	28	26
7	29	25	23	24	22	25
8	36	26	20	24	24	24
9	35	23	24	21	23	20
10	34	21	20	19	20	18
Total		258	238	238	230	234

Table 3: Volume of Gas Produced for Second Four Setups

Day	Temp	F (cm^3)	G (cm^3)	H (cm^3)	I (cm^3)
1	36	24	24	25	21
2	33	26	26	28	25
3	32	25	27	26	26
4	36	23	25	24	27
5	34	23	24	23	25
6	32	24	23	22	23

7	35	23	20	24	28
8	30	20	13	20	19
9	33	21	20	19	22
10	34	19	20	18	20
Total		228	222	229	236

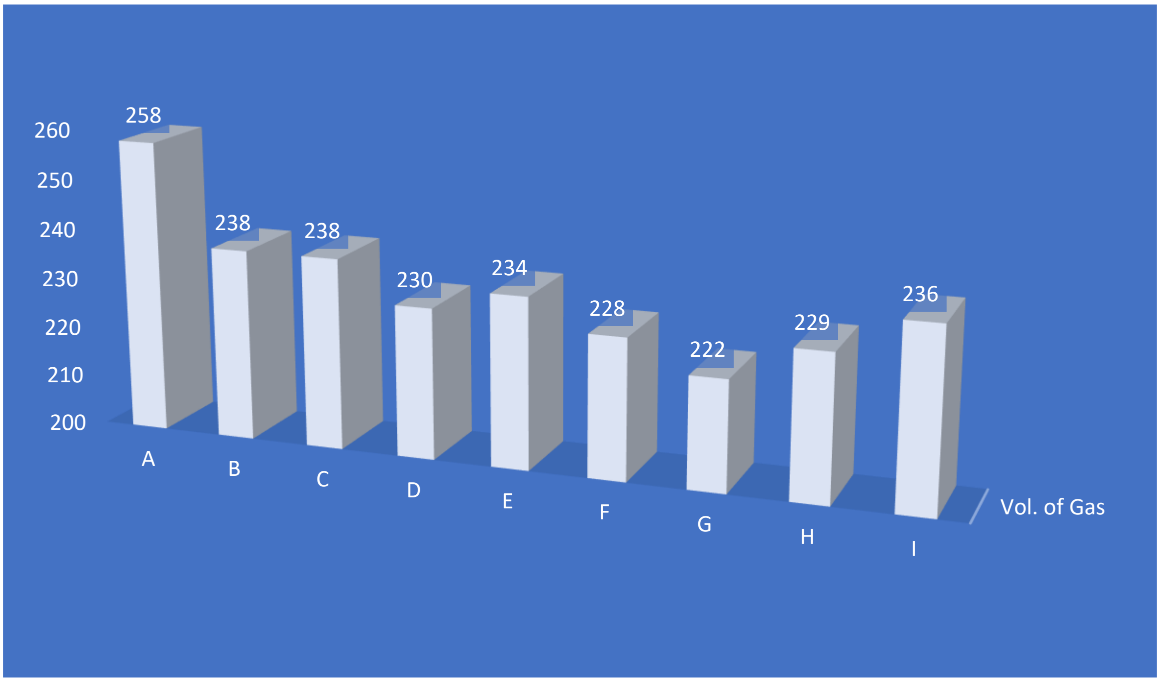

Fig 2. Total Volume of gas produced for all samples for the period of ten days (10)

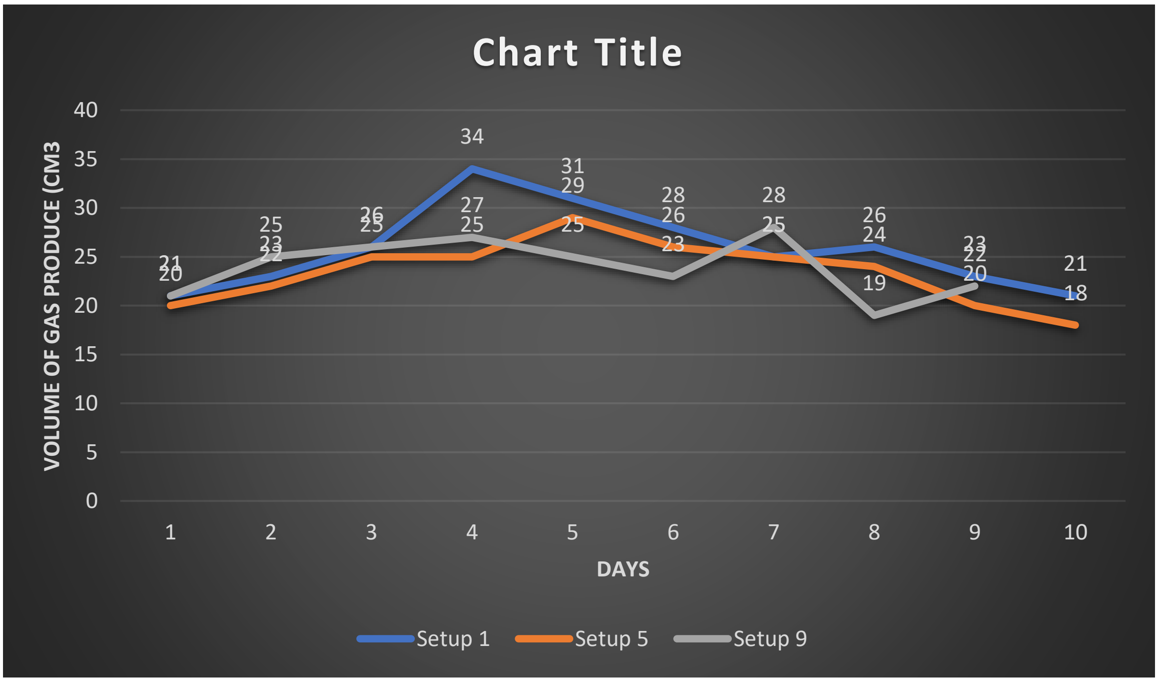

Fig. 3. Comparison of volume of gas produced by A, E and I

Biogas production from mixtures of cow dung and poultry waste was observed and recorded for the period of ten (10) days. Nine (9) different set ups were used with different quantity of cow dung and poultry waste. From Table 1. and Figure 1 the result shows that for sample A, the minimum and maximum value of gas produced ranged from 21 to 34 cm^3 with 258cm^3 as the total volume of gas produced for the period of ten days. The minimum value was obtained from first day and day tenth while the maximum value was obtained at the fourth day. The volume of gas produce from sample E were range from 18 cm^3 as the lowest volume of gas obtained at day tenth to 29 cm^3 as the highest volume of gas obtained at the fifth day, with total volume of gas produce of 234 cm^3. Also, from table:2. and figure 1. At sample I the volume of gas were range from 19 cm^3 as the minimum volume of gas produced at day eight to 28cm^3 as the maximum volume of gas produced at day six with total volume of gas produced of 236 cm^3.

The findings of this study revealed that the 34 is the highest volume of gas produced by sample A. Also, the total volume of gas produce was range from 222 cm^3 to 258 cm^3 as the minimum and maximum volume of gas produce from sample A and sample G. The volume of gas produce in the current study were found to be significantly higher than the previous study in the literature. However, the study was in accordance with research carried out by Ibrahim *et al*., 2021; Ukpai *et al*., 2012. But slightly higher than the study carried out by Alfa *et al*., 2014. Also, the study revealed that cow dung produced more biogas than poultry waste, because the highest total volume of gas produced in this study was obtained from sample A. this may be due to long time it take to dissolve in water unlike poultry waste that quickly dissolve. Also, it may be high because early retention of time and heat Ukpai and Nnabuchi 2012. It was also observed that as the amount of cow dung decrease or as the amount of poultry increase the total volume of gas produce also is slightly decreased. Thus, cow dung played a vital role in improving the good quality production of biogas. This significant improvement may be attributed to the addition of the cow dung.

Another important factor which determine the performance of the anerobic digestion is operating temperature. Because it is the necessary condition for the optimum flourishing and survival of the microbial associates. Bacteria have two optimum range of temperature namely: thermophic and mesophilic temperature optimum. The temperature of this study was range from 29 ^0C to 36 ^0C with average value of 33.5 ^0C. This temperature was slightly in agreement with research carried out by Ibrahim s. et al., 2021 who's the temperature range between 26 ^0C to 30 ^0C. From table 3 it was observed that, the temperature at the first day is high but the volume of gas produced was very low, that is to say that the temperature at the first day has a negligible impact in the production of biogas because the fermentation was at early stage. The result of this study shows that flammable 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 cow dung and poultry waste as animal waste has great potentials for generating of biogas and its use should be encouraged due to its early retention time and high volume of biogas yields.

CONCLUSION

Assessment of biogas production from mixtures of poultry waste and cow dung was carried out using affordable, applicable, local and simple method for generating biogas. Biogas produced from nine (9) different set-ups with different mass of poultry waste and cow dung was observed and recorded for the period of ten days. The results show that set -up A has the highest total volume of gas produced (258 cm^3) and set – up G has the lowest total volume of gas produced (222 cm^3). From table 1, table 2 and figure 1 the study revealed that the total volume of gas decreased with decreasing of the quantity of cow dung or with increasing the quantity of poultry waste. This is to say that based on the result obtained from this study cow dung produced more gas than the poultry waste which may be result as the early retention time and heat. Hence biogas production from cow dung will play a vital role in resolving the increasing price of cooking gas more especially in the urban areas. Also, this study will serve as a prime way of reducing the high rate of flood due to deforestation (firewood) in the rural areas. Therefore, establishing factories or industries that make use of the available animal waste in abundance to be producing biogas are recommended so that the over-dependence on other forms of energy should be minimized.

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