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Variation of factors and parameters in biogas production and resultant effect in biogas yield

Abstract

This research was done to ascertain the effect of variation of factors and parameters in biogas production and their resultant effect in biogas yield. Co-digestion of pig and poultry dungs were used as substrate for anaerobic fermentation. Nine plastic container of 4 liter capacity were used to fabricate the bio-digester and hose used to connect them to wheelbarrow tubes for gas collection. The lingo-cellulose (the co-digested mixture of pig and poultry) was allowed to stay in the digester for 14 days pending when gas production will stop during the batch culture fermentation. Bovine blood, $MgSO_4$ and Charcoal water were used as additives. For digester with blood, the cumulative gas production range for series 1, 2 and 3 are 0-74.4, 0-122.1 and 0-342.3 respectively. For the one with MgSO4, the range was 0-101.4, 0-180.7 and 0-262.3. For the last with charcoal water the range was 0-192, 0-290.3 and 0-373.3. The results shows that as the measure of the substrates as well as the additives increases, the gas production increases. This research recommend that bovine blood which contains nutrients; $MgSO_4$ which increases catalyzes of the reaction and charcoal water which increases the carbon content of reaction should be used in biogas production.

Keywords: lignocellulose, bio-digester, methane, batch culture, biogas

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Introduction

Biogas is a renewable and an environmentally friendly form of energy which can substitute wood and fossil fuels in a number of applications and thus mitigate the rising costs of petroleum products and deforestation.[1] Biogas is a combination of gases produced during anaerobic decomposition of organic materials of plant origin. It is produced from the organic wastes by a concerted action of various groups of anaerobic bacteria. 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.

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.

Some Factors that affect anaerobic fermentation are:

- Effect of pH
- Effect of temperature
- Mixing or agitation
- Effect of nutrients for bacteria
- Effect of inoculation on
- Varying of process parameters
- Effect of chemical and physical pre-treatment

These factors have effect on the reaction Wang, Wan,[3]

Aim

The aim is to vary some three factors/process parameter and ascertain their resultant effect on biogas yield.

Materials and methods

Sample collection

The substrates used in this work are the piggery and poultry dungs. They were collected from a private farm using empty rice bag and subsequently co-digested. This was done as reported by Angelidaki, Ellegaard.[4] Slurry preparation and set-up setting.

According to Ikeokwu and Osuji et al.,[5] cow, pig and poultry dungs are good substrates for biogas production. They gave enough gas yield when used. When they were co-digested, their gas production was enhanced. In this research work, different measures of poultry and pig dungs were co-digested. Also varying quantities of Bovine blood, $MgSO_4$ and charcoal water were used as additives to optimize biogas production. According to Osuji et al.,[6] Bovine blood and MgSO4 have been researched and discovered to have great effect on biogas yield and production. A total of nine (9) four liter plastic containers were used to fabricate the digester. 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 The bovine blood was measured using measuring cylinder while the Magnesium Sulphate was weighed using a digital weighing balance. The charcoal was weighed, crushed and mixed with the substrate. All mixed with two (2) liters of water.

Digester 1(Pig=100g, Poultry= 50g, Blood=100ml), Digester 2(Pig=200g, Poultry= 100g, Blood=200ml)

Digester 3 (Pig=300g, Poultry= 150g, Blood=300ml), Digester 4(Pig=100g, Poultry= 50g, $MgSO_4$= 20g)

Digester 5(Pig=100g, Poultry= 50g, $MgSO_4$= 50g), Digester 6(Pig=100g, Poultry= 50g, $MgSO_4$= 80g)

Digester 7 (Pig=100g, Poultry= 50g, Charcoal=50g), Digester 8 (Pig=100g, Poultry= 50g, Charcoal=100g)

Digester 9(Pig=100g, Poultry= 50g, Charcoal=150g)

Hydraulic retention time: This is the time the slurry will be in the digester. In this research, the retention time was 14 days pending when the set-up stopped producing gas.

Results

The following results were obtained as they are put in the tables. The masses of the tubes with gas daily were recorded and the mass of the tubes at day 0 which was 350g were subtracted to get the mass of the gas as shown in the tables below. (Figure 1)

Figure 1 Fabricated digester used in the fermentation.

Discussion

This research was carried out to vary some three factors/process parameters monitor and ascertain their resultant effect on biogas yield in the fabricated digester at the retention time of 14 days.

From table 1, series 1, 2 and 3; the reaction was at lag phase at day zero (0). The bacteria that will be involved in the four stages of biogas production are trying to adjust to the new environment. According to Osuji et al.,[5] the lignocellulose (co-digested substrate) must have to be broken down. This process will break down the recalcitrant Lignin and the Hemicellulose. From day 4, significant gas production was noticed for series 1, 2, and 3 (4.2, 8.6, and 10.1 respectively). This trend continued till day 13 which has gas production of 9.4, 14.7, and 37.8 for series 1, 2, and 3 respectively. This shows that as the volume of the substrate as well as the blood increases, the volume of gas production increases as reported by Montalvo, et al.[7]

Table 1 Gas production and cumulative gas production for pig, poultry and blood

Day	Series 1		Series 2		Series 3	
	Pig=100g Poultry= 50g Blood=100ml (g)	Cumm. Gas production. (g)	Pig=200g Poultry= 100g Blood=200ml (g)	Cumm. Gas production (g)	Pig=300g Poultry= 150g Blood=300ml (g)	Cumm. Gas production (g)
0	0	0	0	0	0	0
1	0.2	0.2	0.9	0.9	1.8	1.8
2	0.9	1.1	1.9	2.8	3.5	5.3
3	1	2.1	2.1	4.9	4	9.3
4	4.2	6.3	8.6	13.5	10.1	19.4
5	4.8	11.1	9.1	22.6	30.7	50.1
6	5	16.1	10.2	32.8	35	85.1
7	5.7	21.8	10.8	43.6	35.4	120.5
8	6.4	28.2	11.2	54.8	35.9	156.4
9	7.2	35.4	11.7	66.5	36	192.4
10	7.8	43.2	12.4	78.9	36.6	229
11	8.4	51.6	13.8	92.7	37.7	266.7
12	9.4	61	14.7	107.4	37.8	304.5
13	9.4	70.4	14.7	122.1	37.8	342.3

For table 2; the same trend of gas production was observed (as the volume of substrate and $MgSO_4$ increases, the volume of gas produced increased). The same applied for table 3 where Charcoal water was used as additive. This shows that the Carbon in C:N ratio increased, the volume of methane production increased.[8]

$$C + 2H_2O \text{ ---------- } CO_2 + H_2$$

$$C_6H_{12}O_6 + 8H_2 \text{ ---------- } 6CH_4 + H_2O$$

The carbon added will react with the water part of the slurry and hydrogen is formed. The hydrogen formed will react with the sugar from the lignocellulose. This will lead to the formation of methane.

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Table 2 Gas production and cumulative gas production for pig, poultry and $MgSO_4$

Day	Series 1		Series 2		Series 3	
	Pig=100g Poultry= 50g $MgSO_4$= 20g (g)	Cumm. Gas production (g).	Pig=100g Poultry= 50g $MgSO_4$= 50g (g)	Cumm. Gas production (g)	Pig=100g Poultry= 50g $MgSO_4$= 80g (g)	Cumm. Gas production (g)
0	0	0	0	0	0	0
1	0.2	0	0.9	0.3	1.8	0.9
2	0.9	0.3	1.9	1.2	3.5	2.2
3	1	1.3	2.1	2.6	4	4.2
4	4.2	4	8.6	9.1	10.1	12.8
5	4.8	8	9.1	16.1	30.7	23.1
6	5	13.1	10.2	26.2	35	38.5
7	5.7	20.3	10.8	36.5	35.4	59
8	6.4	28.4	11.2	54.5	35.9	86.2
9	7.2	38.6	11.7	76	36	116.6
10	7.8	52.1	12.4	101.6	36.6	150.3
11	8.4	68.4	13.8	127.7	37.7	187.2
12	9.4	84.9	14.7	154.2	37.8	224.7
13	9.4	101.4	14.7	180.7	37.8	262.2

Table 3 Gas production and cumulative gas production for pig, poultry and charcoal

Day	Series 1		Series 2		Series 3	
	Pig=100g Poultry= 50g Charcoal=50g (g)	Cumm. Gas production (g)	Pig=100g Poultry= 50g Charcoal=100g (g)	Cumm. Gas production (g)	Pig=100g Poultry= 50g Charcoal=150g (g)	Cumm. Gas production. (g)
0	0	0	0	0	0	0
1	1	1	3	3	5.2	5.2
2	2.7	3.7	7.9	10.9	10.3	15.5
3	5.8	9.5	10.3	21.2	15.7	31.2
4	9.5	19	11.7	32.9	18.6	49.8
5	10	29	17.5	50.4	20.2	70
6	12	41	20.6	71	32	102
7	18.1	59.1	22.5	93.5	35	137
8	20.3	79.4	30.1	123.6	37	174
9	21.6	101	31.7	155.3	38.9	212.9
10	22.3	123.3	32	187.3	39	251.9
11	22.7	146	33.6	220.9	39.8	291.7
12	23	169	34.7	255.6	40.8	332.5
13	23	192	34.7	290.3	40.8	373.3

From the tables and figures shown above, it was ascertained that co-digestion of substrates is a good strategy to enhance biogas production. This was also supported by Torkian et al.[1] These substrates are lignocellulose. As the stay in the biodigester, reactions will take place leading to breakdown of the cellulose, lignin and Hemicellulose,. Osuji et al,.[5] This research showed that as the amount of the substrates increases, the volume of gas produced increases. This supports the work of Ikeokwu et al.[9]

Conclusion and recommendation

Addition of charcoal water was done to increase the carbon content of C:N ration in the substrate (Lignocellulose). It has been studied in previous and reported that as the nitrogen level increases, there is the possibility of ammonia formation which will affect the Methanogens and the actions, Polizzi et al.[10] This research is recommending as follows

- That that the quantity of the substrates should be enough to ensure more gas yield as shown in series three (3) of the tables and the graphs.
- That the volume of blood should not be more than the water used in the slurry formation as this could affect proper mixing.
- That carbon content of the lignocellulose should be increased to ensure formation of Methane (CH4) which is the main biogas.
- That measured amount of bovine blood, Magnesium Sulphate and Charcoal can be used as additive in biogas production.

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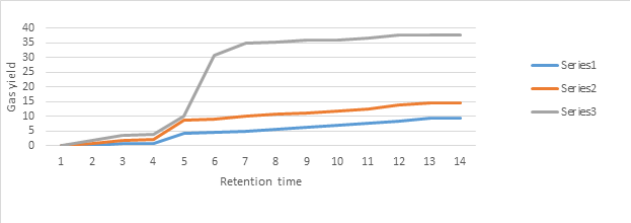
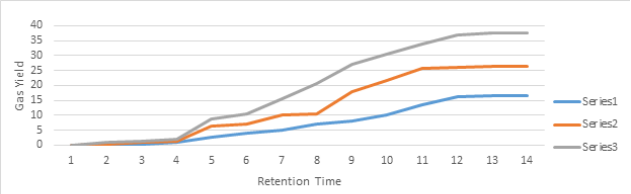
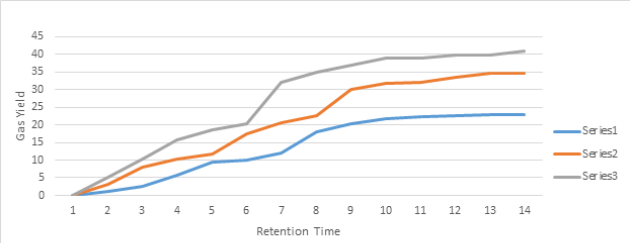
The authors are happy and acknowledge this honorable journal for the publication of this work. Graph 2 Graph showing gas production for pig, poultry and MgSO4.



Graph 1 Graph showing gas production for pig, poultry and blood.



Graph 2 Graph showing gas production for pig, poultry and MgSO4



Graph 3 Graph showing gas production for pig, poultry and charcoal.

Conflicts of interest

The authors declare there is no conflict of interest.

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