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Enhancement of biogas production by addition of bovine blood and magnesium sulphate (hard water) to the substrate

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Abstract

This research was done ascertain how to enhance biogas production by introducing Bovine blood (as source of nutrient) and $MgSO_4$ (for water hardness) into a slurry of mixture of cow and poultry dungs in a bio digester. Local digesters were fabricated. Mixture of piggery and poultry dungs were used as feedstock or substrate. The retention time of 21 days was allowed. At the end of the retention time, it was observed that; bovine blood which started with 19.9 g increased to 231 g. The set up with $MgSO_4$ which started with 24.3 g increased to 136.3 g. the last one which serve control for comparison started with 4.2 g ended up with 80 g. it was noticed that there was initial speed and increase in the set with magnesium sulphate. This is attributed to positive nature of enzymatic activities of Magnesium Sulphate. But that of bovine blood surpassed it. This research is recommending that in the production of biogas, the following should be used. First is mixture of substrate which is called co-digestion. It enhances production. Other ones include addition of bovine blood and measured amount of Magnesium sulphate. Also, the research revealed that the more bovine blood added, the more gas production enhanced.

Keywords: Substrate; Co-Digestion; Anaerobic; Biogas; Methanogen; Fermentation

1. Introduction

Biogas is a household name and has become a project many individuals, nations and organizations would want to invest into. Because of crisis in energy sector and its short fall in the wild world; there is great need for a replacement of the already used fossil generated energy. Biogas is a renewable and an eco-friendly form of energy which can substitute wood and other fuels in several applications and bring down the rising costs of petroleum products and falling of trees for energy production. Urbanisation has led to rapid production of "wastes" leading to poor management practices in developing nations. Because man must generate waste at all times and his inability to manage it well. Biogas generation has become way of waste reduction. The high standards of living has increased the release of pollutants and greenhouse gases (GHGs) into the environment.

Though biogas is environmentally friendly, it has negative implications. These implications can come when the processes that will lead to biogas generation are not followed. Also, because the gas is generated from household, compost and other degradable waste. If the wastes are not properly handled, it will become a threat to the environment. Nowadays both energy crisis and climate change are key issues all over the world. There will be severe energy shortage in the coming 50 years. According to current research and future predictions, the crude oil will run out within 40 to 70 years, and natural gas will be finished within 50 years (Courtney and Dorman, 2003). Biogas production is a sustainable solution to treat waste and the cost of the waste treatment is low (Verstraete et al., 2005). There is limited competition with food by using industrial wastewater and residues to produce biogas (Wellinger, 2009). The effluent from the biogas process supplies essential nutrients which can also be utilized as fertilizer (Vasudeo, 2005). The major raw materials or

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substrate in biogas production is the lignocellulose waste. This lignocellulose is rich in food nutrients. It has three major components.

1.1. Factors that affect anaerobic fermentation inside a digester

Biogas production through anaerobic digestion can be enhance and optimized through the following factors

- Effect of pH
- Effect of temperature
- Mixing or agitation
- Effect of organic loading rates
- Effect of hydraulic retention time
- Effect of nutrients for bacteria
- Effect of inoculation on ad process parameters
- Effect of chemical and physical pre-treatment

1.2. Aim of the research

To optimize biogas production by introducing Bovine blood (as source of nutrient) and $MgSO_4$ (for water hardness) into a slurry of mixture of cow and poultry dungs in a biodigester.

2. Materials and methods

2.1. Sample collection and analysis

The piggery and poultry samples were collected using 10 empty pain buckets of 20 litre capacity from Onyewuchi Ejiaku Farms at Ubah in Mbaoma autonomous community in Owerri North Local Government Area of Imo State as reported by Angelidaki, & Ellegaard, 2003. Batch culture anaerobic fermentation method was used. The following factors were conducted on the feed samples: N, P, K, NO_3, OC, NH_3 and COD. Units of Measurements: K, milliequivalent per litre; N, milligram per litre; P, millimole per litre; NO_3, milligram per litre; OC (organic carbon), %; COD (conductivity); S/m (Siemens per meter) were determined.

2.2. Fabrication of digester and anaerobic digestion

Ten (10) Plastic cans of twenty (20) capacity were used in the fabrication of the local digester for different treatments. Holes were bored on the corks and a hosepipes were fitted into them. Super glue was applied to ensure airtight condition to avoid leakage of gas. The hosepipes were connected to a vehicle tube and a T-valve attached to enable control of the gas entering the tubes. One (1kg) kilogram of the substrate was mixed with 2 litre of water and poured into the already fabricated digester. To one digester, one liter of bovine blood was added. To the second digester, 200g of MgSO4 per $1dm^3$ of water was added while the third one has only substrate and water. This third one serves as control.

2.3. Hydraulic retention time

This is the time the slurry will be in the digester. In this research, the retention time was 21 days.

3. Results

After the 21 days of hydraulic retention time, the following results were obtained and recorded.

Table 1 Masses of tubes for the 3 digesters for 21 days

DATE	NO 1(g)	NO 2(g)	NO 3(g)	TEMP(^{0}C)
2/4/2024	670.10	420.00	419.70	32
3/4/2024	690.00	424.20	444.00	40
4/4/2024	702.30	429.00	461.10	32
5/4/2024	710.50	432.40	470.50	35

6/4/2024	721.70	452.10	488.00	30
7/4/2024	750.40	461.50	490.80	30
8/4/2024	757.80	472.00	497.20	35
9/4/2024	770.60	481.10	510.10	29
10/4/2024	778.60	487.90	517.00	30
11/4/2024	785.70	489.00	520.70	29
12/4/2024	795.20	495.00	523.40	25
13/4/2024	880.10	496.00	540.10	30
14/4/2024	890.00	497.10	549.00	26
15/4/2024	892.80	498.20	550.00	35
16/4/2024	891.90	499.00	550.40	30
17/4/2024	899.10	500.00	556.90	29
18/4/2024	901.40	500.00	556.90	29
19/4/2024	902.90	500.20	557.00	31
20/4/2024	902.00	500.20	556.10	30
21/4/2024	901.20	500.00	556.00	33
22/4/2024	901.20	500.00	556.00	29

Table 2 Calculated Mass Of Gas From Table 1 **(M_x-M_1)**

Day	**Substrate mixed with bovine blood (No1)**	**Substrate mixed with water only (control) (No2)**	**Substrate mixed with $MgSO_4$ (hard water) (No3)**	**Temp (^{0}c)**
1	0	0	0	32
2	19.9	4.2	24.3	40
3	32.2	9	41.4	32
4	40.4	12.4	50.8	35
5	51.6	32.1	68.3	30
6	80.3	41.5	71.1	30
7	87.7	52	77.5	35
8	100.5	61.1	90.4	29
9	108.5	67.9	97.3	30
10	115.6	69	101	29
11	125.1	75	103.7	25
12	210	76	120.4	30
13	219.9	77.1	129.3	26
14	222.7	78.2	130.3	35
15	221.8	79	130.7	30
16	229	80	137.2	29

17	231.3	80	137.2	29
18	232.8	80.2	137.3	31
19	231.9	80.2	136.4	30
20	231.1	80	136.3	33
21	231.1	80	136.3	29

M_x is masses of tubes for other days, M_1 is mass of tube for day 1

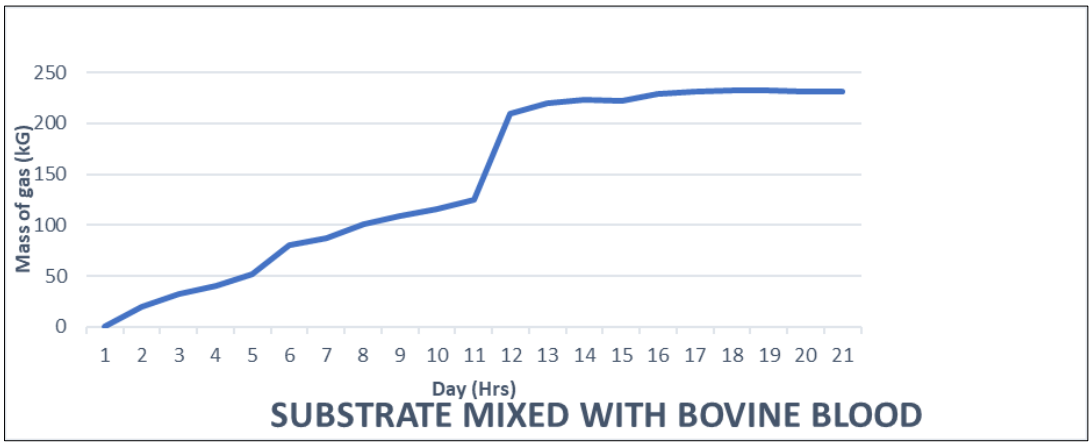

Figure 1 Graph showing the effect of bovine blood in enhancing Biogas production

Figure 2 Graph showing the effect of $MgSO_4$ in enhancing Biogas production

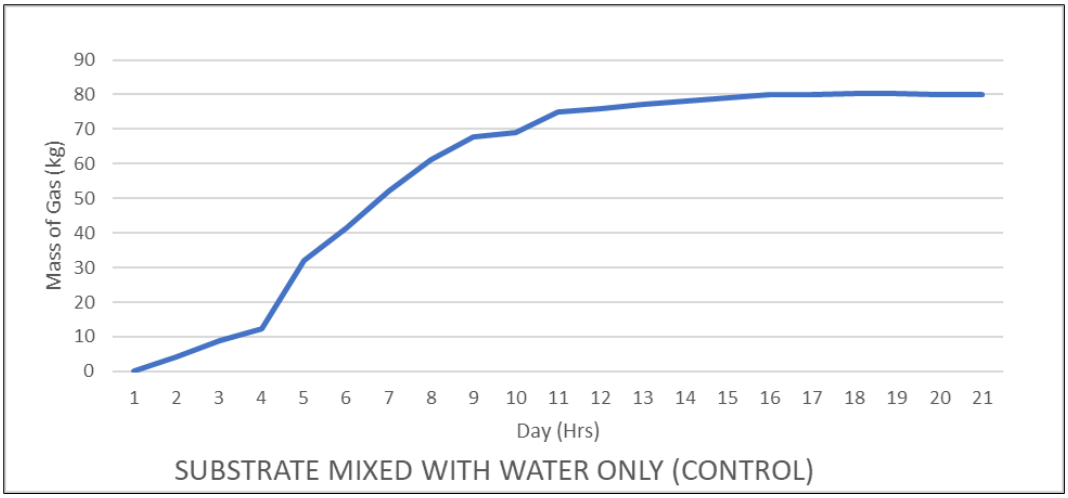

Figure 3 Graph of control set up in Biogas production

4. Discussion

This research was carried out to ascertain the effect of calculated amount of bovine blood and $MgSO_4$ in biogas production. According to Angelidaki, & Ellegaard, 2003, It was observed that the sample with the mixing ratio 5:2:1 (S3) of nutrient medium, cattle blood and rumen content respectively produced the highest cumulative biogas volume of biogas. Calcium is the most important component of hard water and it is known to be essential for the growth of certain strains of methanogens. It is also important in the formation of microbial aggregates. Calcium, Magnesium and other salts are known to be essential for the growth of certain strains of methanogens hence it plays a leading role in determining the pattern of the rate of biogas production. But when they are in excess, they will inhibit the cell growth. In this research, 200g/dm^3 of magnesium sulphate was added. Chen et al., (2007) reported that excessive amounts of calcium and magnesium salts will lead to precipitation of carbonate, sulphate and phosphate, which may result in scaling of reactors and pipes, scaling of biomass and reduced specific methanogenic activity, loss of buffer capacity and essential nutrients for anaerobic degradation.

5. Conclusion

From the result, got after 21 days of anaerobic digestion. When compared with results of other related works of many authors, I recommend as follows;

Bovine blood which contains some nutrients will help to increase bacterial growth which will in turn enhance their ability to work during hydrolysis, acidogenesis, acetonogenesis and methanogenesis. This was also reported by Sun, & Cheng, (2002)

Addition of measured amount of $MgSO_4$ will activate the enzymatic activities of various bacteria that will carry out the already above-mentioned processes.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest in this research work.

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