EFFECTS OF SINGLE SUPER PHOSPHATE AND WOOD ASH ON BIOGAS PRODUCTION USING COW DUNG

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ABSTRACT
This study was carried out to examine the catalytic effects of Single Super Phosphate (SSP) with Wood ash on the production of biogas from Cow Dung. 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 of cow dung. The control which was Cow dung digested without any catalyst had the longest lag phase of 7.5 days as compared to 5.9 days for those digested with catalyst. At the end of 32 days digestion period, total volume of biogas produced across the digesters were 0.0906m^3 (no catalyst), 0.0973m^3, 0.0937m^3, and 0.1141m^3 (200gSSP/100gWood ash), which indicated an increment with increase in catalyst. The Modified Gompertz equation was applied to describe the cumulative biogas generation. The Biogas production Kinetic Constants estimated by the linear regression method using the solver function in Microsoft Excel as well as other characteristics obtained for the four digesters were 0.0037m^3/day 0.0036m^3/day 0.0045m^3/day and 0.0056m^3/day for Biogas Production Rate and 0.0893m^3, 0.0841m^3, 0.0977m^3 and 0.1188m^3 for Biogas Production Potential. The average temperatures of the digesters recorded were 35.20 ^oC, 35.30 ^oC, 35.17 ^oC, and 35.18 ^oC respectively while the average ambient temperature observed during the study was 36 ^0C which were within the mesophilic range.

Keywords: *Biogas, Cow Dung, Single Super Phosphate, Wood ash, Modified Gompertz equation*

INTRODUCTION

There is a great deal of environmental pressure in many parts of the world to ascertain how livestock waste 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. 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.

Environmental quality has been largely affected as a result of excessive use of petroleum base fuel. The detrimental consequences of the fossil based fuels and the depleting supplies of crude oil products have prompted and triggered the search for renewable alternative energy. Biogas production will go a long way in reducing over dependency on fossil fuels, in addition to ameliorating the menace and nuisance of urban wastes. Biogas as a renewable energy source could be a relative means of solving the problems 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.

Energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential. Part of the United Nations Sustainable Development Goals is to harness the potential of other sources of energy other than fossil fuel which is clean and sustainable. Sustainable energy is opportunity - it transforms lives, economies and the planet. At the UN conference held in France, December 2015 on climate action, the following were revealed;

i. One in five people still lacks access to modern electricity
ii. Three billion people rely on wood coal, charcoal or wood fuel for cooking
iii. Energy is the dominant contributor to climate change, accounting for around 60 percent of total global greenhouse gas emissions
iv. Reducing the carbon intensity of energy is a key objective in long term climate goals.

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 effect of catalyst on biogas production using Cow Dung was assessed. The effectiveness of Single Super Phosphate (SSP) and Wood Ash to accelerate the rate of digestion to produce biogas in batch operation was determined. The scope of this research is limited to the studying of effects of SSP and Wood ash on biogas production using cow dung, and also to calculate the cumulative biogas production using the modified Gompertz kinetic equation.

MATERIALS AND METHOD

Substrate Collection and Slurry Preparation

Cow Dung was obtained from Kawo Abattoir Kaduna, dried for a period of 3 weeks and pounded to enhance better mixing. 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 cooking were taking together with the dung to the research site. Partly decomposed slaughter house waste was used as Inoculum in this study.

1.5kg of dried Cow dung was measured using spring balance and poured into reactor A_1 (Control). Same quantity was measured in bio reactor B_1, C_1, and D_1. 100gSSP/50gAsh, 150gSSP/75gAsh and 200gSSP/100gAsh (2:1) was then added into the three reactors respectively. After which slaughter house waste (inoculum) with warm water was added to about 90% capacity 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 was calibrated to enable the reading of 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);

$$R = A\, exp\left[-exp\left[\frac{B\times e}{A}(\lambda - t) + 1\right]\right] \qquad (1)$$

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.

This Gompertz equation was utilized by researchers to study the cumulative methane production in biogas production. Zwietetring *et al.* (1990), and LAY *et al.* (1996) applied this equation to study bacteria growth. Budiyono *et al.* (2010) and Momoh (2008) also utilized this modified equation to describe biogas yield from cattle manure and co-digestion of horse manure and cow dung respectively. Alfa *et al* (2014) applied this equation to model effects of temperature variability on biogas production from Cow Dung and Chicken Droppings.

RESULTS AND DISCUSSIONS

The experimental results obtained during the monitoring period of 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 influence of time on the volume of gas generated. The daily fluctuations in biogas production from Cow Dung are shown by the peaks in Figure 1. These fluctuations could be attributed to possible variation in environmental conditions which affected the microbial activities in the system. Figure 1 shows that gas production started on the second day of set up and the reactor with higher proportion of the catalyst (more percentage of single superphosphate and wood ash) (D_1) produced more biogas.

On the 8th day, the gas produced were burnt but a clear blue flame was not achieved indicating the presence of excess carbon dioxide (CO_2), however, blue flame was achieved after passing the biogas through water and saturated wood ash respectively. From Fig.1, D_1 contained more catalyst (200gSSP and 100gAsh) which resulted in higher gas production followed by C_1 (150gSSP and 75gAsh) then B_1 (100gSSP and 50gAsh). The control A_1 has the lowest gas production at the early stage but produces more gas just before the final days of digestion.

Weekly Gas Production from Cow Dung

Figure 2 shows the weekly gas production. Although gas production started from the first week of setup, appreciable production was observed in the second and third weeks. In the final week, gas production drops significantly. It can be seen that gas production in the bio reactor with more catalyst is lower in the final week as compared to the first three weeks of set up. This is likely as a result of the catalyst which speed up activities of the bacteria.

Monitoring of Operational Parameters

The pH for each of the four substrate were measured before and after digestion. The daily temperatures were adequately monitored also to determine the daily temperature of the reaction, in addition to the daily ambient temperature. The following results were obtained.

pH Before and After Digestion.

pH of the four substrate were measured immediately after preparation. The pH value for the control was neutral (7.0), while acidity increases slightly with increase in catalyst. (200gSSP/100gWoodash > 150gSSP/75gWoodash > 100gSSP/50GWoodash), as seen below.

Table 1:Nature of reaction (pH) of the Substrate Before and After Digestion

Feedstock pH	A_1	B_1	C_1	D_1
Before Digestion	7.0	6.9	6.8	6.7
After Digestion	6.7	6.7	6.5	6.5

After digestion, there was general drop in pH across all the bio reactors

Average Daily Digester and Ambient Temperature

Table. 2 Variation in Digesters and Ambient Temperature

Average Temperature	A_1	B_1	C_1	D_1
Digester (^oC)	35.20	35.30	35.17	35.18
Ambient (^oC)	36			

Table 2 shows the daily average digester and ambient Samaru temperature recorded during the digestion period.

Scrubbing of the Biogas

The gas produced were burnt after the daily readings has been recorded. However, Blue flame is an evident of high methane concentration. In the early stages of burning, pure blue flame was not achieved indicating the presence of CO_2 and H_2S. The gas was passed through water and saturated wood ash respectively to achieve blue flame.

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_1 to D_1 are shown in the Table 3.

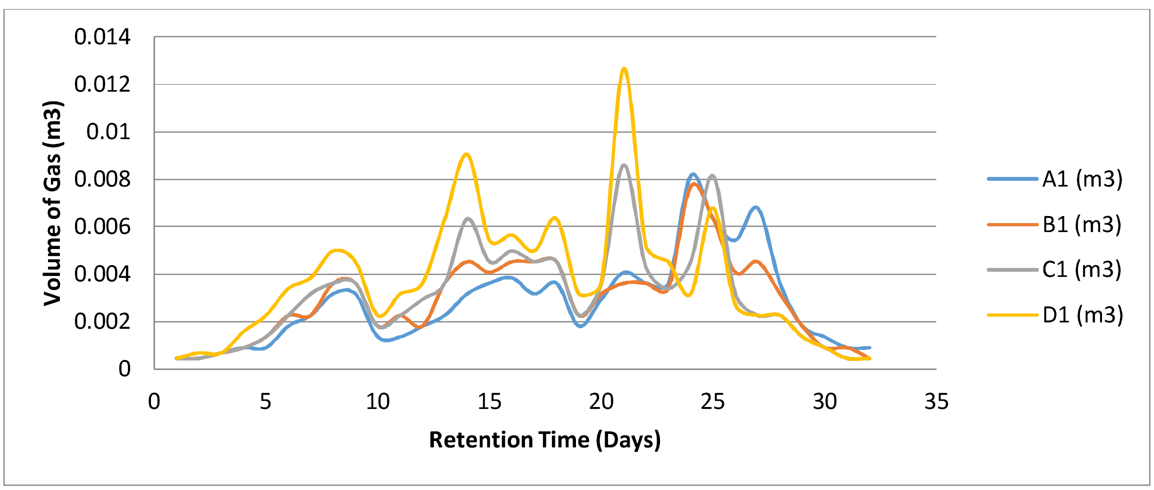

Fig. 1: Daily Biogas Production

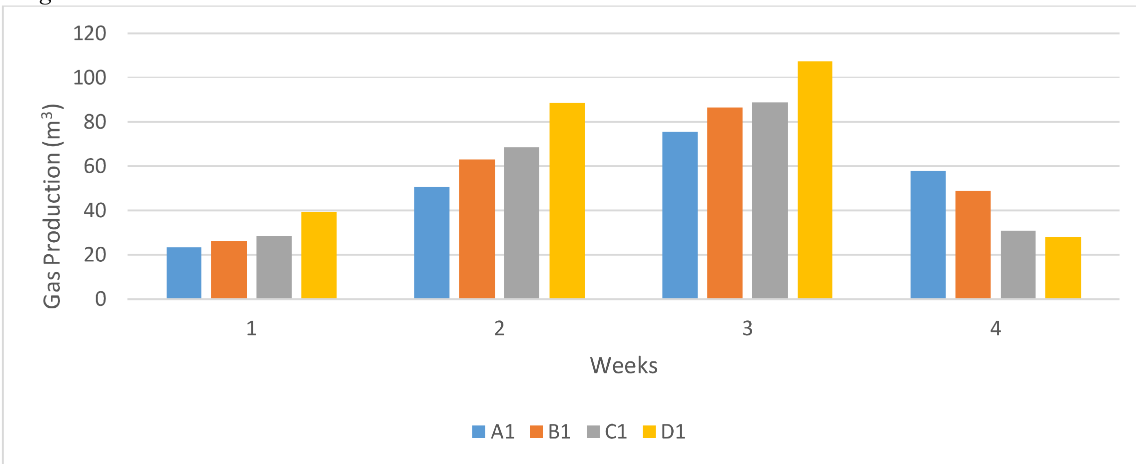

Fig. 2: Weekly Biogas Production

Tab. 3 Composition of Digesters and their Corresponding Kinetic Parameters

Digesters	Quantity of Substrate	Biogas Production Rate (m^3)	Biogas Production Potential (m^3)	λ, Lag Phase (Days)	R Square
A_1	1454g Cow Dung	0.0037	0.0893	7.54	0.9695
B_1	1454g Cow Dung and 100gSSP with 50gAsh	0.0036	0.0841	5.5	0.996
C_1	1454g Cow Dung and 150gSSP with750gAsh	0.0045	0.0977	6.355	0.994
D_1	1454g Cow Dung and 200gSSP with 100gAsh	0.0056	0.1188	5.875	0.9925

From Table 3, it is observed that digester D_1 has the highest biogas production potential of 0.1188m^3 at a biogas production rate of 0.0056m^3/day with a lag phase of 5.9days. Digester D1 contains 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 Cow dung.

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 and Modified Gompertz Kinetic Data for Biogas Production

Figure 3 shows the experimental pattern for biogas production for the four substrates digested, while Figure 4 shows the corresponding modified Gompertz model for the digestion

As seen from Figure 5, the Experimental data and Modified Gompertz data fits perfect except for the final stage of digestion. This is possibly as a result of sudden drop in temperature which affected the microbial activities and subsequently biogas production.

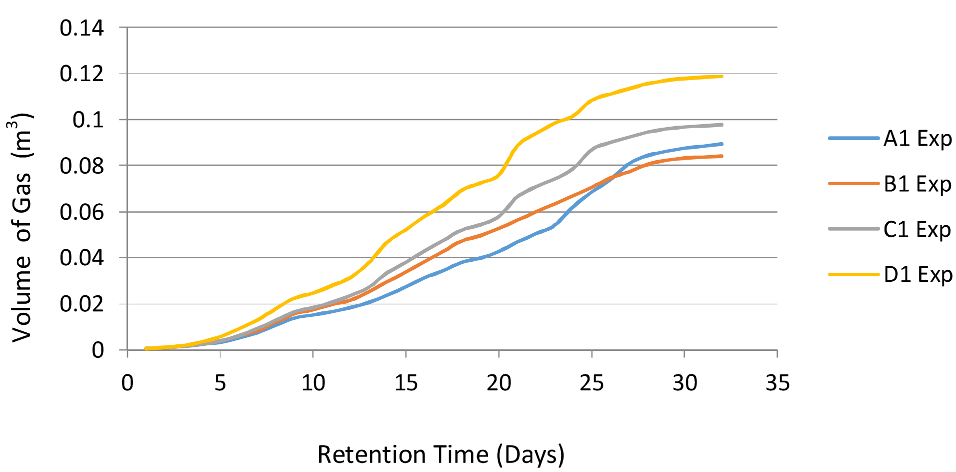

Fig. 3 Biogas Yield from the four Substrates

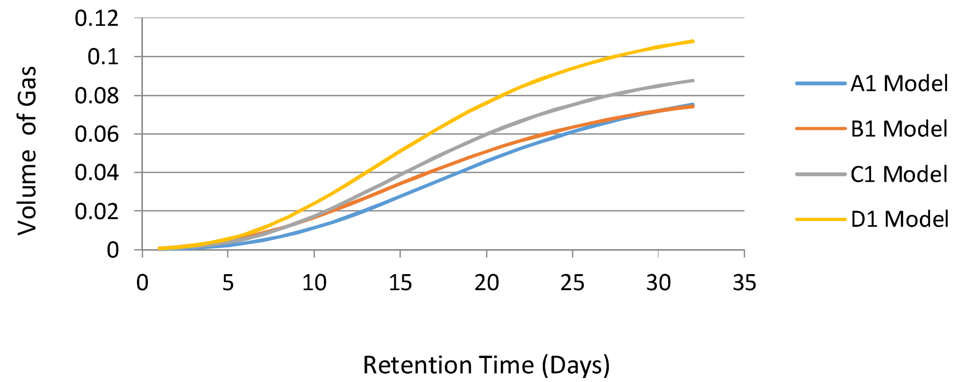

Fig. 4 **Modified Gompertz Kinetic Data**

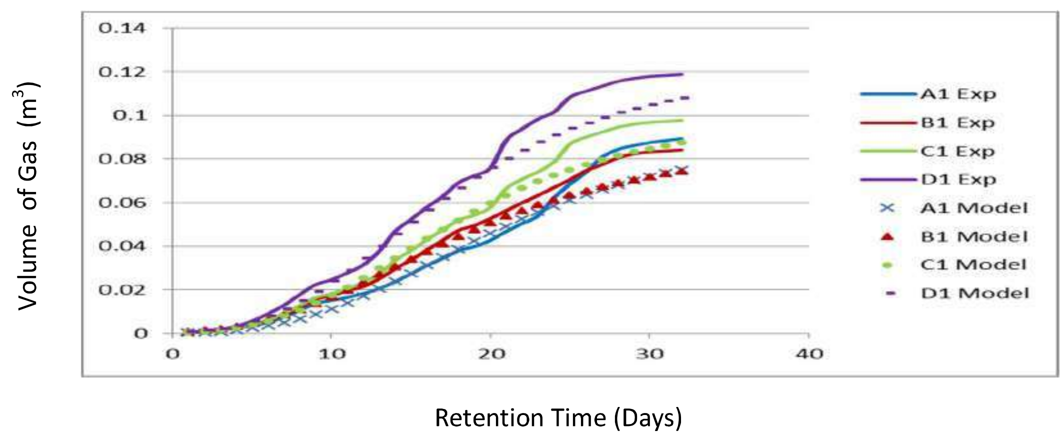

Fig. 5 Experimental Data Vs Modified Gompertz Data

CONCLUSION

This study identified that single super phosphate (SSP) and wood ash performed adequately as catalyst in increasing the volume of biogas produced from the various substrates using Cow dung. There was increase in total biogas production for the 32 days retention time from $0.0906m^3$ (no catalyst) to $0.1141m^3$ (200gSSP/100gWood ash), indicating 20.6% increment. The temperature measured ranged from 25 – 45 ^oC 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 - Zaria (Igboro, 2011 and Alfa, 2013). 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.

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