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BIOGAS PRODUCTION FROM ORGANIC WAS WASTES (COW DUG AND MELON WASTE) IN KEFFI LOCAL GOVERNMENT OF NASARAWA STATE, NIGERIA

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Abstract

This research aimed to experiment biogas production from organic was wastes (cow dug and melon waste) in Keffi Local Government of Nasarawa State, Nigeria. This aim was achieved through the following objectives. To experiment and record the daily production of biogas from cow dug and melon waste and determine the relationship between: (i) temperature and biogas yield (ii) pH and biogas yield. The following null hypotheses were tested at 95% confidence level: (i)"There is no significant relationship between amount of temperature and volume of biogas yield (ii) "There is no significant relationship between pH and volume of biogas yield. A twenty-five (25) liter capacity digester was fed up to eighty percent (80%) with cow-dug slurry mixed with grounded melon waste through the inlet pipe provided with suitable arrangements to ensure zero entry of air into the digester to achieve anaerobic conditions during substrate feeding and evacuation. All connections (cylinder, inlet and outlet pipes) were designed and operated to maintain anaerobic conditions. Gas production were recorded on daily basis from calibrated measuring cylinder to find out possible daily biogas production using cow dug and melon waste. Moreover, temperature and pH were measured and recorded alongside the volume of biogas produced on daily basis to find out the influence of temperature and pH on biogas yield. Result shows that there was no gas production for the first three (3) days, gas production started gradually on the fourth day when it recorded the smallest volume (9.50Ml) and accelerated until the twentieth (20th) day when it reached its peak (65.60Ml) and started reducing to second least volume recorded (10.50Ml) on the thirtieth (30th) day. There was a significant positive relationship between amount of temperature and volume of biogas yield at 95% confidence level but slight negative relationship was found between pH and volume of biogas yield. It was found that biogas yield increases from 0 at p H 7.8 to the peak 65.30Ml when p H have decease to 6.7 and then started decreasing as pH continue to decrease to 10.5Ml when pH became more acidic. It can be concluded that organic wastes can be utilized for biogas production.

Introduction

1.1 Background to the Study

Globally, waste management and energy supply are among the major contemporary challenges that thwart sustainable development. These challenges are more pronounced in developing countries like Nigeria largely due to increasing population and consumption which increase energy demand and waste generation. In Nigeria, dumping and burning of waste are the most common ways of managing waste and about eighty percent (80%) of Nigerian households use wood fuel and charcoal for cooking and heating(Sambo *et al.*, 2006; IEA, 2012). These practices promote environmental degradation, climate change and disease spread and therefore, unhealthy and unsustainable. Thus, the solution to cooking energy should not be fuel wood and fossil fuel which are not renewable and unfriendly to the natural environment and that of waste should not be disposal rather it should be seen as a resource by way of energy recovery, it should be converted to energy (biogas).

Biogas technology is an alternative energy source which utilizes various organic wastes in order to produce Biogas (cooking, heating and lighting), mineralized water and organic fertilizers (Ani, 2014). So, in the face of ongoing population growth, increasing rate of deforestation for fuel wood and growing demerits of fossil fuels, their finitude and unsustainability, biogas energy is becoming a favoured emerging alternative as it combat climate change, convert waste to energy and reduce the volume of waste that ends in landfills. Energy supply and waste management are crucial to the wellness of humans and to a country's economic development. Organic waste commonly generated from farm, could be fermented by anaerobic bacteria to produce a very versatile and cheap fuel (biogas) which can be utilized as fuel for small-scale industries, household cooking energy etc. Biogas production has diverse benefit economically it create wealth, job and energy, environmentally it is friendly as it reduce volume of waste.

Biogas production from organic waste has dual functions; it produces energy and organic fertilizer and at the same time reduces waste volume (Abila, 2012). The development and utilization of renewable energy should be given a high priority, especially in the light of increased awareness of the adverse environmental impacts of fuel wood usage, fossil-based generation. The need for sustainable energy is rapidly increasing in the world. A widespread use of renewable energy is important for achieving sustainability in the energy sectors in both developing and industrialized countries.

Biogas production from waste is not a new technology; historical evidence indicates that Anaerobic Digestion (AD) is one of the oldest technologies. Even around 3000 BC the Sumerians practiced anaerobic cleansing of waste (Deublein and Steinhauser, 2008). However, the industrialization of anaerobic digestion began in 1859 with first AD plant sited in Bombay India (Khanal, 2008). According to Deublein and Steinhauser (2008), other countries that pioneered the evolution of biogas technology are France, China and Germany. China is recently, credited as having the largest biogas programme in the world with over 20 million biogas plants installed (Tatlidil *et al.*, 2009).

Biogas technology was introduced in Africa between 1930 and1940 when Ducellier and Isman started building simple biogas machines in Algeria to supply farm houses with energy. Despite this early start in Africa the development of large scale biogas technology is still in its embryonic stage in this region, though with a lot of potentials (Deublein and Steinhauser, 2008).

The earliest record of biogas technology in Nigeria was in the 80s when a simple biogas plant that could produce 425 litres of biogas per day was built at Usman Danfodiyo University, Sokoto (Dangogo and Fernado, 1986). About 21 pilot demonstration plants with a capacity range of between 10m³ and 20m³ have been sited in different parts of Nigeria (Achara, Nsukka LGA, Enugu State, Ifelodun farmer's cooperative at Ojokoro, Agege lagos, ANAPRI, Zaria,Kaduna State, Kano, Yobe, Kebbi States, etc) and none is functional (Ani, 2014). However, presently efforts are being made by individuals, companies to reinstate biogas production in Nigeria. Experimentation of biogas production is ongoing in some States like Akwa Ibom, Niger, Lagos and the Federal Capital Territory (FCT) Abuja. But countries like India, United States, Pakistan and China have actualized this idea and are still thriving well (John and Twidell, 2007; Tyagi, 2009).

Thus, currently, there are moves within government agencies to make biogas more popular as a way of providing energy for cooking and organic fertilizer for farming (Onuh, 2017). With over 60% of Nigeria being engaged in agriculture, there is likelihood that demand for organic fertilizer is high and organic wastes are in abundant especially in the middle belt that are fertile due to favourable climate and geological formation. However, this favourable conditions coupled with misfortunes (desertification and Boko Haram) in the far north hove not only resulted in rapid population growth in the middle belt but also to environmental degradation (pollution of all sort) and land use conflicts. The common primary economic activity of the indigenous people is crop production. The migration of the Fulani herdsmen southwards, with majority settling in the middle belt should have been a compliment and symbiotic association if both farming and animal rearing are well planned and managed in the region. If herds are confined, animal and crop

wastes can easily be collected to produce biogas which in turn would benefit both the farmers and herders in managing their waste and energy supply.

Keffi Local Government of Nasarawa State, Nigeria is typical region in the middle belt Nigeria that is being confronted with poor waste management and energy deficiency due to rapid population growth resulting from FCT urban sprawl. Thus, there is need to key into biogas production from organic wastes that are in abundant in keffi Local Government area, Nasarawa State, Nigeria. This will add value to waste, promote sustainable energy and development in general. Thus, this research aimed to experiment biogas production from organic wastes) in Keffi Local Government of Nasarawa State, Nigeria. This will objectives. To experiment of Nasarawa State, Nigeria. This aim was achieved through following objectives. To experiment and record the daily production biogas from cow dug and melon waste and determine the relationship between (i) temperature and biogas yield (ii) pH and biogas yield.

The following null hypotheses were tested:

- i. "There is no significant relationship between amount of temperature and volume of biogas yield at 95% confidence level
- ii. "There is no significant relationship between concentration pH and volume of biogas yield at 95% confidence level

Material and Procedure

Material: the materials used for the experiment are 25 liter capacity digester constructed with valve, inlet and outlet pipes, substrates (cow dug and melon waste), water, bowl 50 liter capacity, weighing scale, and calibrated measuring cylinder with paraffin oil displacement arrangement.

Procedure

A twenty-five(25) liter capacity digester were fed up to eighty percent (80%) with cow-dug slurry mixed with grounded melon waste through the inlet pipe provided with suitable arrangements to ensure zero entry of air into the digester to achieve anaerobic conditions during substrate feeding(Ukpabi, et al., 2017). All connections (cylinder, inlet and outlet pipes) were designed and operated to maintain anaerobic conditions. For example, there were intermediate covering between the digester and feeding/ residue evacuation pipes. In the process of feeding substrate, the intermediate cover remained close while substrate is being passed through the inlet after which the inlet pipe was covered then intermediate cover w then was open to allow the feeding of substrate without entrance of air into the digester to achieve anaerobic conditions. After feeding, both entrances were closed. The digester was connected to a calibrated measuring cylinder with paraffin oil displacement arrangement to measure the volume of biogas produced (Ukpbi et al., 2017). Gas production were recorded on daily basis from the calibrated measuring cylinder to find out possible daily biogas production using cow dug and melon waste. Moreover, temperature and pH were measured and recorded alongside the volume of biogas produced on daily basis to find out the influence of temperature and pH on biogas yield. Previous studies indicated that temperature and pH influence biogas production. The mercury atmospheric temperatures were measured with thermometer while the pH values were measured from small slurry taken from the outlet device of the digester using pH meter.

Results and Discussions

Table 1 present the daily record of biogas produced from the experiment carried out

Table 4.1 Daily Record of Biogas, Temperature and pH

	Biogas (Ml)	Temperature (o _C)	pН
1	0.00	33	7.8

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2	0.00	32	
3	0.00	34	
4	9.50	35	
5	19.40	33	
6	28.60	32	
7	35.70	35	
8	39.70	35	
9	37.80	34	
10	41.60	32	
11	45.70	35	
12	48.20	36	
13	51.50	36	
14	55.20	34	
15	57.30	35	
16	59.00	33	
17	60.30	33	
18	64.20	32	

65.30

65.60

61.50 48.50

35.20

30.00

27.80

25.40

20.90

18.70

19

20

21

22

23

24

25

26

27

28

among other things that there was no gas production for the first three (3) days, gas production started gradually on the fourth day when it recorded the smallest volume (9.50Ml) and accelerated until the twentieth (20th) day when it reached its peak (65.60Ml) and started

36

34

34

36

34

35

32

34

33

34

7.8 7.6 7.4 7.4 7.2 7.3 7.4 7.1 7.2 7.1 6.9 7.0 6.9 7.0 6.9 6.8 6.8

6.7

6.7

6.5

6.6

6.5

6.3

6.5

6.3

6.2

6.0

milliliters

reducing to second least volume recorded (10.50Ml) on the thirtieth (30th) day (Figure 1).

(36Ml)

approximately.



Figure 1: The Daily Volume of Biogas Produced

Figure 1 shows zero production of biogas for the first three days. The inability of the digester to produce gas in the first three days may be due to presence of oxygen in both the digester and substrate before the setup. Thus, fermentation could not take place until the oxygen is used up by aerobic bacteria. Even after gas production has started, the volumes of biogas produced were never constant at any point however; the volumes of gas recorded were more uniform within the 14th to 21st day. Thus, standard deviation and coefficient of variation were used to determine the degree of uniformity or diversity in volume of biogas produced daily (Table 2).

Table 2: Calculation of Standard Deviation and Coefficient of Variation Between Volumes of Biogas Produced Daily

	Biogas produced		
	in Ml (Y)	Y-Y	$Y-Y^2$
1	0.00	35.95	1292.40
2	0.00	35.95	1292.40
3	0.00	35.95	1292.40
4	9.50	-26.45	699.60
5	19.40	-16.55	273.90
6	28.60	-7.35	54.02
7	35.70	35.95	1292.40
8	39.70	35.95	1292.40
9	37.80	35.95	1292.40
10	41.60	5.65	31.92
11	45.70	9.75	95.06
12	48.20	12.25	150.06
13	51.50	35.95	1292.40
14	55.20	35.95	1292.40
15	57.30	35.95	1292.40
16	59.00	23.05	531.30
17	60.30	24.35	592.92
18	64.20	28.25	798.06
19	65.30	35.95	1292.40
20	65.60	35.95	1292.40
21	61.50	35.95	1292.40
22	48.50	12.55	157.50
23	35.20	-0.75	0.56
24	30.00	-5.95	35.40
25	27.80	35.95	1292.40
26	25.40	35.95	1292.40
27	20.90	35.95	1292.40
28	18.70	-17.25	297.56
29	15.30	-20.65	426.42
30	10.50	35.95	1292.40
Total	1078.40		24822.76
Mean	35.95		

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Variance = $EY - Y^{2/N} = 24822.76/30 = 827.43$

Standard deviation =root of variance ± 28.77

Coefficient of variation (CV) sd/n×100/1

CV= 28.77/35.95×100/1=0.77×100= 77%

Decision:

The coefficient of variation (CV) being 77% shows great disparity in biogas yield

The diversity in daily output of biogas in the same digester, substrate and location may be due to fluctuation in temperature and pH concentration in the slurry. Spearman Rank correlation was used to determine the relationship between: (i) the amount of temperature and volume of biogas produced on daily basis (ii) pH concentration and volume of biogas (Table 3 and 4).

 Table 3: Spearman Rank Correlation Between the Amount of Temperature and Volume of

 Biogas

	Biogas (Ml)	Temperature	R1	R2	d (R2-R1)	d^2
1	0	33	29	22.5	-6.5	42.25
2	0	32	29	28	-1	1
3	0	34	29	16	-13	169
4	9.5	35	27	9	-18	324
5	19.4	33	23	22.5	-0.5	0.25
6	28.6	32	19	28	9	81
7	35.7	35	18	9	-9	81
8	39.7	35	14	9	-5	25
9	37.8	34	15	15	0	0
10	41.6	32	13	28	15	225
11	45.7	35	12	9	-3	9
12	48.2	36	11	3	-8	64
13	51.5	36	9	3	-6	36
14	55.2	34	8	16	8	64
15	57.3	35	7	9	2	4

16	59	33	6	22.5	16.5	272.25
17	60.3	33	5	22.5	17.5	306.25
18	64.2	32	3	28	25	625
19	65.3	36	2	3	1	1
20	65.6	34	1	16	15	225
21	61.5	34	4	16	12	144
22	48.5	36	10	3	-7	49
23	35.2	34	16	16	0	0
24	30	35	17	9	-8	64
25	27.8	32	20	28	8	64
26	25.4	34	21	16	-5	25
27	20.9	33	22	22	0	0
28	18.7	34	24	16	-8	64
29	15.3	36	25	3	-22	484
30	10.5	35	26	9	-17	289
Total						3738

 $rs = 1 - 6\epsilon d^2/n^3 - n$



=1-0.83=0.17

 $rs = 0.17 r^2$

The Spearman rank correlation coefficient (rs) being 0.17 means there is positive correlation between temperature and biogas yield. In order words, increase in temperature leads to increase in biogas yield. The significance of this positive correlation was tested using t test as follows:

$$t = \frac{\sqrt{n-2}}{1-r^2} = \frac{\sqrt{30-2}}{1-(0.17)^2} = \frac{\sqrt{28}}{0.97} = \frac{5.29}{0.97} = 5.46$$

Calculated t =5.46

Degree of freedom (n-2) i.e 30-2=28

Critical t at 28 degree of freedom = 2.76

5.46 > 2.76 (Calculated t >Critical t)

Since the calculated t value of 5.46 is greater than the critical t value of 2.76, Ho " there is no significant relationship between amount of temperature and volume of biogas yield at 95% confidence level is rejected. Therefore, there is a significant positive relationship between amount of temperature and volume of biogas yield at 95% confidence level. Thus, high temperature is an advantage to biogas production. So given the relative high temperature in Keffi Local Government Area, Nasarawa State; potential of biogas production in the study is high.

 Table 4: Spearman Rank Correlation Between the pH Concentrations and Volume of

 Biogas

	Biogas (Ml)	pН	R1	R2	d (R2- R1)	d ²
1	С	7.8	29	1.5	-27.5	756.25
2	0	7.8	29	1.5	-27.5	756.25
3	0	7.6	29	3	-26	676
4	9.5	7.4	27	4.5	-22.5	506.25
5	19.4	7.4	23	4.5	-18.5	342.25
6	28.6	7.2	19	8	-11	121
7	35.7	7.3	18	7	-11	121
8	39.7	7.4	14	6	-8	64
9	37.8	7.1	15	10.5	-4.5	20.25
10	41.6	7.2	13	9	-4	16
11	45.7	7.1	12	10.5	-1.5	2.25
12	48.2	6.9	11	15	4	16
13	51.5	7	9	12.5	3.5	12.25
14	55.2	6.9	8	15	7	49

15	57.3	7	7	12.5	5.5	30.25
16	59	6.9	6	15	9	81
17	60.3	6.8	5	16.5	11.5	132.25
18	64.2	6.8	3	16.5	13.5	182.25
19	65.3	6.7	2	18.5	16.5	272.25
20	65.6	6.7	1	18.5	17.5	306.25
21	61.5	6.5	4	21.2	17.2	295.84
22	48.5	6.6	10	20	10	100
23	35.2	6.5	16	21.5	5.5	30.25
24	30	6.3	17	24.5	7.5	56.25
25	27.8	6.4	20	23	3	9
26	25.4	6.3	21	24.5	3.5	12.25
27	20.9	6.2	22	26	4	16
28	18.7	6	24	27	3	9
29	15.3	5.8	25	28.5	3.5	12.25
30	10.5	5.8	26	28.5	2.5	6.25
Total						5010.09

 $rs = 1 - \frac{6\epsilon d^2}{n^3} - n$

 $=1-(6x5010.09/30^{3}-30)$

= 1 - (30060.54/26970)

=1- 1.11=

rs= - 0.11

The Spearman rank correlation coefficient (rs) being -0.11 means there is a slight negative correlation between concentration of pH and biogas yield. In order words, decrease in pH leads to increase in biogas yield. However, lower pH (acidic) leads to lower yield. The significance of this negative correlation was tested using t test as follows:

$$t = \frac{\sqrt{n-2}}{1-r^2} = \frac{\sqrt{30-2}}{1-(-0.11)^2} = \frac{\sqrt{28}}{0.99} = \frac{5.29}{0.99} = 5.34$$

Calculated t =5.34

Degree of freedom (n-2) i.e 30-2=28

Critical t at 28 degree of freedom = 2.76

5.34 > 2.76 (Calculated t >Critical t)

Since the calculated t value of 5.34 is greater than the critical t value of 2.76, Ho " there is no significant relationship between concentration of pH and volume of biogas yield at 95% confidence level is rejected. Therefore, there is a significant relationship between the concentration of pH and volume of biogas yield at 95% confidence level. This is because biogas production is optmal when pH is neutral. So biogas yield increase from decline in alkalinity but decline as acidity increase (Figure 4.3).



Figure 3: Relationship Between Concentration of pH and Volume of Biogas Produced

Figure 3 shows among other things that biogas yield increases from 0 at p H 7.8 to the peak 65.30Ml when p H have decease to 6.7 and then started decreasing as pH continue to decrease to 10.5Ml when pH became much lower .

Conclusion

There was diversity in daily output of biogas in the same digester, substrate and location which may be due to fluctuation in temperature and pH concentration in the slurry. There was a significant positive relationship between amount of temperature and volume of biogas yield at but slight negative relationship between pH and volume of biogas yield. It can be concluded that organic wastes can be utilized for biogas production but its use needs substitute due to fluctuation in yield

References

- Abila N (2012) Biofuels development and adoption in Nigeria: synthesis of drivers, incentives and enablers.EnergyPolicy2012;43:387–95. http://dx.doi.org/ 10.1016/j.enpol.
- Ani Nina Chioma (2014) *biogas technology Reasons why the industry is being undermined in Nigeria*. Seminar on "Biogas".www.avenamlinks.com.

Deublien, D. and Steinhauser, A. (2008) "Biogas from Waste and Renewable Resources".

- IEA, (2012) Energy from Biogas and Landfill Gas. Working Group .www.ieabioenergy.com /task/energy-from-biogas/.
- John W. and Twidell A. (2007) *Renewable energy resources*, D Weirs ELBS/E and F.N. Span Ltd., p. 310-320, 1987.
- Khanal, S.K. (2008) Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. Wiley-Blackwell.
- Onuh (2017) "The Nigeria Minister of Science and Technology Oral speech on AIT in August 7, 2017".

Sambo AS, Iloeje OCJ, Ojosu OJ, Olayande S, Yusuf AO(2006) Nigeria's Experience on the

Application of IAEA''s Energy Models (MAED & WASP) for National Energy Planning, Paper presented during the Training Meeting /Workshop on Exchange of Experience in Using IAEA's Energy Models and Assessment of Further Training Needs, pp 24–28.

Tatlidil, F., Bayramoglu, Z. and Akturk, D. (2009) Animal Manure as One of the Main Biogas

Production Resources: Case of Turkey.J. Anim. and Vet. Adv. 8(2): 2473-2476, 2009.

Tyagi T.H(2009) Batch and multistage continuous ethanol fermentation of cellulose hydrolysate

and optimum design of fermentor by graphical analysis, Biotechnology and Bioengineering, Vol. 22, Issue 9, p. 1044-1052.

Ukpabi Chibueze, Ndukwe Okorie, Okoro Oriaku, John Isu and Eti Peters (2017) The Production

of Biogas Using Cow Dung and Food Waste. International Journal of Materials and Chemistry. 7(2): 21-24.

