Green Conversion of Abattoir Wastes to Bio-Methane under Anaerobic Condition

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Abstract: Abattoir wastes in the form of abdominal waste of Cow, Sheep and Goat were converted into bio-methane via anaerobic fermentation at mesophilic temperatures (30-35^{o}C). Slurries were prepared by adding 800ml of water to 200g of each abdominal waste giving sample to water ratio of 1:4 equivalents to 0.25gcm^{-3} slurry concentration. Each slurry was digested in a corresponding digester under anaerobic condition (absence of oxygen) to generate bio-methane within the retention period of seven weeks. The total volume of bio-methane produced over 49 days was 7.95L, 3.17L and 1.41L for abdominal waste of Cow, Sheep and Goat respectively. This indicated that the abdominal waste of Cow produced highest volume of bio-methane than abdominal waste of Sheep and Goat respectively.

Keywords: Abbattoir waste, bio-methane, anaerobic condition, green chemistry.

1. INTRODUCTION

Bio-methane is a green source of energy derived from renewable resources such as animal dung, plants and human waste. [1] It is a well established fuel for domestic and industrial uses such as cooking, heating, internal combustion and even more so electricity generation. The energy generated is economic and environmentally friendly and thus said to be green as it keeps CO_2 emission level neutral and emit no sulphur. It therefore, makes a meaningful contribution to energy supply by supplementing the conventional sources of energy supply such as firewood, coal, petroleum and natural gas. [2]

However, a tremendous amount of work has been conducted in the area of bio-methane generation using various organic matters as substrates under different conditions and operating parameters. Recent study was conducted on the production of bio-methane from the leaves and stems of Ricinus *communis* using Cowdung as reference sample. [1] The authors found out that the leaves and stems of the plant produced significantly substantial amount of bio-methane with Cowdung producing the largest volume.

In this study, the abdominal waste arising from abattoir was used to generate bio-methane. These wastes tends to pollute the environment and may cause adverse sanitary problems to the community health harboring diseases such as diarrhea, amebiasis, and parasitosis arising from soil, air or even water contamination. The conversion of these wastes to bio-methane could be green method of waste utilization and prevention of environmental pollution.

2. MATERIALS AND METHODS

2.1 Sample Collection and Processing: About 2.5 kg each of fresh abdominal waste of Cow, Sheep and Goat were collected from abattoir at Jega town during the morning hours immediately after the animals were slaughtered.

2.2 Processing of the Samples: The fresh samples were sun-dried with intermittent turning for a week. Using pestle and mortar, the dried samples were ground into fine powder. The powdered samples were, transferred into polyethylene bags and stored until needed. Thereafter, exactly 200 g of each of the three samples were weighed out and transferred into labeled containers.

2.3 Preparation of slurries and digesters: Three slurries, labeled AWC (Abdominal waste of Cow), AWS (Abdominal waste of Sheep) and AWG (Abdominal waste of Goat) were prepared by mixing 200 g of each sample in 800 ml of water giving sample to water ratio of 1:4 (w/v) equivalent to $0.25 g/cm^3$ slurry concentration. After 30 minutes, the pH of each prepared slurry was measured and recorded.

Three clean washed transparent plastic jars each having 5 litres capacities were labeled AWC, AWS and AWG. In the middle of each lid, a hole was made. Three rubber tubes (3 mm in diameter and 30 cm long) were inserted (one per tin lid) in this hole and gummed with glue. These formed the simple digesters as shown in figure 1 below.

2.4 Digester Feeding and Gas Generation: To each digester, corresponding slurry was transferred and the lid replaced and glued. One retort stand and one water trough, and a measuring cylinder filled with tap water was closed with the palms to avoid bubbles and then placed in an inverted position on the water trough. The clip of the retort stand was used to clip the cylinder upright in position as shown in figure 1 below.

The other ending of the rubber tubes were directed into the inverted measuring cylinders ensuring that air bubbles were not introduced. The inlet of the rubber tube in the cylinder appeared directed upward. The downward depression of the water in the cylinder serves as measurement of the volume of gas produced.

Fig. 1: Bio-methane generation from abdominal waste of Cow, Sheep and Goat (left to right)

2.5 Physicochemical Analysis of Samples: Physicochemical characterization of the fresh and digested samples for percentage moisture content (%MC), ash content (%AC), volatile matter (%VM), total solid (%TS), and Carbon contents (%CC) were also carried out according to the methods of AOAC (2000). [4]

3. 3. RESULTS AND DISCUSSION

3.1 Results

The results on bio-methane production are given in figure 1, 2 and 3. While for all the analyses carried out on the physicochemical characteristics of the digested and undigested samples are given in Table 1 below:

Table 1: Results on physical characteristics

S/N	Parameter	Samples					
		AWC_1	AWC_2	AWS_1	AWS_2	AWG_1	AWG_2
1	% Moisture content	1.02	1.08	1.15	1.10	1.15	1.20
2	% Ash content	8.50	10.20	9.00	10.38	5.40	6.0
3	% Volatile matter	85.30	82.65	86.80	84.40	90.50	80.70
4	% Total solid	98.40	98.45	98.85	98.65	98.55	98.55
5	% Carbon content	55.55	50.25	52.50	50.57	52.38	52.02
6	pH	7.1	7.2	7.2	7.4	6.8	7.1

***Key**: 1 = Undigested sample 2 = Digested sample.*

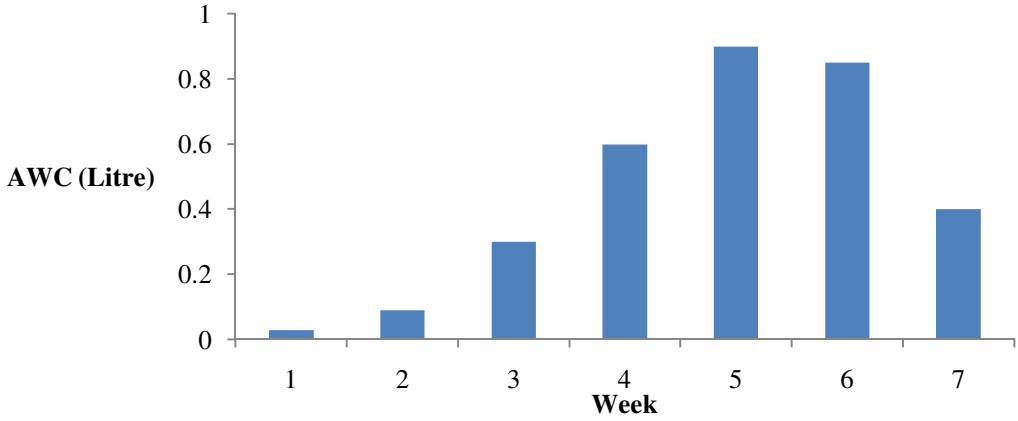

Figure 2: Weekly volume of Biogas produced from Abdominal waste of Cow

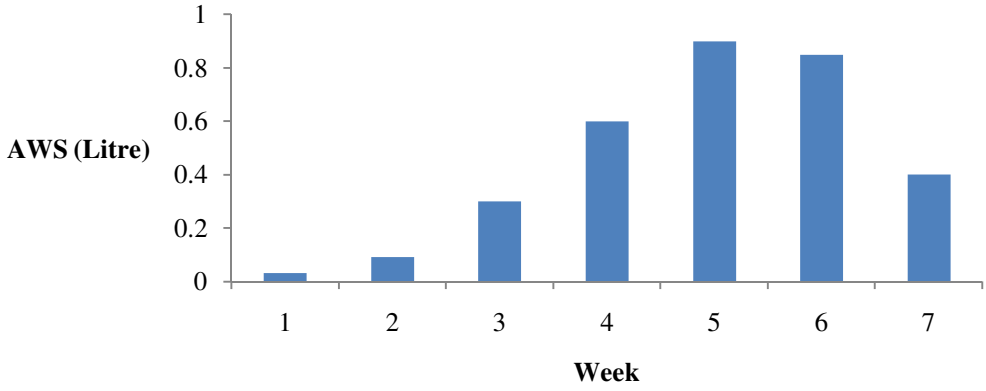

Figure 3: Weekly volume of Biogas produced from Abdominal waste of Sheep

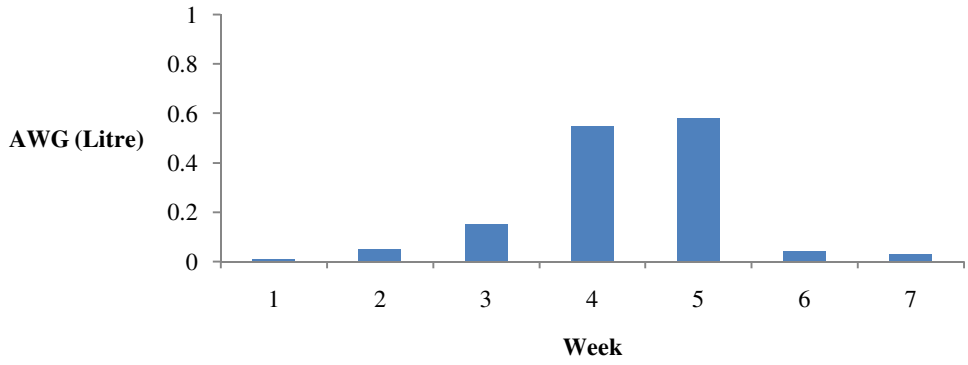

Figure 4: Weekly volume of Biogas produced from Abdominal waste of Goat

The foremost aspects of interest were the day of commencement of gas production, the peak production, the weekly cumulative and total gas yield. Bio-methane production commenced 4 hours after the set up was completed on the very first day. Abdominal waste of Cow (AWC) produced 0.02 L, while abdominal waste of Sheep (AWS) and abdominal waste of Goat (AWG) each produced gas volume of 0.005 L and 0.00 cm^3 respectively. It was observed that gas production from the abdominal waste of Goat did not start until after 24 hours and its peak occurred in the 4^{th} and 5^{th} weeks where it then slowed down to zero towards 6^{th} and 7^{th} weeks. Hence, the abdominal waste of Goat (AWG) recorded the least gas volume among the three samples (Table 1).

However, the abdominal waste of Cow and Sheep were observed to show peak volume of gas production between the 4^{rd}, 5^{th} and part of 6^{th} weeks respectively. Gas production from abdominal waste of Cow and Sheep began to depreciate to zero and fluctuated between 6^{th} and 7^{th} weeks.

It is obvious that abdominal waste of Cow is the more potentially viable substrate than abdominal waste of Sheep and Goat. Thus the biogas production capacity order for the three samples over the 12 weeks period is abdominal waste of Cow > abdominal waste of Sheep > abdominal waste of Goat.

It is worth mentioning, that the higher the moisture contents the less the volatile matter, thus higher moisture content could lead to lower gas production. It could be seen from table 2 that the moisture contents of the fresh sample varied from 1.15% in the abdominal waste of Goat to 1.02% in abdominal waste of Cow, with a range of 0.13% only, while in the digested samples, the moisture content varied from 1.20% in abdominal waste of Goat to 1.08% in abdominal waste of Cow with a range of 0.12%. It is thus deduced that the abdominal waste of Goat produced the least volume of gas due to its high moisture contents.

The result of the ash contents of the fresh and digested samples given in table 1 showed increases after anaerobic digestion. This is as a result of loss of carbon, hydrogen and oxygen out of the substrate during the fermentation process under anaerobic condition.

The results of the volatile matter contents given in table 1 suggests that the biogas production capacity order of the three samples should be AWG > AWC > AWS arguing the observed total gas volume produced. This may be attributed to the fact that, even though, the biodegradation process was terminated after 7 weeks, there contained a significant amount of volatile matter in abdominal waste of Goat and lesser quantities in abdominal waste of Cow and Sheep to have been bio-converted into bio-methane.

The remaining mineral after the moisture has been extracted from the sample at 105^{o}C is the total solid. In addition, the value for the carbon content is optimum, as carbon provides the microbes with the energy needed for their metabolic activities. The pH values for the fresh and digested samples varied from 6.8 and 7.4. Although gas production is satisfactory between 6.8 and 7.6. Garba and Sambo (1992) reported that when the pH drops below 6.8, there is a significant inhibition of methanogenesis. [3]

4. CONCLUSION

The abdominal waste of Sheep and Goat produced significantly appreciable quantity of biogas, although, abdominal waste of Cow was the most potential sample in terms of gas yield. The bio-conversion of these abattoir wastes into bio-methane is an attractive method of converting waste to wealth via preventing environmental pollution and other hazards associated with unsystematic dumping of these wastes in the environment. Thus, the bio-conversion of these wastes to bio-methane is a recommendable green process.

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