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Production of biogas from goat dung by anaerobic digestion

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Abstract
Anaerobic digestion has been considered as waste-to-energy technology, and is widely used in the treatment of different organic wastes, for example: organic fraction of municipal solid waste, sewage sludge, food waste, animal manure, etc. 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. Recently, large volume of goat dung generated from feedlot farming increases annually, most of which are disposed into landfills or are applied to the land without treatment. Anaerobic digestion provides an alternative option for energy recovery and waste treatment. This experiment was performed at National Centre for Energy Research and Development, University of Nigeria, Nsukka. The maximum atmospheric temperature recorded for the first four days of the experiment are 27^0C, 29^0C, 28^0C and 30^0C respectively. The highest volume of biogas recorded in the experiment was 7.1 litres. The moisture content of the dung was 15%.

Keywords: Biogas, Goat dung, Anaerobic Digestion, Methane, Moisture Content

1. Introduction

Before biogas, fuel wood and combustible organic materials have been man's first and most frequently used domestic fuel for cooking, primarily because fuel wood and such materials are cheaper and accessible to mankind [1]. Recently, due to increasing human number, desertification, increasing cost of petroleum energy resources, government regulated laws and in some cases, it is completely not available, especially in dry land community's fuel wood has been scarce and expensive. NAP (2000) [2] observed that nearly three quarter (3/4) of Kano city (the second largest city in Nigeria) fuel wood fuel wood requirement is about 75000 tons, similarly, Mende and Ahmed (1991) [3] identified fuel wood as the staple energy source of three quarters (3/4) of the developing country's population, especially in the tropical regions. Therefore, due to the increasing demand for fuel wood which caused deforestation resulting into desertification, erosion and land degradation, considering this a number of measures were taken to cut down the use of fuel wood or look for alternatives [1]. In an attempt, therefore, to reduce and divert the rural domestic fuel demand from fuel wood to alternative, biogas (methane) was chosen due to the abundance of the raw material such as organic waste material which are not in use for any purpose, but constituting an eye sore in the environment, such materials include cow dung, household waste, industrial sewage, plant, plants, leaf litter and flowers (Maishanu and Sani 1991) [4]. Biogas or methane (CH4) is an alternative source of energy for domestic cooking, especially in rural areas,www.beg.utexas.edu (2003) [5] indicated that natural gas has an energy content higher than methane because of added gas liquids while include other hydrocarbons other than methane, such as ethane, propane and butane. As a result, natural gas has a higher caloric value than pure methane. Biogas can be used in all energy consuming applications designed for natural gas. It is burned in an internal combustion engine to generate electricity, running fuel engines, cooking light and pumping water, it was reported using biogas can save about 610g/ day of fuel wood at the rate N50.00 (Abbasi *et al.*, 1991) [6]. The gas is trusted and popular, produced by the use of local resources, like cow dung, sugar cane waste (peels and bites), chicken droppings (guano), grasses, decomposed vegetable, large and small animal waste, bedding materials, rice straw, rice hull, water hyacinth, banana peels and other organic materials of low lignin content [1]. The technology and yield of biogas depend on the composition and biodegradability of the organic feedstock, microbial growth, pH and temperature conditions. The feedstock in decomposed anaerobically by methagenic bacteria in an airtight digester, where the substance is subjected to the process of fermentation, acidification and methanization under a given range of temperature usually 25^0C and a moisture content of 20% 40% and 1 atm pressure (Letcher and Kolbe 1994) [7]. Depending on the digestion process, the methane content of biogas is generally between 55% - 80% (Anon 2004b), the remaining composition is primarily $C0_2$ with trace quantities (015000 ppm) of corrosive hydrogen sulphide and water (Anon 2004a) [8]. Meynell (2004) indicated that the energy content of pure methane is 8961069 btu /ft^3, to obtain useful methane to biogas is scrubbed of $C0_2$, hydrogen sulfide and water. There are several factors, affecting biogas production, which include temperature, retention time, air, bacteria, C:N ratio, pH, water ratio and solid contents required. There are various designs of biogas such as floating steel drum design, fixed dome design and tunnel design, plastic bag bio digester, brick mortar, dome designed by various engineers [9]. On production the gas is collected in a floating collector which is connected directly to the kitchen for use in a gas

burner. The spent or slurry of digestion is collected as a nitrogen fertilizer or bio fertilizer, based on a number of trails to generate the biogas or methane (CH_4) in the Department of Biological Sciences, University of Maiduguri where waste materials, like cow dung and sugar cane waste with chicken waste or guano as seeding material (inoculants) were used. This research therefore intends to assess the rate of biogas production from cow dung per unit time of cooking in a home. A similar effort was used by numerous authors to determine biogas production from organic material as indicated by Letcher and Kolbe1994) that the maximum possible volume of gas from a ton (1000kg) of dry organic plant material in 416m^3 at 25^{0}C with 20-40 moisture content. The maximum heat energy that can be obtained from burning 25 liters of methane (CH_4) gas 1mole is 890 kj/mol. It is estimated that 1kg of cow dung can generate 600 liter of methane gas. As part of effort to probe this ascertain effort were made to generate biogas from cow dung. Ramasamy (1990) reported that the performance of floating dome biogas plant was better than the fixed dome gas plant. Measurement of the gas was made easy by displacement of water by the gas. The gas displaces water, being insoluble, where the height of the cone was measured as the amount of gas collected. The amount of gas produced was assessed on the basis of three meals for a family in a day. A meal of rice was prepared with ingredients to determine sustainability. Where 477g of rice was cooked. The digester was fed with 40kg of waste organic material (cow dung) with the crumbs, broken into fine pieces and thoroughly mixed and stirred into 80 liters of water and 10 liters of seeding material (chicken waste) as source of methagenic bacteria. In the second trial using the same digester, about 39kg of waste material mixed and stirred properly in 172 liters of water with only 4 liters of seeding material.

2. Materials and Method

Nitrogen/Crude Protein Determination

The micro-Kjedahl method as described in Pearson (1976) was used. This method involves the estimation of the total nitrogen in the waste and the conversion of the nitrogen to protein with the assumption that all the protein in the waste is present as nitrogen. Using a conversion factor of 6.25, the actual percentage of protein in the waste was calculated

% crude protein = % Nitrogen x 6.25.

Digestion

Apparatus used: Micro-Kjedahl digestion flask (500ml capacity) (Make: Barloworld U.K, model Fk 500/3l) Ohaus weighing balance (0.001g accuracy, model AR3130, Made in England).

Reagents used

Catalyst mixture (Mixture of 20g potassium sulphate, 1g copper sulphate and 0.1g selenium powder), concentrated tetraoxosulphate (VI) acid.

Procedure

1g of the ground waste sample was weighed into the Kjedahl digestion flask. 1g of the catalyst mixture was weighed and added into the flask. 15 ml of conc. H_2SO_4 was also added. Heating was carried out cautiously on a digestion rack in a fume cupboard until a greenish clear solution appeared. The digest was allowed to clear for about 30 minutes. It was further heated for more 30 minutes and allowed to cool. 10 ml of distilled water was added to avoid caking. Then the digest was transferred with several washings into a 100 ml volumetric flask and made up to the mark with distilled water.

Distillation

Apparatus used: micro Kjedahl distillation unit (make: Barloworld, UK model 734205) 100 ml conical flask. (Receiver flask)
Reagents used: 40% NaOH, Boric acid indicator solution

Procedure

A 10ml aliquout was collected from the digest and put in the flask. A 100ml receiver flask containing 5ml boric acid indicator solution was placed under the condenser of the distillation apparatus so that the tip was 2cm inside the indicator. 10ml of 40% NaOH solution was added to the digested sample through a funnel stop cork. The distillation commenced by closing the steam jet arm of the distillation apparatus. The distillate was collected in the receiver flask (35ml).

Titration

Titration was carried out with 0.01M standard HCl to first pink colour.

% Nitrogen =

$$\frac{Titration\ vol. \times 0.014 \times M \times 100x \frac{100}{10}}{wt.ofsample}$$

Where

M= molarity of std HCl
% crude protein =% N x 6.25

Equation of the Reaction

N in waste + conc. $H_2SO_4 \longrightarrow (NH_4)_2SO_4$

$(NH_4)_2SO4 + 2NaOH \xrightarrow{Catalyst} Na_2SO_4 + 2H_2O + 2NH_3$

The ammonia generated was collected in excess boric acid.

$NH_3 + H_3BO_3 \longrightarrow NH_4BO_2 + H_20$

After complete ammonia distillation, the ammonium borate solution is titrated with a standard HCl solution. Strong acid (HCl) displaces weak boric acid from its salt.

$NH_4BO_2 + HCl \longrightarrow NH_4Cl + HBO_2$

1 mole of ammonia is equivalent to 1 mole of ammonium borate which is equivalent to 1 mole of HCl.
Knowing the amount of 0.01 M HCl used for the titration, the amount of ammonia bound to borate can be calculated. From this amount, the quantity of nitrogen in the sample can be calculated.

Crude Fibre Content Determination

This determination is done to have an idea of the materials that are indigestible in the waste. It is largely made up of

cellulose and small lignin.

Crude fibre is obtained as an organic residue left behind after the raw waste has been subjected to standard condition with organic solvents, dilute mineral acids and sodium hydroxide.

The A.O.A.C (1990) method was used. 1g of the sample was weighed (w_1) into a 600ml beaker and 150ml of preheated 0.128M H_2SO_4 was added to it. This was heated for 30 minutes and filtered under suction and washed with hot distilled water until the washings were no longer acidic. The residue was then transferred to a beaker and boiled for 30 minutes with 150ml of preheated KOH (0.223M). It was filtered and washed with hot water until the washings are no longer alkaline. The residue was washed three times with acetone and dried in an oven at 105ºC for 2 hours. It was then cooled in a desiccator, weighed (W_2) and ashed in a muffle furnace (make: Vecstar, model LF3, made in U.K) at 500ºC for 4 hours. The ash obtained was cooled in a desiccator and weighed (W_3)

$$\% \text{ Crude fibre} = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}$$

Where

W_1= weight of sample
W_2= Weight of dry residue
W_3=Weight of ash.

Ash Content Determination

The residue remaining after all the moisture have been removed and the fats, proteins, carbohydrates, vitamins and organic acids burnt away by ignition at about 600ºC is called ash. It is usually taken as a measure of the mineral content of the raw waste [9].

Using AOAC (1990) method, 1g of the finely ground samples were weighed into porcelain crucibles which have been washed, dried in an oven at 100ºC, cooled in a desiccators and weighed. They were then placed inside a muffle furnace and heated at 600ºC for 4 hours. After this, they were removed and cooled in a desiccator and then weighed.

$$\% \text{ Ash} = \frac{A - B}{C} \times \frac{100}{1}$$ [9].

Where;

A = Weight of crucible + ash
B = Weight of crucible
C = Weight of original sample

Fat Content Determination

Pearson (1976) method was used. This involves the use of Soxhlet extraction apparatus. This method involves continuous extraction of waste with organic solvent such as petroleum ether for 4 hours or so depending on the volume of sample. To carry out the extraction, the flask was washed and dried in an oven. It was then cooled in a desiccator and weighed.

1g of the ground waste sample was accurately weighed and transferred into a rolled filter paper and then placed inside the extraction thimble. The thimble was placed inside the extractor. Some quantity of petroleum ether was poured inside the extraction flask (usually three-quarter of the volume of flask). The condenser and the flask were connected to the extractor. The whole unit was place on a heating mantle for 4 hours after which the petroleum ether was recovered. The oil collected in the flask was dried in an oven at 105ºC. It was then weighed and the percentage fat calculated as shown below.

$$\% \text{ fat} = \frac{C - A}{B} \times \frac{100}{1}$$

Where

C = weight of flask +oil
A = weight of empty flask
B = weight of original sample.

Carbon Content Determination

Walkey-Black (1934) method was used. 0.05g of the finely ground sample was weighed into a 500ml conical flask. 10ml of 1M potassium dichromate was poured inside the flask and the mixture was swirled. 20ml of conc. H_2SO_4 was added and the flask was swirled again for 1 minute in a fume cupboard. The mixture was allowed to cool for 30 minutes after which 200ml of distilled water; 1g NaF and 1ml of diphenylamine indicator were added. The mixture was shaken and titrated with ferrous ammonium sulphate.

The blank was also treated in the same way.

$$\% \text{ carbon} = \frac{B - T \times M \times 1.33 \times 0.003 \times 100}{g}$$

Where

B = Titration volume (Blank)
T = Titration volume (Sample)
M =Molarity of Fe solution
g = Weight of sample.

3. Results and Discussion

The result of the experiments indicates that there was poor start-up of biogas yield at the beginning of the experiment. The table 1 below showed that there was no biogas production for day 1, day 2 and day 3. Biogas production started on day 4 with 0.4 litres produced, then biogas yield increased gradually from day 4 to day 21. Then start decreasing from day 21 to day 30. The poor start-up of anaerobic digestion was due to inadequate lignocelluloses breakdown and slow activities of anaerobic bacteria. Ukwuani and Ugwuoke *et al* [10] observed that as the anaerobic digestion progresses to a certain stage the biogas yield decreased due to decrease in the activity of anaerobic bacteria. Ugwuoke, *et al*., reported that more disintegration of lignocelluloses gives higher biogas yield [11]. The atmospheric temperature fluctuates between 27^0C to 30^0C during the experiment. It was also observed that increased in solar radiation leads to increase in biogas yield. A.O.A.C method (1990) was used [9] to determine the moisture content of the dung. Porcelain crucibles were washed and dried in an oven at 100ºC for 30 minutes and allowed to cool in a desiccator. One gramme of the raw waste was placed into weighed crucibles and then put inside the oven set at 105ºC for 4 hours. The samples were removed from the oven after this period and then cooled and weighed. The drying was continued and all the samples with the crucibles weighed until a constant weight was obtained. The moisture content was determined to be 15%.

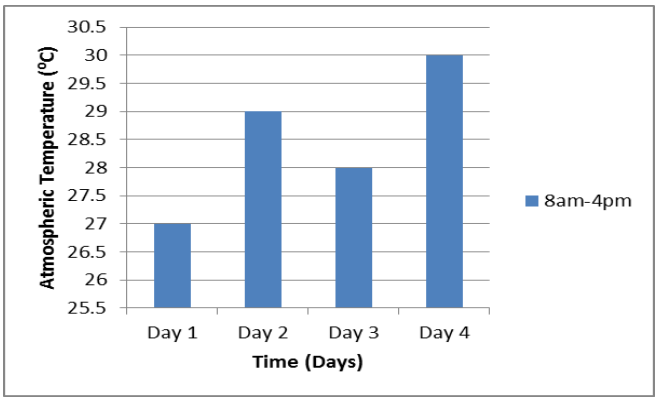

Fig 1: Maximum Atmospheric Temperature (^{0}C) recorded on the first four Days.

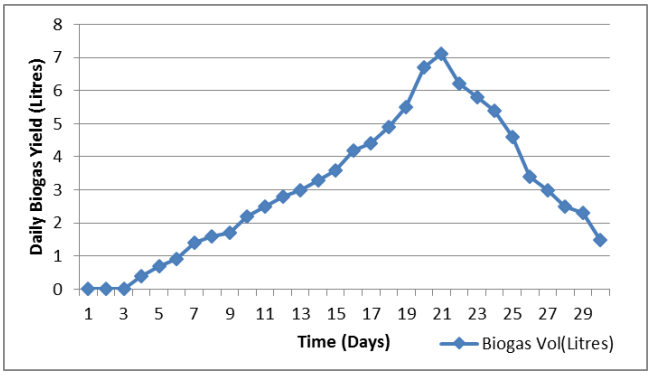

Fig 2: Daily Biogas yield (Litres) versus Time (Days)

Table 1: Biogas yield (Litres).

Time (Days)	Biogas Volume (Litres)
1	0
2	0
3	0
4	0.4
5	0.7
6	0.9
7	1.4
8	1.6
9	1.7
10	2.2
11	2.5
12	2.8
13	3
14	3.3
15	3.6
16	4.2
17	4.4
18	4.9
19	5.5
20	6.7
21	7.1
22	6.2
23	5.8
24	5.4
25	4.6
26	3.4
27	3
28	2.5
29	2.3
30	1.5

4. Conclusion

Biogas is another source of renewable energy; it is produced when biomass is subjected to biological gasification and a methane-rich gas is produced from the anaerobic digestion of organic materials. Achieving solutions to possible shortage in fossil fuels and environmental problems that the world is facing today requires long-term potential actions for sustainable development. In this regard, renewable energy resources appear to be one of the most efficient and effective solutions. Biomass is the biological organic materials that are renewable and can be recycled to produce biogas. This work produced maximum biogas yield of 7.1 litres and minimum yield of zero litres at the first three days of the test. The highest temperature recorded within the first four days of the test was 30^{0}C.

5. References

1. Yerima I. Sustainability of Biogas Generated from Cow Dung as Household Fuel for Cooking. Pyrex Journal of Research in Environmental Studies. 2016; 3(2):7-9. http://www.pyrexjournals.org/pjres.
2. NAP. To Combat Desertification and Mitigate the Effect of Drought towards the Implementation of the United Nation Convention to Combat Desertification and Mitigate the Effect of Drought in the Country, 2000, pp16-17.
3. Mendie Akaninyenene, Ahmed Sani. Problems and Issues in Afforestation (A Case Study of Fuel wood Situation in the Jos Region) Proceedings International Workshop on Ecology Society in the History of the African Sahel and Savanna, 1991, 22-28.
4. Maishanu SM, Sambo AS. Biogas Generation from Leaf Litter: A Preliminary Investigation. Nigerian Journal of Solar Energy. 1991; 10:138-144.
5. www.beg.utexas.edu, 2003.
6. Abassi SA, Nipaney PC, Panholzer MB. Biogas Production from the Aquatic Weed (Pistia strtoides) Bio resource Technology. 1991; 37(3):211- 214.
7. Letcher TM, Kolbe FE. Energy. Journal of Energy in South Africa. 1994; 5(3):1-5.
8. Anon. Energy and Anaerobic Digestion, 2004a. htt://www.biogasworks.com/Index/Environment% 20% AD. Html, 2004a, pp1of 3 to 2 of 3
9. Ntunde DI. Biogas production from municipal organic waste. International Journal of Research in Advanced Engineering and Technology, 2016. www.engineeringresearchjournal.com.
10. Ukwuani ST, Ugwuoke EC, *et al.* Anaerobic Plan for Waste Treatment. *The Pacific Journal of Science and Technology*. 2016; 17. http://www.akamaiuniversity.us/ PJST.html.
11. Funda C. Improving Biogas production by Anaerobic Digestion of Different Substrates, Canada, 2011.