SOSEH
ISSN 2426-8685
Journal of Occupational Safety and Environmental Health
A Publication of the Society for Occupational Safety and Environmental Health

EFFECTS OF SINGLE SUPER PHOSPHATE AND WOOD ASH ON BIOGAS PRODUCTION USING CHICKEN DROPPINGS WITH *DIGITARIA SMUTS II* (WOOLY FINGER GRASS)

Musa,*[1] R., Igboro[1], S.,B. E. M. Shaibu-Imodagbe[1], M. I. Alfa[2], and A. Ishaq[3]

[1]Department of Water Resources & Environmental Engineering,
Ahmadu Bello University, Zaria, Nigeria
[2]Department of Civil Engineering, University of Jos, Jos, Nigeria
[3]Department of Civil Engineering, NuhuBamalli Polytechnic, Zaria, Nigeria
***Corresponding Author**
E-mail: rabiumusa99@gmail.com, Tel.: 08068085039

Paper Received 15th March, 2016 **Accepted 13th June,2017**

ABSTRACT

This study was carried out to examine the catalytic effects of Single Super Phosphate and Wood ash on biogas production from co digestion of Chicken Droppings with Digitaria Smooth II. Apre designed digester was adopted and fabricated using locally available materials. The study was carried out in four identical reactors to enable variation of the catalyst combination (100gSSP/50gWoodash, 150gSSP/75gWoodash and 200gSSP/100gWoodash). The research showed that SSP and Wood ash could reduce the lag phase in anaerobic digestion.The Modified Gompertz equation was used to adequately describe the cumulative biogas production.The control had the longest lag phase 8.9 days as compared to 7.9 days with catalyst.At the end of 32 days digestion period, there was significant difference in volume of biogas produced across the digesters from $0.0646m^3$ (no catalyst) to $0.1087m^3$ (200gSSP/100gWood ash), indicating 40.6% increment.The Modified Gompertz equation was applied to describe the cumulative biogas generation. The estimated Kinetic Constants using linear regression and other characteristics of the four digesters were obtained. $0.0025m^3$, $0.0028m^3$, $0.0031m^3$, and $0.0046m^3$ for Biogas Production Rate and $0.0647m^3$, $0.0737m^3$, $0.0808m^3$ and $0.1088m^3$ for Biogas Production Potential. The average temperatures of the digesters recorded were 35.25 ^{0}C, 35.28 ^{0}C, 35.30 ^{0}C, and 35.40 ^{0}C respectively while the average ambient temperature observed during the study was 36 ^{0}C which were within the mesophilic range.

Keyword: *Biogas, Chicken Droppings, Single Super Phosphate, Wood ash, Modified Gompertz equation*

INTRODUCTION

Anaerobic digestion has been considered as waste to energy technology, and is widely used in the treatment of different organic wastes like, municipal solid waste, sewage sludge, food waste, animal manure among others. Anaerobic treatment comprises of decomposition of organic material in the absence of free oxygen resulting in the production of methane, carbon dioxide, ammonia and traces of other gases.

Poultry farming has been one of the most lucrative agro business in recent years in Nigeria. It attractiveness and popularity is so high some women take it as hobby, using their backyards for the farming. There is however great deal of environmental pressure to ascertain how waste generated from poultry can best be handled. These wastes in the absence of appropriate disposal methods can cause adverse environmental and health problems such as pathogen contamination, greenhouse gases, air borne ammonia and odour. Biogas as a renewable energy source could be a relative means of solving the problems constituted by these wastes. Which will in turn tackle the challenges of rising energy prices and creating sustainable development in Nigeria. It is one of the cheapest forms of energy and hence will serve as a way of creating wealth.

Igboro (2011) stated that, with the rapidly increasing waste generation threatening to prevent humans from carrying out their activities for lack of space, the society is therefore faced with the choice to either allow this biomass waste to continue polluting the environment, methane and carbon dioxide production to continue to increase global warming or boldly take the initiative of converting the biomass into alternative energy.

It is important to note that in biogas, the substrate basically organic wastes helps in environmental cleanup, it produces lower CO_2 emissions compared to fossil fuels. The sources of Anaerobic Digestion can be classified as either industrial waste and waste water, Sewage sludge, Farm waste, Municipal solid waste, or Green waste. (Alfa, 2013).

Over the years, a lot of research has been made to produce gas from various bio degradable materials. In this study, the effectiveness of SSP (Single Super Phosphate) and Wood ash to accelerate the rate of digestion to produce biogas in batch operation was assessed.The scope of this research was limited to the studying of effects of SSP and Wood ash on biogas production using Chicken Droppings with grass, and also the cumulative biogas production using the modified Gompertz kinetic equation.

MATERIALS AND METHOD

Substrate Collection and Slurry Preparation

Chicken droppings was obtained from Salma Farms Kaduna, dried for a period of 3 weeks and pounded to enhance better mixing, *Digitaria Smuts II* obtained from National Animal Protection and Research Institute (NAPRI), Zaria was dried for forty days. Single Super Phosphate obtained from Kawo Market Kaduna was pounded also using mortar and pestle then sieved and ash collected from burnt wood used for house hold cooking were taken together with the feedstock to the study site (Department of Water Resources and Environmental Engineering Biogas Garden, ABU, Zaria). Partly decomposed slaughter house waste was used as inoculum in this study.

1090.64g grass and 363.55g Chicken droppings were measured into Digester A_2 (Control). Same quantity of grass with Chicken droppings were measured into digesters B_2, C_2 and D_2 with 100gSSP/50gAsh, 150gSSP/75gAsh and 200gSSP/100gAsh respectively. Slaughter house waste (inoculum) with warm water was added and stirred continuously for about 30s. A clear space of 10% of reactor volume was left for fermentation and gas production.

Measurement of Gas Production

The gas holder were calibrated to enable the reading of the daily gas production of the four substrates in the anaerobic digesters the daily gas production measurement was done just before sun set. The produced biogas was measured by adopting the method previously described by Alfa *et al* (2014). It involves computation of the volume of gas holder above the water jacket.

Model Description of Cumulative Biogas Production

The Modified Gompertz Kinetic equation is as shown in Eq. (1):

$$R = exp\left[-exp\left[\frac{B \times e}{A}(\lambda - t) + 1\right]\right] \quad \text{.......................} \quad (2)$$

Where; R = Cumulative Biogas Produced (m^3) at any time (t)
A = Biogas Production Potential (m^3)
B = Maximum Biogas Potential (m^3/day)
λ = Lag phase (days), which is the minimum time taken to produce biogas or time taken for bacteria to acclimatize to the environment in days

The Constant A, B and λ were determined using the linear regression approach with the aid of the solver function of MS Excel Toolpak. The equation was utilized by researchers to study the cumulative methane production in biogas production. LAY *et al.* (1996) applied this equation to study bacteria growth. BUDIYINO *et al.* (2010) and Momoh (2011) also utilized this modified equation to describe biogas yield from cattle manure and co-digestion of horse manure and cow dung respectively.

RESULTS AND DISCUSSIONS

The experimental results obtained during the monitoring period in the study were tabulated and analyzed using statistical methods. They are presented in tables, graphs, and bar charts, and discussed as follows.

Daily Gas Production

Figure 1 shows the daily biogas production from Co digestion of Chicken Droppings with *Digitaria Smut II.* The peaks shows daily fluctuation in biogas produced using Chicken droppings with grass.The fluctuation could be attributed to possible variation in environmental conditions which affected the microbial activities in the system. The set up with more percentage of single superphosphate and wood ash (D_2) produces more gas while there were no significant difference in the other three setup, whereas the control (without catalyst) produces the least gas at the end of 32-day RT. Gas production was highest on the 26th day for all the set up as shown in figure 1.

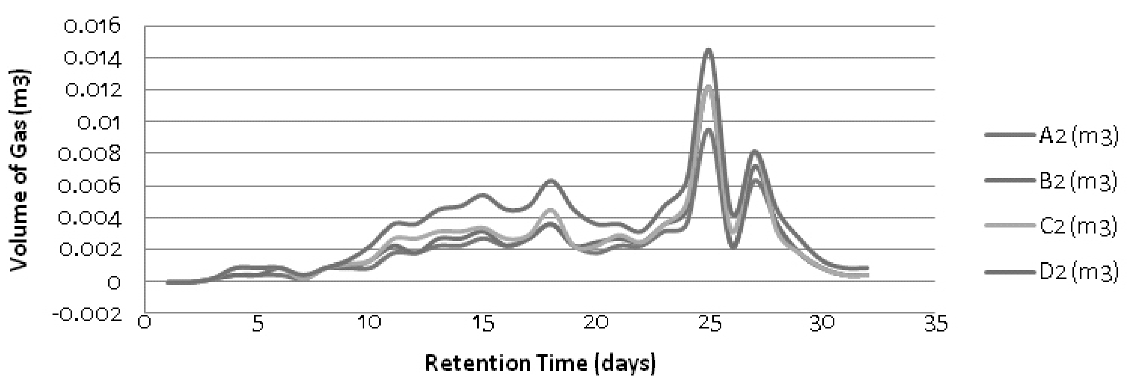

Fig. 1 Daily Biogas Production

Weekly Gas Production from Chicken Droppings with Grass

Although, gas production started from the first week of setup. Appreciable Production was obtained in the second week, while production was maximum in the third and fort weeks. The gas production improved daily as the substrate fermented further as seen in figure 2.

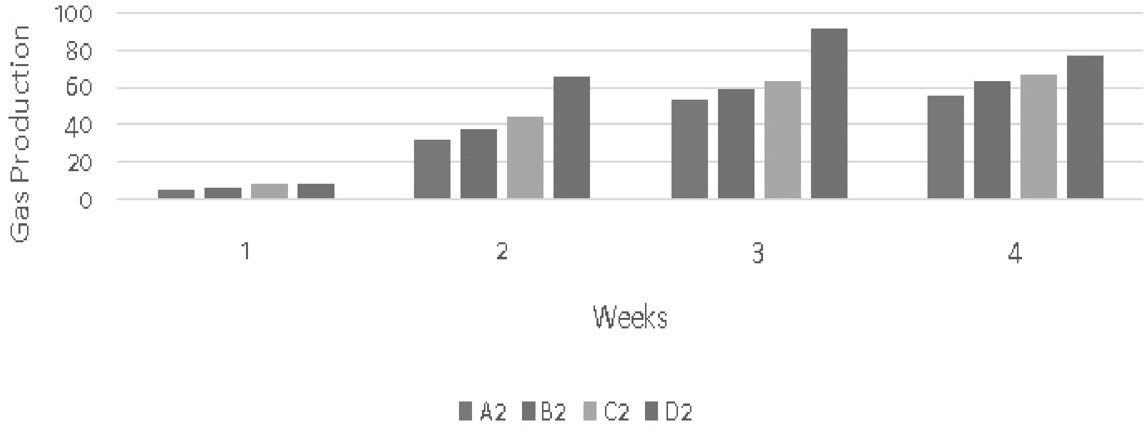

Fig. 2 Weekly Biogas Production

Monitoring of Operational Parameters

The pH for each of the four substrates was measured before and after digestion. The daily temperatures were also adequately monitored, these generated the results shown in Table 1 and Table 2.

pH Before and After Digestion

Table. 1 pH of the Substrate Before and After Digestion

Feedstock pH	A_2	B_2	C_2	D_2
Before Digestion	5.9	5.5	5.2	5.2
After Digestion	7.0	6.7	6.7	6.9

The results of pH measured immediately after preparation depicted slight acidic conditions ranging 5.2 5.9 with control having the highest pH value, while the treatments with 150gSSP/75gAsh and 200gSSP/100gAsh had the least pH value. This indicated that there was an increase in acidity as the proportion of SSP and ash increased in the bio reactors. A slightly different trend was observed after digestion. Even though the pH of the control was still the highest about neutral (pH7). The lower proportion of the catalyst (100gSSP/50gash and 150gSSP/75gash) were least indicating reduced acidity after digestion.

Average Daily Digester and Ambient Temperature

Table 2 shows average of the daily temperature recorded during digestion period across the bio reactors, as well as the average ambient Samaru temperature.

Table 2 Temperatures

Average Temperature	A_2	B_2	C_2	D_2
Digester (^oC)	35.25	35.28	35.30	35.40
Ambient (^oC)		36.1		

Scrubbing of the Biogas

The gas produced was burnt after the daily readings has been recorded. Despite the fact that blue flame is an evidence of high methane concentration, this was not obtained at the early stages of burning due to the presence of C_2O and H_2S. This necessitated scrubbing the biogas to remove the C_2O and H_2S by passing it through water and saturated wood ash respectively to achieve blue flame. Plates 1 and 2 shows the scrubbing set up and flaming of the biogas.

Plate 1: Scrubbing

Plate2: Flaming

Biogas Kinetic Parameters

Biogas production in the four digesters were measured until production reduced significantly. The modified Gompertz equation was then used to fit the cumulative daily biogas production which was observed to adequately describe the biogas production from these substrates. The estimated kinetic constants using linear regression and other characteristics of the digesters $A_2$to$D_2$are shown in the Table 3.

Digesters	Quantity of Substrate	Biogas Production Rate (m^3/Day)	Biogas Production Potential (m^3)	5, Lag Phase (Days)	R Square (R^2)
A_2	1090g Chicken Droppings with 364g Grass	0.0025	0.0647	8.88	0.9973
B_2	1090g Chicken Droppings with 364g Grass and 100gSSP with 50gAsh	0.0028	0.0737	8.571	0.9969
C_2	1090g Chicken Droppings with 364g Grass and 150gSSP with 75gAsh	0.0031	0.0808	7.935	0.9974
D_2	1090g Chicken Droppings with 364g Grass and 200gSSP with 100gAsh	0.0046	0.1088	8.565	0.9971

From the table, it is observed that digester D_2has the highest biogas production potential of $0.1088m^3$at a biogas production rate of $0.0046m^3$ with a lag phase of 8.6days. Digester D_2contains more quantity of SSP and wood ash which is an indication that they are a good source of catalyst to increase the volume of biogas production using Chicken droppings with *Digitaria Smuts II*.
The modified Gompertz equation was observed to adequately describe biogas production with a goodness of fit (R^2) as shown in Table 3.

Experimental data Vs Modified Gompertz Model for Biogas Production

Figures below shows the experimental pattern for biogas production for the four substrates digested with their corresponding modified gompertz kinetic data.

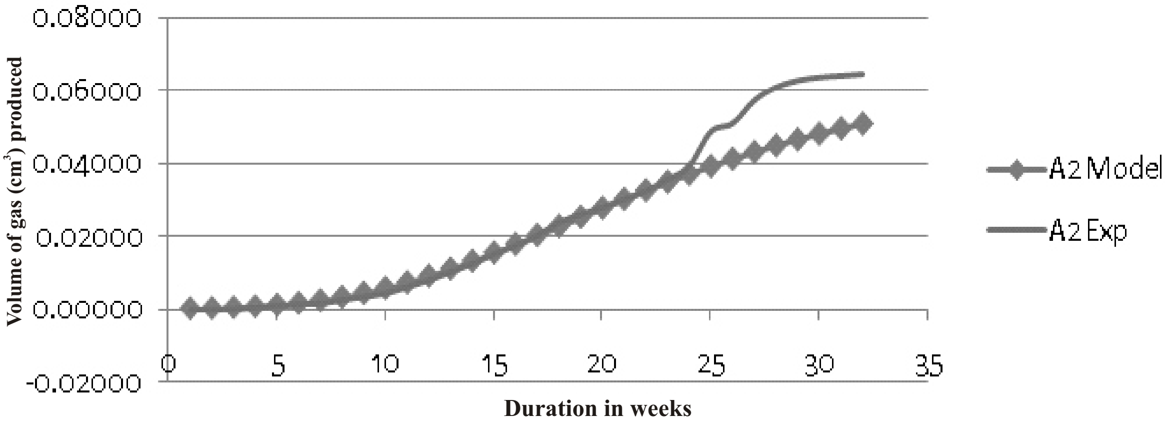

Fig. 3 Experimental data (A_2) Vs Modified Gompertz Kinetic Data

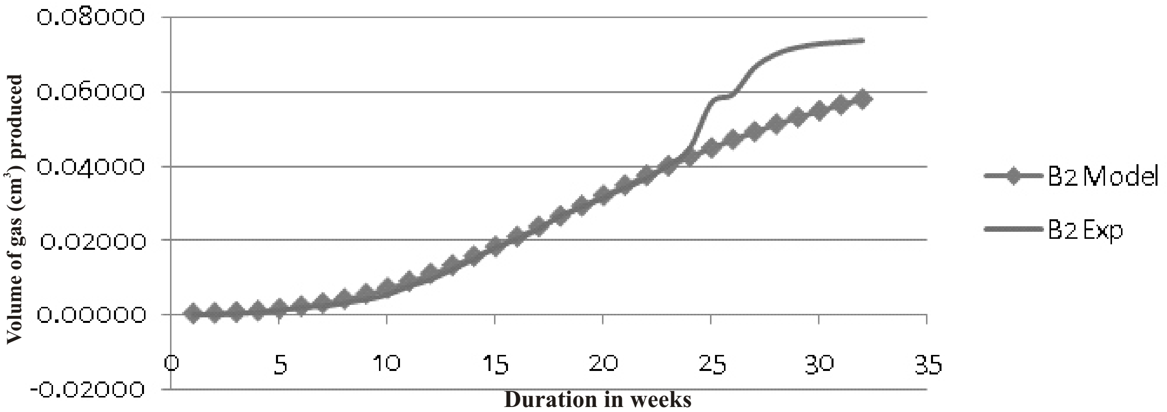

Fig. 4 Experimental data (B_2) Vs Modified Gompertz Kinetic Data

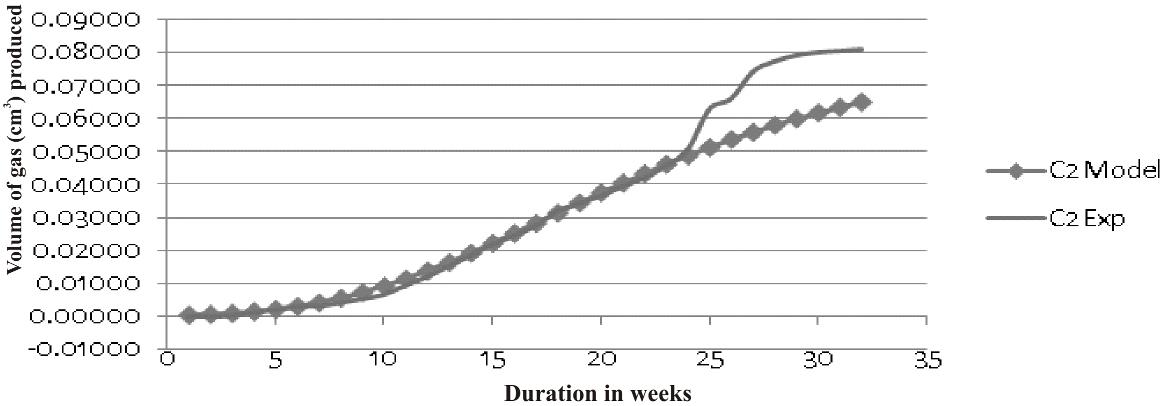

Fig. 5 Experimental data (C_2) Vs Modified Gompertz Kinetic Data

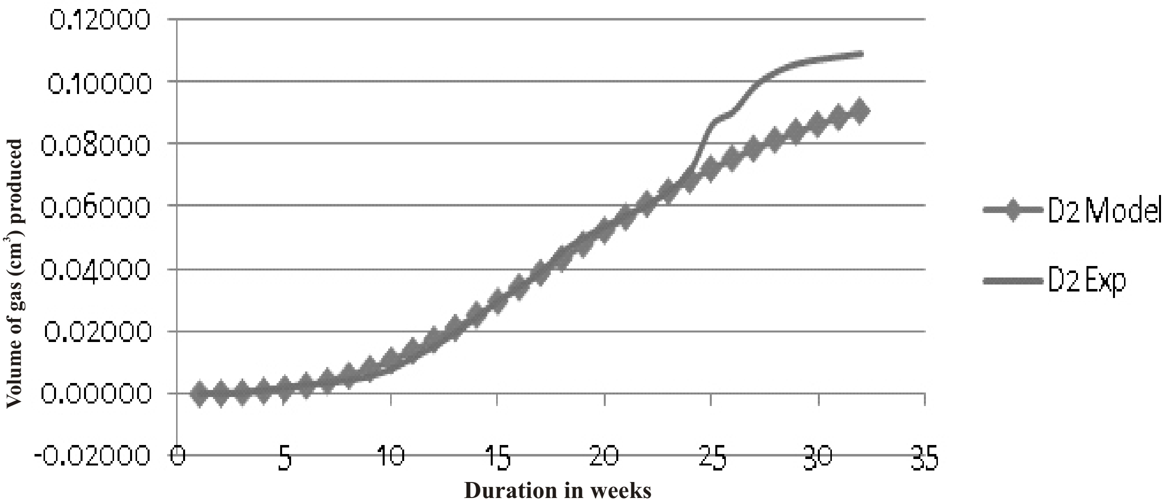

Fig. 6 Experimental data (D_2) Vs Modified Gompertz Kinetic Data

From Figures (3 to 6), the experimental data fits with modified gompertz model perfectly except towards the end of the reaction. This is possibly due to sudden drop in temperature which greatly affected the rate of microbial activities in the system. 0.9973, 0.9969, 0.9974, 0.9971 indicated a very good goodness of fit (R^2) as seen in Table 3.

CONCLUSION

This paper identified that single super phosphate (SSP) and wood ash can be used to increase the volume of biogas production from using Chicken dropping.

There was increase in total gas production for the 32 days retention time for co digestion of Chicken droppings with *Digitaria Smuts II* from 0.0646m^3 (no catalyst) to 0.1087m^3 (200gSSP/100gWood ash), indicating 40.6% increment.

The temperature measured ranged from 25 - 45^{0}C which indicate that the digester operated within the mesophilic temperature range. This study was also able to show that digesters can conveniently operate within this range of temperature in Samaru (Igboro, 2011 and Alfa, 2013).In addition, Modified gompertz kinetic equation was used to adequately describe the cumulative of biogas produced with high goodness of fit (R- square). In addition, the model was used to predict the biogas production potential for each substrate digested.

Water and saturated wood ash were used to remove hydrogen sulphide and carbon dioxide. This was done to achieve clean blue flame which indicated the presence of methane.

REFERENCES

Alfa M. I. (2013). Comparative Evaluation of Biogas Production from Cow Dung, Chicken Droppings and *Cymbopogoncitratus*(lemon grass) as activative energy source in Nigeria. MSc Thesis Presented to the Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria Nigeria.

Alfa, I., Dahunsi, S., Iorhemen, O., Okafor, C., & Ajayi, S. (2014). Comparative evaluation of biogas production from Poultry droppings, Cow dung and Lemon grass. *Bioresource Technology, 157*, 270-277.

Anonymous (2012). Beginnners Guide to Biogas, the University of Adelaide. Available on http://www.anaerobic-digestion.com/html/biogas-production-and-explosion.php (30/01/2012)

Budiyono, Widiasa, I.N., Johari, S., Sunarso, 2010. The kinetic of biogas production rate from cattle manure in batch mode. Int. J. Chem. Biol. Eng. 3 (1), 3944.

Igboro, S. B. (2011). Production of Biogas and Compost from Cow Dung in Zaria, Nigeria, PhD Dissertation Presented to the Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria Nigeria.

Nigeria Bureau of Statistics (2009). Social Statistics in Nigeria available on http://www.nigerianstat.gov.ng/ext/latest_release/ssd09.pdf (21/09/2011)

Lay J.J., Li Y.Y., Noike T., 1996. Effect of moisture content and chemical nature on methane fermentation characteristics of municipal solid wastes. Journal of Environmental Systmem and Engineering JSCE, 552/VII-1: 101108.

Momoh O.L.Y., Nwaogazie I.L., 2008. Effect of waste paper on biogas production from co-digestion of cow dung and water hyacinth in batch reactors. Journal Applied Science and Environmental Management, *124*: 9598.

Ojolo, S. J., Dinrifo, R. R and Adesuyi, K. B., (2007). Comparative Study of Biogas Production from Five Substrates, *Advanced Materials Research Journal, Vols. 18-19 (2007) pp. 519-525 published by Trans Tech, Switzerland online at http://www.scientific.net*

http://www.sosehnigeria.org