International Journal of Research in Advanced Engineering and Technology
ISSN: 2455-0876
www.engineeringresearchjournal.com
Volume 2; Issue 1; January 2016; Page No. 19-21

Comparative study of biogas production from cow dung and brewer's spent grain

[1] Okoye BO, [2] Igbokwe PK, [3] Ude CN

[1] Projects Development Institute (PRODA), Enugu, Nigeria.

[2] Department of Chemical Engineering, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria.

[3] Projects Development Institute (PRODA), Enugu, Nigeria.

Abstract
Production of biogas from cow dung and brewer's spent grain was investigated using the anaerobic digestion in 50litre digester. The experiment was batch operated and daily gas yield from the plant was monitored for 30 days. The ambient and slurry temperature, pH, and Pressure were also monitored and presented. The slurry was characterized before charging with the American Public Health Association standard. The digester was charged differently with these wastes in the ratio of 1:2 of waste to water respectively. The mesophilic ambient temperatures range attained within the testing period were 20 – 32 ºC and a slurry temperature range of 22–36 ºC. The biogas produced was analyzed with digital gas analyzer. The result obtained from the gas production showed that cow dung produced the highest methane content of 58% while brewer's spent grain has the least methane content of 20%. During the digestion period, the volume of biogas production and the changes in pH indicate that at neutral pH, the highest peak of gas production was attained and that at slightly acidic pH range, there was no gas production. These results showed that these wastes could be a source of renewable gas if managed properly since each of the waste sluggishly continued gas production after the 30 days retention time.

Keywords: Cow dung, brewer's spent grain, biogas, anaerobic fermentation

1. Introduction

Handling of livestock waste and plant waste that pose threat on environment has generated great pressure in many parts of the world. Livestock manure, like cow dung in the absence of appropriate disposal methods can cause adverse environmental and health problems such as: pathogen contamination, odour, air borne ammonia, green house gases, etc [1]. Anaerobic digestion has been considered as waste-to-energy technology, and is widely used in the treatment of different organic wastes, such as organic fraction of municipal solid waste, sewage sludge, food waste, animal manure, etc [2]. 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].

Anaerobic fermentation of the livestock waste generates energy which is renewable and environmental benign. 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 [4].

Biomass is the biological organic materials that are renewable and can be recycled to produce biogas. A huge amount of wastes is generated daily from the various processing industries in Nigeria. The wastes that are usually disposed off either into the sea, river, or on the land as a solid amendment materials, which causes support for breeding of flies, and constitute health hazards to people living around the area are converted into biogas by anaerobic fermentation [5].

Therefore, this work was carried out to compare biogas produced by anaerobic fermentation of cow dung and brewer spent grain.

2. Materials and Methods

The biodigester used for this work is a 50L capacity metallic prototype digester and the study was carried out Energy Centre Nsukka, Nigeria. Cow dung and brewer spent grain were the two wastes used for this study. Fresh cow dung was collected from the slaughter house, in Ugwuoba Gariki Market, Enugu, Nigeria whereas brewer spent grain waste were collected from Ama Brewery, 9th Mile Ngwo, Enugu, Nigeria. Other materials such as Top loading balance (50kg "Five goat" model Z051599), 13L calibrated plastic transparent bucket, and Digital pH meter and thermometer were used. A minimum and maximum ambient temperature of 20 ºC and 32 ºC respectively and a minimum and maximum slurry temperature of 22 ºC and 36 ºC respectively were recorded.

2.1 Substrate Preparation

The quantity of cow dung and brewer's spent grain was each mixed with water for biogas production as stated in Table 1.

Table 1: Compositions of materials in each sample.

Sample	Mass(kg)	Mass of water(kg)	Ratio
Cow dung (CD)	25	50	1:2
Brewer's spent grain (BSG)	25	50	1:2

2.2 Analytical Methods

The samples taken were analyzed for total solids (TV), volatile solids (VS), moisture content and chemical oxygen demand (COD) using the American Public Health Association standard (1998; 2005) [6, 7]. The biogas was analyzed usin digital gas analyzer.

2.3 Synthesis of biogas

Cow dung and brewer's spent grain were used as substrate in the experiments. Two 50L digesters equipped with pH probe, stirrer, and sampling port were used in this study. The working volume of the bioreactor was maintained at 37.5L and ran under uncontrolled pH, which is without acid or base solution. Experiment was carried out at 30 °C and the mixing was aided by a mechanical stirrer at a set speed of 150rpm. Each reactor was seeded with the two samples using the same organic loading rate of 6kg/m^3 and stirred for 5minutes at interval of 3h thrice daily. After 3 days retention biogas evolved from the reactor was measured and collected in a gas holder by water displacement and analyzed with gas analyzer PAC2 model. Also small quantity of the samples were withdrawn from the reactor and sent for analysis.

3. Results and Discussion

3.1 Characterization of the substrate

The properties of all the substrates used are shown in Table 2. It was shown that all samples contain total volatile solids, chemical oxygen demand (COD), volatile solid, protein, moisture content, nitrogen and carbon content. Cow dung substrate is alkaline while Brewer's spent grain is acidic.

Table 2: Characteristics of samples

S/N	Properties	Cow dung	Brewer's spent grain
1	Total volatile solids (TVS) (%)	6	10
2	Volatile solids (VS) (%)	5	8.4
3	Moisture content (%)	97	94.9
4	Carbon content (%)	4	7.5
5	Protein content (%)	0.8	3.3
6	Nitrogen (%)	0.015	0.4
7	Chemical oxygen demand (mg/l)	300	150
8	pH	8	5.08

3.2 Biogas Production

The biogas production during the period of the study is shown in Figure 1. It was observed that biogas production actually started after 3 days of observation for cow dung only. This is predicted because biogas production rate in batch condition is directly equal to specific growth of methanogenic bacteria [8]. Brewer' spent grain gas production started at the 9th day after the charging of the digester, the gas production ranges from 1.2-4.8 litres. Within the range of 9 to 18 days, biogas production increases substantially due to exponential growth of methanogens for the substrates. For the two samples studied, cow dung gave highest biogas yield while brewer's spent grain produced lower yield. This could be due to unregulated pH region employed. The pH of cow dung was found to be basic and later became neutral while brewer's spent grain was acid and later became neutral. The unregulated pH region can lead to increase/decrease in concentration of ammonia nitrogen and might be assumed to inhibit the process. It was reported by Chen *et al*., (2008) [9] that high concentration of ammonia nitrogen is toxic to anaerobes, which will decrease the efficiency of the digestion and upset the process. It is obvious from Figure 1 that cow dung is an effective feed stock for anaerobic digestion and could significantly enhance the biogas production. Similar result was reported by Umar and Ismail (2012) [10] and Sadaka and Engler (2000) [11] for cow dung.

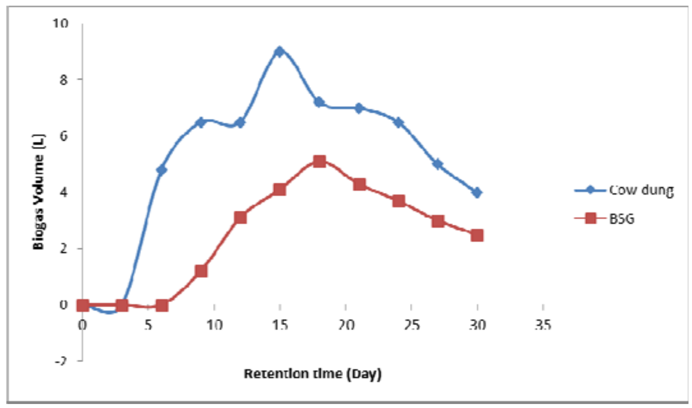

Fig 1: Production of biogas at different period

3.3 Characterization of biogas

Table 3 presented the result of cumulative gas content of the biogas produced from cow dung and brewer's spent grain. From the table, it could be observed that brewer's spent grain has the highest carbon dioxide content of 27% while cow dung has 23% content of carbon dioxide. Cow dung yield the highest biogas with methane content of 58% while brewers spent grain yielded 20% methane content. This could be that considerable amount of anaerobic bacteria in the cow dung function effectively to degrade the organic fraction to produce biogas with reasonable amount of methane content.

Table 3: Gas content of biogas produced.

S/N	Cumulative Methane CH_4 gas (%)	Cumulative CO_2 (%)	Cumulative CO (%)	Others (%)	Total
Cow dung	58	23	10	9	100
Brewer's spent grain	20	27	25	28	100

3.4 Total solids and volatile solids in bioreactor

Figure 2 shows the total solids, TS profiles of the bioreactor content during the experiment. TS destruction is a vital aspect in evaluating anaerobic digestion performance. The most effective performance in terms of TS degradation was observed in samples during digestion which could be through efficient hydrolysis in the acid phase. Slight removal of TS was observed with large fluctuation probably due to sampling difficulties. Although there is still tendency for further TS reduction with low or non-biogas production, it presumably because of the inherent hardly biodegradable constituents, consequently higher ammonia concentration contribute to process inhibition Umar and Ismail (2012) [10] reported the similar result.

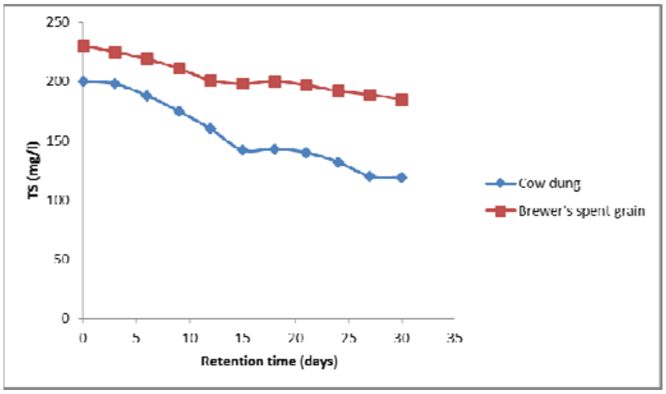

Fig 2: Total solid profile of samples

The results show that factors like temperature, pH, concentration of total solids, etc affect the production of the biogas. The ambient and slurry temperature values were monitored in determining the rate of digestion and retention of the process, since temperature is very important. The ambient temperature affects the rate of digestion due to the outside walls of the digester surface make direct contact with the atmosphere, hence the digester walls absorb or loose heat depending on the temperature gradient between the digester and its immediate environment. This implies that seasons affect the rate of heat loss or gain from the digester which in turn affects the microbial activities in the slurry at each stage. The bacterial involved may not play its role completely. Ambient temperature fluctuated due to climatic conditions. The mesophilic (20 °C – 45 °C) is the temperature range that was identified for the slurry temperature (T_s). In the mesophilic temperature, the reaction of the slurry is slower, long retention time and moderate gas production. With experiment carried out during the season showed that slurry temperature up to 32 °C can at times be recorded whereas ambient temperature varied between 20 °C and 32 °C. A pH of 7 was found to be the most favourable at the mesophilic temperature range, as the organic acids were always formed during the anaerobic decomposition process.
In general, as gas produced by the microbial is evacuated from the top of slurry, it is automatically replaced by new gas molecules formed in the slurry.

4. Conclusion

The result of this research on the production of biogas from cow dung and brewer's spent grain has shown that flammable biogas can be produced from these wastes through anaerobic digestion for biogas generation. These wastes are always available in our environment and can be used as a source of fuel if managed properly. The study revealed further that cow dung as animal waste has great potentials for generation of biogas than the brewer's spent grain and its use should be encourage due to its early retention time and high volume of biogas yields. Also in this study, it has been found that temperature variation, pH and concentration of total solid etc, are some of the factors that affected the volume yield of biogas production.

5. References

1. Harikishan S, Sung S. Cattle waste treatment and class-A biosolid production using temperaturephased anaerobic digester. Advances in Environmental Research. 2003; 7:701-706.
2. Li R, Chen S, Li X. Anaerobic co-digestion of kitchen waste and cattle manure for methane production. Energy Sources. 2009; 31:1848-1856.
3. Lopes WS, Leite VD, Prasad S. Influence of inoculum on performance of anaerobic reactors for treating municipal solid waste. Bioresource Technology. 2004; 94:261-266.
4. Ofoefule Akuzuo U. Adv. Appl. Sci. Res., 2010; 1(2):1-8.
5. Ezeonu FC. Nigerian Journal of Energy. 2002, 53-57.
6. APHA (American Public Health Association). Standard methods for the examination of water and wastewater. 20th Edition, APHA, Washington DC, 1998.
7. APHA (American Public Health Association). Standard methods for the examination of water and wastewater. 21th Edition, APHA, Washington DC, 2005.
8. Nopharatana A, Pullammanappallil PC, Clarke WP. Kinetic and dynamic modelling of batch anaerobic digestion of municipal solid waste in a stirred reactor. Waste management. 2007; 27:595-603.
9. Chen Y, Hashimoto AG. Kinetic of Methane Fermentation. Biotechnol. Bioeng. 1978; 8:269-282.
10. Umar Ibn Abubakar BS, Ismail N. Anaerobic digestion of cow dung for biogas production. Asian Research Publishing Network Journal of Engineering and Applied Science. 2012; 7(2):169-172.
11. Sadaka S, Engler C. Effects of mixing on anaerobic composting of beef manure. In: Proceeding of ASAE Annual International Meeting, Technical papers: Engineering Solutions for a New Century, 2000, 4993-5001.