Anaerobic Digestion of Cow Dung with Rumen Fluid

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Abstract: Production of biogas from agricultural and animal wastes is one of the viable options to mitigate the scarcity of energy and hazards of fossil fuels to both human and ecology. Therefore, this project work was on generation of biogas using cow dung and rumen fluid as co-substrate. A biogas digester with a capacity of 105 liters was used to produce the gas. The substrate (cow dung and rumen fluid) was mixed in the ratio 3:2 and water to substrate ratio of 2:1 was used. The digester was stirred thrice daily to avoid scum formation in the digester and to allow for easy escape of the gas produced. The retention time used for this experiment was 42 days during which the daily internal temperature readings were taken in order to determine temperature variations and also to determine the effect of heat on the production rate. A rubber hose was connected to the digester gas outlet located at the top of the digester and the other end of the rubber hose was connected to a PVC Tyer tube provided for storing the gas generated. The gas produced was collected and taken to the laboratory for chemical analysis. The results showed that biogas yielded consists of 57.98 % of methane (CH4), 39.99 % of carbon dioxide (CO2), 0.10 % of oxygen (O2), 0.01 % of hydrogen sulphide (H2S) and 0.01% of water vapour. The methane has the highest percentage, which represents the main source of energy and oxygen having 0.10 %, which shows that the process was purely carried out under anaerobic condition. Result of this study showed that methane has the highest percentage and generally cow dung with rumen fluid easily lent itself to process of anaerobic digestion.

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1. Introduction:

Agricultural residues and animal wastes are increasingly being diverted for use as domestic fuel to displace fossils fuel and reduce environmental pollution and reduce emission of greenhouse gases (Aremu and Agarry, 2013). Agricultural residues in their natural forms will not bring a desired result because, they are mostly loose and of low-density materials in addition to the fact that their combustion cannot be effectively controlled (Oladeji, 2011). Bio-residues are a major contributor to greenhouse gas emissions and pollution of water courses if not managed properly (Eze and Ojike, 2012).

Agricultural residues and even animal wastes can be degraded anaerobically in a biogas digester for production of biogas. Biogas is essentially a mixture of methane and carbon dioxide, produced by the breakdown of organic waste by bacteria without oxygen (anaerobic digestion). It contains methane and carbon dioxide oxide with traces of hydrogen sulphide and water vapour. It burns with pale blue flame and has a calorific value of between 20 – 30 J/m3 depending on the percentage of methane in the gas (Sagagi, et al., 2009). Biogas production is a profitable means of reducing or even eliminating the menace and nuisance of urban wastes in many cities in Nigeria (Sagagi, et al.2009). Consequently, biogas can be utilized in all energy consuming applications designed for natural gas.

The techniques used for the conversion of organic materials to biogas have been in existence for many years (Kerertic and Archana, 2012). Biogas generation has been applied to meeting the energy needs in rural areas as it is being done in England, India and Taiwan. In the United States, there has been considerable interest in the process of anaerobic digestion as an approach to generating a safer clear fuel as well as source of fertilizer (Garba and Sambo, 1995).

The use of rural wastes for biogas generation, rather than directly used as a fuel or fertilizer, offers several benefits such s the production of energy resource that can be stored and used more efficiently, the production of sludge that retains the fertilizer value of the original material and the saving of energy required to produce equivalent amount of nitrogen-containing fertilizer by synthetic process (Salunkhe, et al., 2012).

The amount of gas produced through anaerobic digestion is a function of the size of the bio-digester, its feeding regime, type of substrate and environmental conditions such as ambient temperature. The biogas consists of mainly of methane, carbon dioxide, hydrogen sulphide, and traces of water vapour. To have more energy per unit volume of biogas, the carbon dioxide as well as hydrogen sulphide (H2S) contents as well should be removed as they may deteriorate compression system due to their corrosive property.

2. Material and Methods:

The choice of feed stocks for this project was cow dung and rumen fluid as co-substrate due to the excess abundance of cattle in Nigeria and its numerous advantages. This is also in line with the findings of Liedl (2006) that residues from animal and poultry are the ideal substrates for bio-digesters because they are not acidic. The cow dung and rumen fluid used in this study were obtained from slaughter house located closed to the University. The fresh cow dung was obtained from animal holding pen unit while rumen fluid was collected from evisceration unit. The cow dung and rumen fluid were mixed in the ratio 3:2 and were analyzed based on its dry matter (DM) content by heating them at 105o C and 550o C, respectively. The substrate was properly mixed with water in the ratio 1:2. To facilitate the anaerobic digestion of the substrate, a 105-litre biogas digester (Plate 1), which essentially consists of the digestion chamber, the substrate inlet duct, and the gas and slurry outlet ducts among others was fabricated and was fed with the substrate.

The digester was stirred three times daily to avoid scum formation and to allow for easy escape of the gas produced. The retention time used for this experiment was 42 days (6 weeks) during which the internal temperature readings were taken with the aid of mercury thermometer in order to determine the temperature variations and also to determine the effect of heat on the production rate. A rubber hose was connected to the digester gas outlet located at the top of the digester and the other end of the rubber hose was connected to PVC tube provided for storing the gas generated. The gas produced was taken to laboratory for further chemical analysis.

3. Results and Discussion:

Table 1shows the results of chemical properties of the substrates before anaerobic digestion took place, while Tables 2 and 3depict the composition of biogas produced and average weekly temperature readings respectively.

Plate 1. A Biogas Plant Set-up

Table 1: *Chemical properties of the substrates before digestion Legend*

Parameters Determined	Replicates 1	2	Average
% D.M at 105oC	23.85	23.83	23.84
% O.D.M at 550oC	72.34	72.36	72.35
NH4-N (g/kg)	17.84	17.89	17.86
Nitrogen (g/kg)	41.18	41.13	41.15
% K on DM	1.56	1.58	1.57
Phosphorus (g/kg)	3759.00	3756.00	3757.50
% C. F	11.48	11.51	11.495
% Lignin	4.80	4.60	4.70
% O.C	31.56	31.59	31.575
PH	5.67	5.63	5.65

(i) D.M: - Dry Matter (ii) O.D.M: - Organic Dry Matter (iii) NH4-N: Ammonium – Nitrogen
(iv) K: - Potassium (v) C.F: - Crude fibre (vi) O.C: - Organic Content

Table 2: *Biogas composition based on chemical analysis*

Substance	Formula	Percentage (%)
Methane	CH4	57.98
Carbon dioxide	CO2	39.99
Nitrogen	N	0.60
Water vapour	H20	0.20
Oxygen	O2	0.10
Hydrogen sulphide	H2S	0.01

Table 3: *Average weekly temperature readings for biogas Production*

Hydraulic Retention Time (Weeks)	Temperature (o C)
1	30.50
2	31.00
3	33.50
4	32.50
5	33.00
6	30.00
Average	31.75

The biogas yielded consists of 57.98 % of methane (CH4), 39.99 % of carbon dioxide (CO2), 0.10 % of oxygen (O2), 0.01 % of hydrogen sulphide (H2S), and 0.01 % of water vapour. The methane has the highest percentage, which represents the main source of energy and oxygen having 0.01 %, which shows that the process was purely carried out under anaerobic condition (in the absence of oxygen).

4. Conclusion:

From the study, the following conclusions were drawn: Cow dung co-digested with rumen fluid easily lent itself to process of anaerobic digestion. Methane has the highest percentage gas generation. Biogas can be produced by the microbial digestion of organic matter in the absence of air. Biogas production took place within the retention period of six weeks from microbial digestion of cow dung and rumen fluid in an anaerobic condition.

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