©IDOSR PUBLICATIONS
International Digital Organization for Scientific Research ISSN:2550-7931
IDOSR JOURNAL OF APPLIED SCIENCES 1(1) 24-35, 2016.

Optimization of Biogas Production from Cow and Goat Manure

*[1]Wante H.P, [2]Ngaram S.M, [3]Bala G. A and [4]Buba M

[1, 4]Department of Science Laboratory Technology, Federal Polytechnic Mubi, Adamawa State, Nigeria.

[2, 3]Department of Physics, Federal University Gashua, Yobe State, Nigeria.

Corresponding author:wante2h@gmail.com; Phone number: +2348064555780

ABSTRACT

This study was carried out to optimize and determine the biogas yield from cow and goat dung. Biogas yield assessment was carried out at room temperatures (26.0– 30.0 ˚C) for a period of 20 days from a solid dung mixture of 1000 g in each sample (fermentation slurry) left to ferment over 35 days. The objectives were to determine cow and goat dung ratio that give optimal output and to model the relationship between cows: goat dung ratio and the output which can be used to predict gas yield at various ratios. Three samples composed of a ratio of cow to goat dung were prepared to make sample D1 (0:100), D2 (75:25) and D3 (25:75). Fermentation occurred in a water dispenser container of 20 litre capacity used as the improvised digester and the temperature of the digesting chamber noted over the fermentation period of 20 days. A constructed metallic prototype digester was used for the collection of biogas produced. Preliminary studies showed that biogas release started to decline at the tenth day of the fermentation period for almost all samples. Sample D2 (75 % by weight cow dung and 25 % by weight goat dung) showed the highest biogas production (361.00 ml) at the end of fermentation. A portion of sample D2 was transferred into the constructed prototype digester and the gas produced was collected into the gas cylinder for determination of volume collected. A mathematical model derived using regression analysis on MATLAB software indicates that biogas production can be predicted based on a dung concentrate.

Keywords: Biogas, Dung, Anaerobic, Cow, Goat and Methanogens.

INTRODUCTION

Biogas is a term used to represent a mixture of different gases produced as a result of the action of anaerobic microorganisms on domestic and agricultural waste. It usually contains 50% and above methane (CH_4) and other gases in relatively low proportions namely, CO_2, H_2, N_2 and O_2. The mixture of the gases is combustible if the methane content is more than 50 %. Anaerobic digestion (AD) is a technology widely used for treatment of organic waste for biogas production. Anaerobic digestion that applies manure for biogas production is one of the highest degrees of the uses of biomass wastes because it provides a source of energy while simultaneously resolving ecological and agrochemical issues [1].

The anaerobic fermentation of manure for biogas production does not reduce its value as a fertilizer supplement, as available nitrogen and other substances remain in the treated sludge [2]. Numerous studies had been conducted by several researchers in order to optimize biogas yield in anaerobic digestion. For example, the anaerobic digestion of solid refuses like municipal solid wastes. Anaerobic treatment comprises of decomposition of organic material in the absence of free oxygen and production of methane, carbon dioxide, ammonia and traces of other gases and organic acids of low molecular weight [3].

Biogas is a sustainable energy source currently used in many countries as car fuel and for generation of heat and electricity. Sugars, starches, lipids and proteins present in municipal solid wastes (MSW) are among the materials easily digested by microorganisms [4].

The aim of this research work is to employ anaerobic digestion process as a sustainable technology for digesting the animal wastes (cow droppings and goat dung), produced in large amounts from farm and Abattoirs respectively, and to provide the renewable source of energy (biogas) that can reduce the potential greenhouse gas emission. The specific objectives are (i) To optimize the biogas evolution from the animal waste. (ii) To model the relationship between cow-goat dung ratio and the output which can be used to predict gas yield at various ratios.

(iii) To get an understanding of the anaerobic digestion of the animal wastes under ambient temperature conditions by conducting a large scale study and hence to investigate the biogas yield.

MATERIALS AND METHODS

Materials/Instruments

The following materials/instruments were used for the purpose of this research:

- Cow and goat dung
- Weighing balance
- Thermometer
- Gas Cylinder
- Compressor (1hp)
- Three metallic prototype digester (20 liters capacity)
- Hose pipes

Design Method

The study was carried out by varying the proportion of biomass, while the amount of total solid and detention time were constant. Also, the ratio of amount of total solid to water in each of the fermentation digester was the same.

Sample Collection

Cow and goat dung were obtained from the farm of the Department of Agricultural Technology, Federal Polytechnic Mubi, Adamawa State, Nigeria. 10kg of cow dung was collected for the purpose of this research. The cow and goat dung collected was sun dried and then crushed manually to ensure homogeneity before mixing with water to produce biogas by anaerobic decomposition.

The most prominent breeds of cows and goats in the livestock farm of Federal Polytechnic Mubi are:

- Cow: 90% white Fulani and 10% sokoto gudali
- Goats: 94% west African dwarf and 6% red sokoto

Experimental Procedures

1000g of goat dung was charged into the digester (D1) without cow dung in the ratio of 1:2 of waste to water and the slurry was properly stirred. Also 750g of cow dung waste and 250g of goat dung was mixed into the digester (D2) in the ratio of 1:2 of waste to water. For (D3) a 250g of cow dung and 750g of goat dung waste was charged into the digester with the ratio of 1:2, of waste to water respectively. The mixing ratio was determined by the moisture content of the different wastes. The daily ambient and slurry temperatures were measured using thermometer (0 to 100^{0}C), The pH Values were monitored on 3 days interval to determine the action of methanogens, which utilize the acids, carbon dioxide and hydrogen produced by non-methane producing bacterial using a digital pH meter (PHS-3c pH meter). The volume of biogas produced was measured by a downward displacement method using a transparent measuring cylinder.

Data collection

Data were collected on daily basis using a downward displacement method that is after absorption of H_2S and CO_2 the remaining gas is methane which was recorded by downward displacement of water in the measuring cylinder.

Data Analysis

This was carried out using a special computer program (MATLAB and EXCEL). Regression analysis was used to determine the fitting coefficient and also to determine the yield versus dung ratio based on the following regression equation, $G_y = k_1 t^{a1} + k_2 t^{a2} + k_3 t^{a3} + k_4 t^{a4} + \ldots$ (1)

Where:

G_y = Gas yield (ml)

t = Time (days)

k_1, k_2, k_3, a1,a2,a3,a4 = Constant

The regression constants were determined leading to an empirical equation relating the yield and the dung ratio.

Total Solid Content

For the purpose of this research, there were three x: y proportions aimed at investigating the efficiency of mixing cow and goat dung in biogas production. The amount of dung combined for the volume of slurry in each digester is as follows.

D1 – 1000g goat dung

D2 – 750g of cow dung and 250g of goat dung

D3 – 250g of cow dung and 750g of goat dung

Experimental Setup for the collection of biogas

The setup was maintained at a retention time of 20days for the assessment and 35days for the collection. The biogas generated was measured and recorded on daily basis. And also the ambient temperature was also observed.

RESULTS AND DISCUSSION

The results of this study are discussed using the variation of ratio of cow and goat dung.

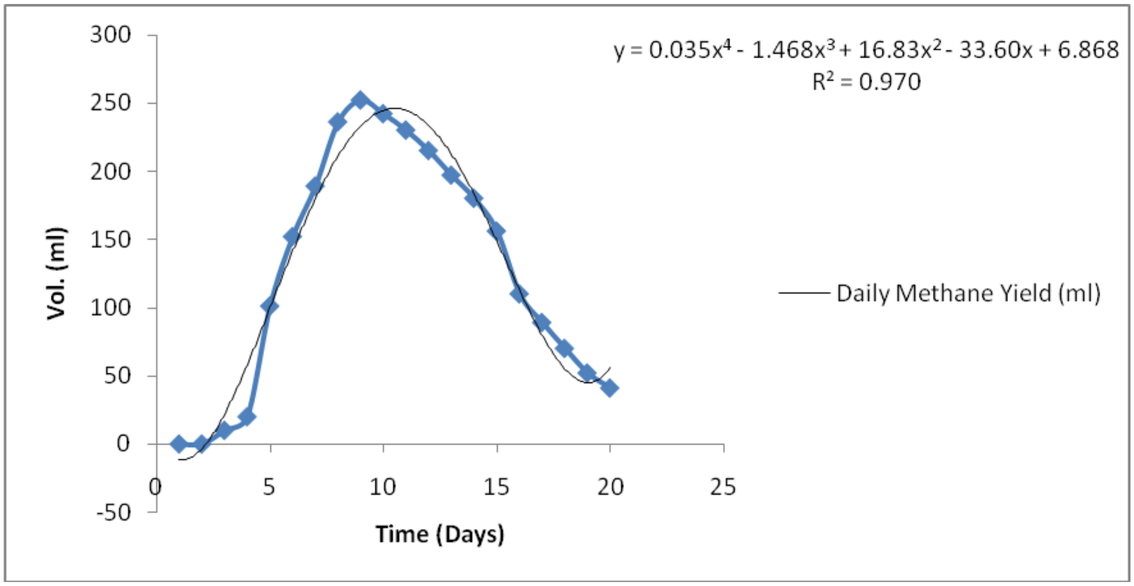

Fig. 2: Graph of Daily Methane Yield for the Variation of the Ratio 0:100 Cow to Goat dung.

According to the graph, there was no production within the first two days of the experiment, because the methanogenic bacteria which act upon the organic material were inactive within this period due to the formation of organic acid which decreases the pH value to below 5.

Linear model polynomial 4:

$G_y = k_1t^4+k_2t^3+k_3t^2+k_4t+k_5$

Coefficient (with 95% confidence bounds)

k_1=0.03584 (0.02478, 0.04691)

k_2=-1.469 (-1.937, -1.001)

k_3= -16.84 (10.22, 23.45)

k_4= -33.61 (-68.95, 1.734)

k_5= 6.869 (-49.68, 63.41)

Goodness of fit:

SSE=4350

R^2 = 0.9706

Adjusted R^2 = 0.9628

RMSE=17.03ml

The equation $G_y = 0.03584t^4 - 1.469t^3 - 16.84t^2 - 33.61t + 6.869$, can be used for the prediction of gas yield for the ratio 0:100 at various digestion time with 97.1%
accuracy.

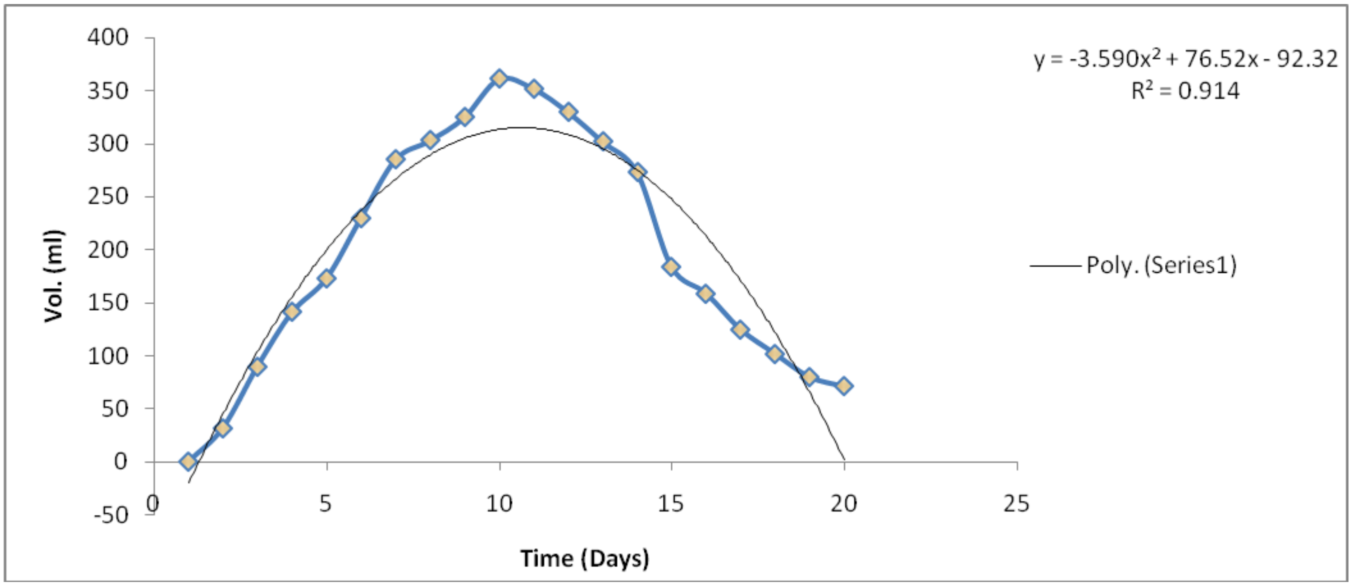

Fig. 3: Graph of Daily Methane Yield of the Variation Ratio of 75:25 Cow to Goat Dung.

According to the graph, there was no production within the first day of the experiment, because the methanogenic bacteria which act upon the organic material were inactive within this period due to the formation of organic acid which decreases the pH value to below 5.

Linear model polynomial 2:

$G_y = k_1t^2 + k_2t + k_3$

Coefficients (with 95% confidence bounds)

k_1=-3.592 (-4.155, -3.029)

k_2 = 76.56 (64.39, 88.73)

k_3 =-92.43 (-147.9, -36.95)

Goodness of fit:

SSE=2.124×10^{004}

R^2 = 0.9146

The R^2 assumes that every independent variables in the model help to explain the variation in the deviation. So, it tells the percentage of explained variation as if all independent variables in the model affect the deviation (as if each independent variable passes the t-test).

Adjusted R^2 = 0.9045

While, the adj. R^2 tells the percentage of variation explained by only those independent variables that truly affect the deviation (only those independent variables that passes the t-test).

The value of the adj. R^2 will be ≤ value of R^2.

RMSE=35.35ml

G_y= -3.892t^2+76.56t-92.43

This equation can be used for the prediction of gas yield at various digestion time with 91% accuracy.

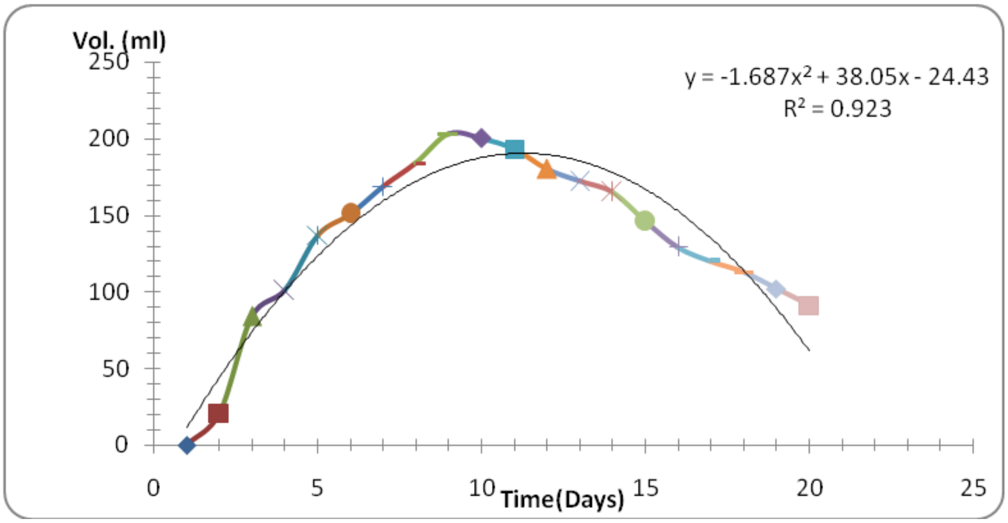

Fig. 4: Graph of Daily Methane Yield for the Variation Ratio of 25:75 Cow to Goat Dung.

According to the graph, there was no production within the first day of the experiment, because the methanogenic bacteria which act upon the organic material were inactive within this period due to the formation of organic acid which decreases the pH value to below 5.

Linear model polynomial 2:

$G_y = k_1t^2+k_2t+k_3$

Coefficients (with 95% confidence bounds)

k_1=-1.687 (-1.948, -1.427)

k_2= 38.06 (32.43, 43.69)

k_3= -24.44 (-50.12, 1.247)

Goodness of fit:

SSE= 4551

$R^2 = 0.923$

Adjusted $R^2 = 0.914$

RSME= 16.36ml

The equation $G_y = -1.687t^2 + 38.06t - 24.44$, can be used for the prediction of gas yield at various digestion time with 92.3% accuracy for the ratio of 25:75.

Collection of biogas

Since the ratio of 75:25 (D2) produces the highest yield compared with the other ratios in the assessment of the gas, then the same ratio was transferred into the constructed metal prototype digester of 35 litres capacity and the gas was compressed into the gas cylinder by the use of a compressor in order to achieve the maximum yield.

Flammability Test

After the gas has been collected into the gas cylinder, it was tested by using a gas burner to check its flammability and it has been confirmed that the gas was flammable.

DISCUSSION

The experiment was conducted within the pH range for optimum methane production and there was little temperature variation throughout the experiment. Accordingly, there was a negligible temperature variation effect on biogas production. The results in (fig. 3 and 4) shows that, there was no methane production in the first day for the D2 and D3 ratios, this may be that the methanogenic bacteria which act upon the organic material within the digester were inactive within this period due to the formation of organic acid which decreases the pH value below 5. On the other hand methane production started beyond second day for D1 ratio, this reaches its optimum at the 9^{th}day, because the carbon nitrogen (C/N) ratio is within the optimum value of 20-30.Methane production drops from the 10th day gradually down to the 20th day for D1 ratio and for the D2 and D3 ratios it started dropping from the 11thday, this is because the C/N ratio being high due to consumption of nitrogen by the methanogenic bacteria.

The experiment was carried out between January to May 2013, where the ambient temperature is between 24-29^{0}C. This temperature range is low compared to the optimum temperature of 35^{0}C at which the methanogenic bacteria are inactive. Hence the low temperatures adversely affect the methane yield. It is well known that the composition of biogas as well as biogas yields depend on the substrates owing to differences in material characterization in each feed material [5, 6, 7, 8 and 9].

CONCLUSION

Anaerobic digestion is the best method for biogas production from cow and goat dung. The generation of biogas from biomass is dependent on the amount of acids formed which depends on the type of biomass used. The biogas production rate was found to be different for different biomasses. The methane yield when the cow and goat is combined in the ratio 75:25 is much higher than the yield obtained from pure cow and goat dung. Thus, this investigation emphasize that the concept of animal waste combination (cow and goat dung) in the ratio 75:25 is a viable alternative source of energy. Hence one can conclude that, pure cow and goat dung is not an ideal concept of animal waste for methane production. It's concluded that the waste can be managed through conversion into biogas, turning waste into wealth which is a source of income generation for the society.

REFERENCES

1. Nnabuchi M. N., Akubuko F. O, Augustine C. and Ugwu, G. Z. (2012) "Assessment of the effect of co-digestion of chicken dropping and cow dung on biogas generation"*International Research Journal of Engineering Science, Technology and Innovation (IRJESTI)* Vol. 1(9) 238-243,

2. Alvarez R, Lide'n G (2008). The effect of temperature variation on biomethanation at high altitude, *Biores. Technol.,* 99: 7278-7284.
3. Lopes W. S., Leite V. D. and Prasad S.(2004). Influence of inoculum on performance of anaerobic reactors for treating municipal solid waste. *Bioresource Technology*. 94: 261-266.
4. Maishanu, S.M, Musa, M and Sambo, A.S. (1990). 1st world renewable Energy congress, Reading, U.K 3rd September.2032-2036.
5. Calzada, J. F, De Porres E, Yurrita A, De Arriola MC, De Micheo F, Rolz C, Menchu J. F .(1984)*Agricultural Wastes* 9, 217-230.
6. Cuzin, N, Farinet, J L, Segretain, C, Labat, M. (1992).*Bioresource Technol*.**,** *41*: 259-264.
7. Kalia, V.C, Sonakya, V. andRaizada, N.(2000).*Bioresource. Technol*,*73*, 191-193.
8. Zhang, R. and Zhang, Z.(1999).*Bioresour. Technol*. 68,235-245.
9. Momoh, Y. (2004). M.Sc, Thesis in Environmental Engineering, University of Port Harcourt.