Utilizing Biogas Technology as Alternative Energy Source in Nigerian Urban and Peri-urban Centres

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***Abstract-* This paper proposes the utilization of biogas technology as an alternative energy source in Nigerian urban and peri-urban centres with a view to highlighting the use of cow dung, poultry droppings and pig faeces as raw materials for biogas technology. The experimental research design was employed for the study, whereby, the primary data source included the collection of substrates of cow dung, poultry droppings and pig faeces from the Ebonyi State University farm. The collection of substrates was carried out in the early hours of the morning to ensure freshness. A weight of 800 kg per substrates type was measured into each bio-digester (airtight system of 25 liters plastic containers) instrument. About 1600ml quantity of water was added to each bio-digester containing each substrate. The temperature, pH and volume/quantity of gas produced was recorded daily. The pH was measured by an electronic pH meter while temperature was measured by mercury in glass thermometer. Results revealed that total gas generated by cow dung substrates was 25.23 and 49.97 for both CO_2 and CH_4 gas; pig faeces generated 21.72 and 62.97 for both CO_2 and CH_4; while the amount of gas generated by poultry droppings substrates was 18.97 and 63.37 for both CO_2 and CH_4. It was revealed that cow dung generated the lowest level of CH_4 gas which makes it more environmentally friendly. The findings also showed that temperature not pH significantly correlated with the amount of gas generated by substrates in the biogas technology experiment. The study further revealed that biogas can be generated from cow dung, pig faeces and poultry droppings through fermentation using fresh substrates. The study therefore recommended the use of biogas as alternative source of energy in Nigeria so that ecological disasters such as deforestation, desertification and climate change can be arrested or mitigated.**

***Index Terms-* Biodigester, Environmental-friendly, Mitigate, Renewable- energy, Substrate, Urban**

I. INTRODUCTION

The process of using fossil fuels as the major source of energy has resulted in environmental degradation, global climate change and numerous human health challenges [1]. In every development, improper waste management poses a major challenge. This results from increased industrial, commercial, agricultural and environmental activities which has caused the generation of large quantities of waste [1]. At the point when these wastes are not properly managed, they add to unhygienic ecological conditions which breads pathogenic microorganisms and the resultant havocs in most urban and peri-urban centres. In this way, when the environment is not clean, it makes it look ugly. Besides, these wastes can be made valuable and ecologically useful as biogas. Biogas is a gas obtained from the anaerobic breakdown of wastes [2],[3]. It is a sustainable power source like sun oriented and wind. This biogas can likewise be produced from provincially accessible crude materials and reused wastes and this lessens the measure of carbon discharged into the air through conventional strategies. So also, biogas ordinarily alludes to a gas delivered by the natural breakdown of organic matter without oxygen.

Biogas is an inexhaustible, elective and practical type of energy which is determined by the aging of biodegradable materials, for example, fertilizer, sewage, city waste, plant materials and crops [4],[3]. The issue of the utilization of sustainable energy sources in urban and peri-urban centres is vital to the development of nations [5]. Animal waste administration has turned into a significant issue in many parts of the world and if sufficient measures are not taken to eradicate it, a great deal of health/ecological issues will be dominant in most urban and peri-urban centres[6]. Vast amounts of dairy animals' excrement, poultry and pig droppings created every day is on the high side, which are generally arranged into landfills or connected to dispose without treatment [4]. Animal wastes are discovered for all intents and purposes in all parts of the world with Nigeria delivering around 227,500 tons of new waste every day, and 1kg of animal waste can create around 6.8million m3 of biogas day by day which is around 3.9million liters of oil [7],[8].

Biogas can be utilized both in the urban and peri-urban settlements. The biogas plant can be created utilizing locally accessible materials particularly here in Nigeria [9]. Biogas innovation reduces health conditions and ecological risks. The biogas delivered can be utilized in industries and at homes for cooking, running engines, electrical power generation and warming machines, with next to zero contamination discharged. This gas is presently utilized in numerous nations of the world [10]. Biogas and other such biofuels are today beginning to end up being utilized at an increasing amount around the globe in appreciable quantities both locally and modern, and in this capacity, it could be one of the responses to the world's energy issues, diminishing worldwide global warming. Biogas, which comprises for the most part, methane (CH_4), which gave rise to the expression "Bio methane", is additionally delivered when family organic waste and agricultural slurries and composts are separated because of their disintegration by micro-organisms; life forms in an encased biogas digester

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[8]. Thus, in light of the fact that biogas is gotten from decayed biogenic material, its utilization as a kind of biofuel in this way, makes it less expensive and temperate for cooking. Biogas can be fundamentally utilized for direct uses, for example, heating and cooling yet this sustainable asset can likewise be utilized as a part of a wide range of applications that will be advantageous to the earth and the economy from warming, to power generation and notwithstanding moving up to flammable gas quality.

Several researchers have carried out experiments related to biogas production. Literature reveals information about various input (substrates) used for biogas generation, effect of operating conditions, various pre-treatment methods employed for improved biogas output, various substrates used for co-digestion in bioreactors etc. Some of the findings mentioned in literature are noted in this paper. Of special interest is the study of [11] on biogas production using cow dung from Abakaliki abattoir in south-eastern Nigeria which revealed that biogas production was less and gradual in the first week of the investigation. [12] carried out experimental investigation of biogas generation from co-digestion of dairy manure and food waste. A first order kinetics model is developed to calculate the methane yields from different inputs. [13] have used 8.0-liter capacity laboratory scale digesters for co-digestion of press water and food waste. Addition of press water or food waste to bio waste co-digestion resulted in buffer capacity, allowing very high loadings without pH control. Magnesium catalyst also improves reliability of biogas plants.

In addition, [14] carried out bio methane potential tests (BMP tests) to check methane generation potential of cotton stalk, cotton seed hull and cotton oil cake. The results indicate that cotton wastes are good sources of biogas. Approximate production of methane from 1 g of cotton stalk, cotton seed hull and cotton oil cake were found to be 65 ml, 86 ml and 78 ml respectively. Hydraulic retention time was kept to be 23 days. [15] on their own, experimented with parametric study of floating type biogas plant. A floating type digester made up of aluminum having volume 0.018 m3capacity and 30 kg slurry capacity were studied in ambient conditions for a retention period of 85 days.

[16] also undertook experimentation on jatropha and pongamia oil cakes in a 20m3/day limit gliding drum biogas plant under mesophilic conditions. The normal gas generation was seen to be 0.394 m3/kg TS and 0.427 m3/kg TS while methane rate was observed to be 66.6 % and 62.5% separately for jatropha and pongamia oil cakes. The biogas generated from jatropha and pongamia oil cakes contains 15-20% more methane than biogas created from cows' dung. [17] performed investigation on anaerobic processing of bloom and vegetable wastes. A research center scale anaerobic absorption of vegetable wastes (brinjal, cabbage, carrot, ladies' finger) and blooms (jasmine, dusk blossom, Roselle, African wattle, Nile tulip bloom, silk tree mimosa) were performed. Digester of one-liter limit was utilized and cow manure has been utilized as an inoculum. Substrate to inoculums proportion of 1:1 has been encouraged to the digester. The substrate focuses are shifted, for example, 5%,7%, and 10% was utilized and measure of gas delivered was dissected utilizing computerized weight check. The Results acquired demonstrated that blooms had given higher yield of biogas than vegetable squanders and the absorption time frame was less. The normal biogas creation capability of wilted blooms was seen as 16.69 g/kg in 4.5days, where if there should arise an occurrence of vegetable squanders it was 9.089g/kgS in 6 days. It is presumed that bloom waste can be a decent potential substrate for biogas creation.

Similarly, the urban and peri-urban centres in Nigeria is rapidly expanding due to rapid urbanization alongside expanding interest for energy. Biogas can therefore be utilized as a wellspring of elective energy for the general population of Nigerian urban and peri-urban settlements [18]. Biogas can also be used as an effective way of dealing with organic wastes, dung, crop residues and dead cattle organs while making optimal use of their nutrient content in the generation of energy; because it is a clean source of energy [19],[3]. This present study however, is unique because of the use of three different animal waste as raw materials for biogas production (cow dung, poultry droppings and pig faeces).

A Hypotheses

Two null hypotheses were tested in this study:

H_o:Thereis no statistically significant relationship between temperature and the amount of gas generated by substrates.

H_o:There is no statistically significant relationship between pH andtheamount of gas generated by substrates.

II. MATERIALS AND METHODS

This experimental research was limited to the poultry and animal ranch located in Ebonyi State University and Presco abattoir located within the Ebonyi State University host community.

The data used for the study were mainly from primary and secondary data sources. The primary data source included the collection of substrates of cow dung, poultry droppings, and pig feces from the Ebonyi State University farm and Presco abattoir. The collection of cow dung, poultry droppings and pig feces were in large quantities and this was carried out in the early hours of the morning in order to ensure that the freshness of the substrates are maintained for the study.

The University farm has 100 cows, 150 pigs and 300 birds respectively. Large quantities of the dungs and droppings were generated daily on the ground. These wastes were collected and used to carry out the analysis for the study. A total of 800 kg of animal wastes was used for each of the bio-digesters containing the substrates (cow dung, pig feces and poultry droppings) and about 1600 ml of water was added to each of the bio-digesters containing the substrates in the ratio 1:2 to form slurry.

Purposive sampling technique was employed for the study because substrates collection from the poultry and abattoir were done in the early hours of the day to retain their freshness. Descriptive and inferential statistics was used for the study. The data collected were presented in tables and charts. Descriptive statistics was used to explain the quantity of gas generated and their pH and temperature levels, while also using the One-way Analysis of Variance (ANOVA) for level of variation among sampled substrates. The two stated hypotheses for the study were tested using Pearson

Correlation Statistics. The data collected on temperature and pH were regarded as the independent variable (X) while each of the data obtained on the quantity of gas was regarded as the dependent variable (Y). Student's t-test was used to test the level of significance of the hypothesis.

A Study Area

Ebonyi State is located geographically between latitude 6^{o}15'00''N and Longitude 8^0 05' 00 E in the South East derived savanna zone of Nigeria (Fig. 1). Ebonyi state was created from parts of both Enugu State and Abia State, which were at first constituents of the old Anambra and Imo States separately. It is home to six tertiary education institutions: Ebonyi State University, Abakaliki (EBSU), Federal University Ndufu Alike Ikwo (FUNAI), Ebonyi State College of Education Ikwo (EBSCOEI), AkanuIbiam Federal Polytechnic, Unwana College of Health Sciences, Ezzamgbo and Federal College of Agriculture, Ishiagu, (FECAI, 2017).

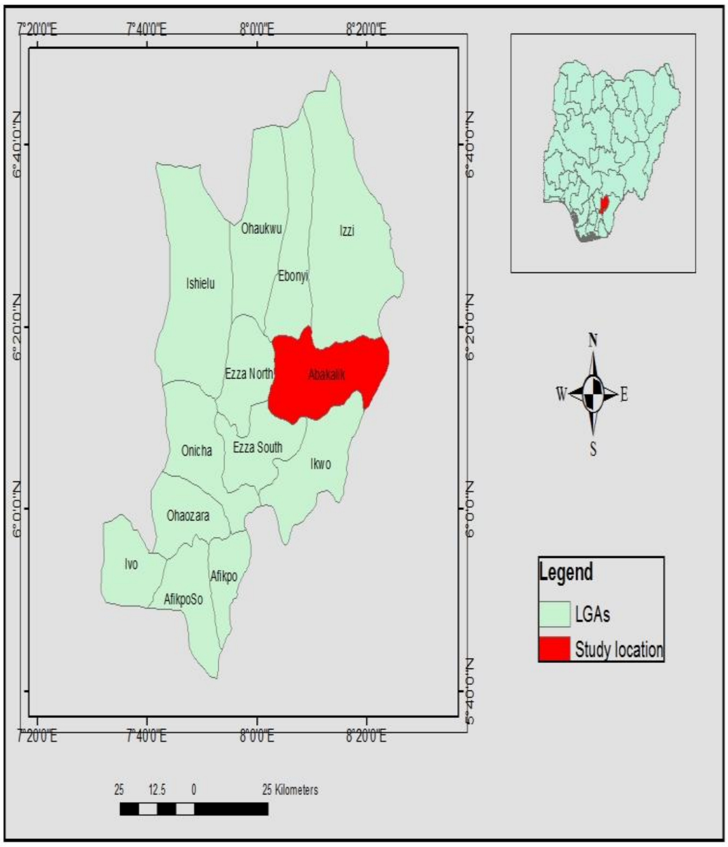

Figure 1: Ebonyi State Showing the Study Area (Abakaliki)

Source: Cartography/GIS Laboratory, Department of Geography and EnvironmentalManagement, University of Port Harcourt, Nigeria

The climate of Ebonyi State is found within the humid tropical climate regions. It experiences one rainy season and one dry season (8 months of rainfall and 4 months of dryness). Harmattan is felt between December and January. The mean yearly temperature remains at 280^{0}C. The temperature in the dry season ranges from 20^{o}C to 38^{o}C and from 16^{o}C to 28^{o}C during the blustery season. The mapped territory has a mean yearly precipitation of 2500mm. Mugginess here is around 50-60% for every annum.

The study area is geographically underlain by the Abakaliki Shale Formation of the Asu River Group. The Asu River Group dregs are overwhelmingly shales, and limited events of sandstones, siltstone and limestone intercalations [21]. It was by and large accepted to have begun storing in the mid-Albian period and was saved inside the lower (or southern) Benue Trough, southeastern [21]. The noteworthy stream that channels in the territory is the Ebonyi River and its tributaries, Udene and Iyiokwu Rivers. The drainage is dendritic in pattern, as a function of lithologic control. The study area is mainly drained by Iyiokwu River, Iyiudene River and Ebonyi River with few major drainage flows. All these, both the major and minor drainage systems flow eastward to join the Cross river [22].

The soil of Abakaliki and its environs is basically clayey, loamy and clayey loam soils. The clayey swampy soil is suitable for rice farming while the other types of soil can be used for cassava cultivation [21]. The vegetation of Abakaliki and its environs is luxuriant vegetation of tropical rainforest, savanna grassland and swamps. Its vegetation is densely populated with grass and trees of different sizes in the area. The area is marked by undulated range of shale outcrops and the shales are either greyish or reddish brown in color depending on its content and degree of weathering [21].

III. RESULTS/DISCUSSIONS

A Quantity of Gas Generated by Substrates

The quantity of gas (CO_2 and CH_4) generated by substrates were presented on Table1 and this shows the variation in the volume of gas produced after 30 days. In the first 6, 9 and 11 days respectively, there was no evidence of gas production in the bio digesters. This could be because the inoculum is either in the lag phase or the methanogens are undergoing a metamorphic growth process. The first gas was produced on the 8th day for cow dung, 10th day for the pig feces and 12th day for the poultry droppings. There were fluctuations in the amount of gas generated by the cow dung, pig feces and poultry droppings which may be due to poor weather conditions. The variations in the volume of gas (CH_4) produced after 30 days shows that the gas was produced daily except for the cow dung which was produced on the 7th day.

In addition, the mean quantity of gas for CO_2 generated by cow dung (25.23) was the highest, followed by the pig feces (21.72) and the poultry droppings (18.97) respectively. The distribution also showed that the poultry droppings generated more CH_4 of 63.37, followed by pig feces of 62.97 and cow dung of 49.97. However, when the total gas generated (CO_2 and CH_4) for the study was computed the cow dung substrate (108.00) generated the highest quantity of gas more than pig feces (104.00) and poultry droppings (102.80) in the sampled experiment. This was also illustrated on Figure 2.

Table 1: Quantity of Gas Generated by Substrates

Days	Substrates					
	Cow Dung		Pig Feces		Poultry Droppings	
	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4
1	0	0	0	52	0	60
2	0	0	0	50	0	60
3	0	0	0	50	0	55
4	0	0	0	52	0	56
5	0	0	0	54	0	56
6	0	0	0	56	0	58
7	0	0	0	58	0	60
8	30	50	0	58	0	60
9	35	55	0	60	0	62
10	29	59	0	62	0	64
11	28	63	30	63	0	65
12	27	68	31.3	65	0	66
13	30	60	32.7	66	30.0	68
14	29	70	32.0	66	30.6	69
15	33	70	32.6	67	30.9	69
16	35	69	32.6	68	31.2	69
17	32	67	32.8	68	31.7	70
18	34	65	33.0	68	32.0	70
19	36	68	33.5	70	32.4	70
20	38	70	34.0	70	32.8	70
21	33	68	32.7	68	30	55
22	30	63	32	65	30.9	56
23	29	60	32.8	66	30.6	58
24	36	65	32.6	67	31.2	60
25	38	67	31.3	66	31.7	62
26	32	65	33.5	66	32.4	64
27	35	68	33	62	32.8	65
28	34	69	32.7	68	32.4	66
29	36	70	32.6	68	32.8	68
30	38	70	34	70	32.8	70
Min.	**0.00**	**0.00**	**0.00**	**50.00**	**0.00**	**55.00**
Max.	**38.00**	**70.00**	**34.00**	**70.00**	**32.80**	**70.00**
Mean	**25.23**	**49.97**	**21.72**	**62.97**	**18.97**	**63.37**
SD.	**14.46**	**28.42**	**15.64**	**6.31**	**15.77**	**5.25**

Source: Authors Field Analysis, 2019
*Min- Minimum ; Max- Maximum ; SD. - Standard Déviations

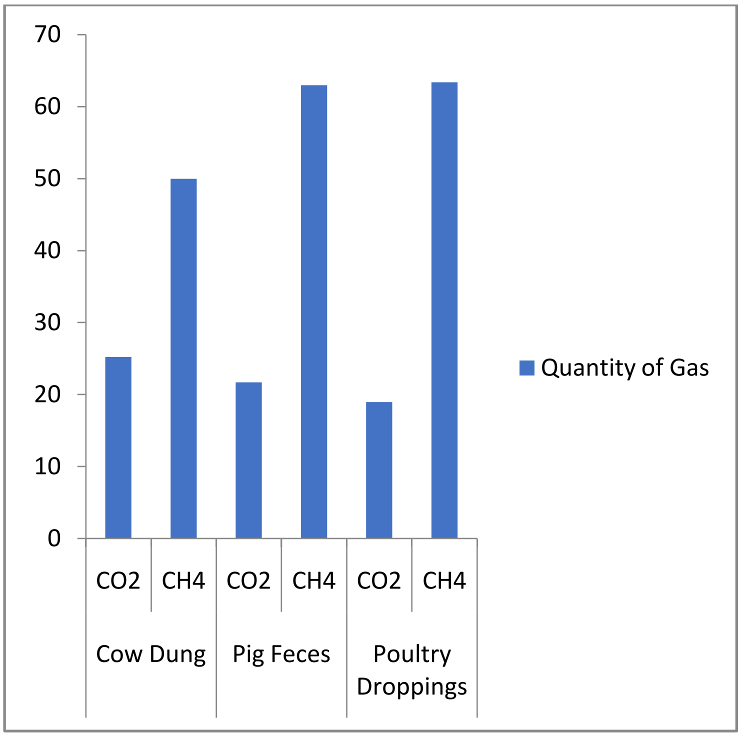

Figure 2: Quantity of Gas Generated by Substrates

B Variation Among Substrates in Quantity of Gas Generated

Table 2 below presents information about the variation in the volume of gas generated by substrates. The results revealed that the F-ratio for the distribution were 1.261 for CO_2 and 5.980 for CH_4 and this indicated a significant level of 0.289 for CO_2 and 0.004 for CH_4 at p=0.05. Thus, no variation existed among substrates as measured by CO_2, but existed among substrates as measured by CH_4. This was because the significant level of 0.289 for CO_2 was higher than p-value of 0.05, while the significant level of 0.004 was lower than p-value of 0.05.

Table 2: Variation in the Quantity of Gas Generated by Substrates

		Sum of Squares	Df	Mean Square	F-ratio	Significant at 0.05 p-value	Decision
CO_2	Between Groups	590.702	2	295.351	1.261	0.289	Not Significant
	Within Groups	20378.759	87	234.239			
	Total	20969.461	89				
CH_4	Between Groups	3487.200	2	1743.600	5.980	0.004	Significant
	Within Groups	25366.900	87	291.574			
	Total	28854.100	89				

Source: Authors Field Analysis, 2019

The information concerning the variation of temperature with fermentation time of the sampled substrates for the study is displayed on Table 3. The quantity of gas (CO_2 and

CH_4) generated per substrate as influenced by mean temperature (^{0}C) rate is also displayed on Table 4. The mean temperature rate was highest under the pig substrate (32.90 ^{0}C), followed by cow substrate of 30.87 ^{0}C and 30.86 ^{0}C for poultry substrate.

Table 3: Variation in Temperature with Fermentation Time

Days	**Temperature (^{0}C)**		
	Pig	**Cow**	**Poultry**
1	31.0	25.0	29.2
2	30.5	28.2	25.0
3	25.0	28.6	27.3
4	27.0	29.0	29.4
5	29.4	29.4	29.9
6	29.7	29.8	30.0
7	30.5	30.0	30.7
8	32.6	30.2	30.9
9	34.4	30.6	31.0
10	34.8	30.9	31.2
11	34.9	31.6	31.6
12	35.0	31.9	31.9
13	35.2	32.0	32.0
14	35.4	32.2	32.6
15	35.5	32.6	32.6
16	35.7	32.9	32.7
17	35.9	33.1	32.9
18	36.0	33.3	33.1
19	36.2	33.6	33.4
20	36.8	34.0	33.6
21	34.8	29.4	29.4
22	36.0	31.6	31.6
23	35.5	33.1	30.3
24	32.6	25.0	30.7
25	27.0	30.9	33.4
26	31.0	34.0	32.6
27	25.0	31.9	32.0
28	36.8	28.2	29.9
29	36.2	33.3	25.0
30	30.5	29.8	30.0
Min.	**25.00**	**25.00**	**25.00**
Max.	**36.80**	**34.00**	**33.60**
Mean	**32.90**	**30.87**	**30.86**
SD.	**3.59**	**2.36**	**2.19**

Source: Authors Field Analysis, 2019

Table 4: Gas Quantity as Influenced by Temperature

	Cow Dung			Pig Feces			Poultry drop		
	Temp. (^{0}C)	CO_2	CH_4	Temp (^{0}C)	CO_2	CH_4	Temp (^{0}C)	CO_2	CH_4
1	31	0	0	25	0	52	29.2	0	60
2	30.5	0	0	28.2	0	50	25	0	60
3	25	0	0	28.6	0	50	27.3	0	55
4	27	0	0	29	0	52	29.4	0	56
5	29.4	0	0	29.4	0	54	29.9	0	56
6	29.7	0	0	29.8	0	56	30	0	58
7	30.5	0	0	30	0	58	30.7	0	60
8	32.6	30	50	30.2	0	58	30.9	0	60
9	34.4	35	55	30.6	0	60	31	0	62
10	34.8	29	59	30.9	0	62	31.2	0	64
11	34.9	28	63	31.6	30	63	31.6	0	65
12	35	27	68	31.9	31.3	65	31.9	0	66
13	35.2	30	60	32	32.7	66	32	30	68
14	35.4	29	70	32.2	32	66	32.6	30.6	69
15	35.5	33	70	32.6	32.6	67	32.6	30.9	69
16	35.7	35	69	32.9	32.6	68	32.7	31.2	69
17	35.9	32	67	33.1	32.8	68	32.9	31.7	70
18	36	34	65	33.3	33	68	33.1	32	70
19	36.2	36	68	33.6	33.5	70	33.4	32.4	70
20	36.8	38	70	34	34	70	33.6	32.8	70
21	34.8	33	68	29.4	32.7	68	29.4	30	55
22	36	30	63	31.6	32	65	31.6	30.9	56
23	35.5	29	60	33.1	32.8	66	30.3	30.6	58
24	32.6	36	65	25	32.6	67	30.7	31.2	60
25	27	38	67	30.9	31.3	66	33.4	31.7	62
26	31	32	65	34	33.5	66	32.6	32.4	64
27	25	35	68	31.9	33	62	32	32.8	65
28	36.8	34	69	28.2	32.7	68	29.9	32.4	66
29	36.2	36	70	33.3	32.6	68	25	32.8	68
30	30.5	38	70	29.8	34	70	30	32.8	70

Source: Authors Field Analysis, 2019

C Relationship between Temperature and Sampled Substrates

The relationship between temperature and each substrate used for the study was computed using the information on Table 4. The results of the analysis are shown on Table 5 below and it revealed that temperature significantly influenced the quantity of gas (CO_2 and CH_4) generated by substrates of cow dung, pig feces and poultry droppings. Interestingly, all relationship was significant and relatively high between temperature and cow dung and pig feces. That is, at p=0.05, r=0.550 (CO_2) and 0.606 (CH_4) for cow dung and r=0.522 (CO_2) and 0.571 (CH_4) respectively. The relationship was significant but a low relationship between temperature and poultry droppings, p=0.05 was r=0.384 (CO_2) and r=0.465 (CH_4). Therefore, it can be concluded that temperature has influence on the quantity of gas generated by substrates. The correlation of determination further explained that temperature can only explain 30.25% and 36.24% of quantity of gas generated by CO_2 and CH_4 for cow dung; 27.25% and 32.60% of gas generated by CO_2 and CH_4 for pig feces; and 14.75% and 21.62% of quantity of gas generated by poultry droppings CO_2 and CH_4.

Table 5: Relationship between Temperature and Sampled Substrates

G T	Gas Type	Cow Dung			Pig Feces			Poultry droppings		
		r	r^2	Coefficient of Determination	r	r^2	Coefficient of Determination	r	r^2	Coefficient of Determination
C	CO_2	*0.550	0.3025	30.25	*0.522	0.2725	27.25	*0.384	0.1475	14.75
C	CH_4	*0.602	0.3624	36.24	*0.571	0.3260	32.60	*0.465	0.2162	21.62

Source: Authors Field Analysis, 2019
*****Correlation significant at 0.05

D Variation in pH with Fermentation Time

The information concerning the variation in pH with fermentation time of the sampled substrates for the study was displayed on Table 6. The quantity of gas (CO_2 and CH_4) generated per substrate as influenced by mean pH level was also displayed on Table 7. The mean pH level was highest under the pig substrate (7.71), followed by cow substrate of 7.54 and 7.21 for poultry substrate.

Table 6: Variation of pH with Fermentation Time

Days	Pig	Cow	Poultry
1	7.2	7.05	6.37
2	6.89	7.22	6.41
3	7.69	7.78	6.49
4	7.7	7.3	6.68
5	7.7	7.26	6.95
6	7.75	7.36	6.32
7	7.79	7.34	7.44
8	7.77	7.29	7.42
9	7.74	7.32	7.45
10	7.72	7.31	7.47
11	7.74	7.54	7.49
12	7.76	7.68	7.51
13	7.75	7.75	7.53
14	7.79	7.79	7.55
15	7.8	7.82	7.57
16	7.82	7.8	7.59
17	7.83	7.83	7.62
18	7.85	7.85	7.64
19	7.86	7.86	7.68
20	7.9	7.9	7.72
21	7.81	7.78	7.47
22	7.7	7.69	6.95
23	7.74	7.05	7.45
24	7.8	7.05	6.37
25	7.88	7.86	6.49
26	7.2	7.42	6.32
27	7.6	7.81	7.55
28	7.69	7.2	7.68
29	7.83	7.9	7.72
30	7.9	7.31	7.51
Min.	**6.89**	**7.05**	**6.32**
Max.	**7.90**	**7.90**	**7.72**
Mean	**7.71**	**7.54**	**7.21**
SD.	**0.22**	**0.29**	**0.51**

Source: Authors Field Analysis, 2019

Table 7: Gas Quantity as Influenced by pH

D	Pig			Cow			Poultry		
	pH	CO_2	CH_4	pH	CO_2	CH_4	pH	CO_2	CH_4
1	7.2	0	0	7.05	0	52	6.37	0	60
2	6.89	0	0	7.22	0	50	6.41	0	60
3	7.69	0	0	7.78	0	50	6.49	0	55
4	7.7	0	0	7.3	0	52	6.68	0	56

5	7.7	0	0	7.26	0	54	6.95	0	56
6	7.75	0	0	7.36	0	56	6.32	0	58
7	7.79	0	0	7.34	0	58	7.44	0	60
8	7.77	30	50	7.29	0	58	7.42	0	60
9	7.74	35	55	7.32	0	60	7.45	0	62
10	7.72	29	59	7.31	0	62	7.47	0	64
11	7.74	28	63	7.54	30	63	7.49	0	65
12	7.76	27	68	7.68	31.3	65	7.51	0	66
13	7.75	30	60	7.75	32.7	66	7.53	30	68
14	7.79	29	70	7.79	32	66	7.55	30.6	69
15	7.8	33	70	7.82	32.6	67	7.57	30.9	69
16	7.82	35	69	7.8	32.6	68	7.59	31.2	69
17	7.83	32	67	7.83	32.8	68	7.62	31.7	70
18	7.85	34	65	7.85	33	68	7.64	32	70
19	7.86	36	68	7.86	33.5	70	7.68	32.4	70
20	7.9	38	70	7.9	34	70	7.72	32.8	70
21	7.81	33	68	7.78	32.7	68	7.47	30	55
22	7.7	30	63	7.69	32	65	6.95	30.9	56
23	7.74	29	60	7.05	32.8	66	7.45	30.6	58
24	7.8	36	65	7.05	32.6	67	6.37	31.2	60
25	7.88	38	67	7.86	31.3	66	6.49	31.7	62
26	7.2	32	65	7.42	33.5	66	6.32	32.4	64
27	7.6	35	68	7.81	33	62	7.55	32.8	65
28	7.69	34	69	7.2	32.7	68	7.68	32.4	66
29	7.83	36	70	7.9	32.6	68	7.72	32.8	68
30	7.9	38	70	7.31	34	70	7.51	32.8	70

Source: Authors Field Analysis, 2019

E Relationship between pH and Sampled Substrates

The relationship between pH and each substrate used for the study was computed using the information on Table 7. The results of the analysis were displayed on Table 8 below and it revealed that pH significantly influenced the quantity of gas (CO_2 and CH_4) generated by substrates of cow dung, pig feces and CH_4 for poultry droppings. However, the relationship between pH and CH_4 for poultry substrate was relatively high because r=0.631 at p=0.05 was significant. The relationship was significant but a low relationship (except for CO_2 for cow dung r=0.522 at p=0.05) between pH and pig feces and cow dung because CO_2 and CH_4 of r= 0.467, 0.452, and 0.460 at p=0.05. Therefore, it can be concluded that pH to some extent have influence on quantity of gas generated by substrates except for CH_4 under the poultry droppings substrate. The correlation of determination further explained that pH can only explain 22% and 20% of quantity of gas generated by CO_2 and CH_4 for pig feces; 27.20% and 21.2% of gas generated by CO_2 and CH_4 for cow dung substrate; and 12.2% and 40% of quantity of gas generated by poultry droppings for CO_2 and CH_4.

Table 8: Relationship between pH and Sampled Substrates

Gas Type	Cow Dung			Pig Feces			Poultry droppings		
	r	r^2	Coefficient of Determination	r	r^2	Coefficient of Determination	R	r^2	Coefficient of Determination
CO_2	*0.467	0.22	22.00	*0.522	0.272	27.20	0.349	0.122	12.2
CH_4	*0.452	0.20	20.00	*0.460	0.212	21.22	*0.631	0.400	40.0

Source: Authors Field Analysis, 2019
*Correlation significant at 0.05

F Hypotheses Testing

The result of the tested hypothesis 1 is displayed on Table 9 below and it revealed that the correlation coefficient (r) of 0.495 was 0.000 and r= 0.352 was 0.001, at p=0.05 for CO_2 and CH_4 respectively. Since the level of significance of 0.000 and 0.001 were lower than p-value of 0.05, we therefore reject the null hypothesis (H_0) for these gases and accept the alternative H_1, which means that there is a statistically significant relationship between temperature and amount of gas generated by substrates in the biogas technology experiment.

Table 9: Pearson Correlation Statistics Computed for Hypothesis 1

		Temperature	CO_2	CH_4
Temperature	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	90		
CO_2	Pearson Correlation	0.495**	1	
	Sig. (2-tailed)	0.000		
	N	90		
CH_4	Pearson Correlation	0.352**		1
	Sig. (2-tailed)	0.001		
	N	90	90	90

Source: Researcher's Analysis, 2019
***Correlation significant at p=0.05**

The result of the tested hypothesis 2 is displayed on Table 10 below and it revealed that the correlation coefficient (r) of 0.425 was 0.000 and r= 0.102 was 0.341, at p=0.05 for CO_2 and CH_4 respectively. Since the level of significance of 0.000 was lower than p-value of 0.05, we therefore reject the null hypothesis (H_0) for CO_2 gas and accept the alternative H_1, which means that there is a statistically significant relationship between pH and amount of CO_2gas generated by substrates in the biogas technology experiment. On the other hand, the level of significance of 0.341 was higher than p-value of 0.05; we therefore, accept the null hypothesis which means that there is no statistically significant relationship between pH and quantity of CH_4 gas generated by substrates.

Table 10: Pearson Correlation Statistics Computed for Hypothesis 2

		pH	CO_2	CH_4
pH	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	90		
CO_2	Pearson Correlation	0.425**	1	
	Sig. (2-tailed)	0.000		
	N	90		
CH_4	Pearson Correlation	0.102		1
	Sig. (2-tailed)	0.341		
	N	90	90	90

Source: Researcher's Analysis, 2018
***Correlation significant at p=0.05**

IV. DISCUSSION OF FINDINGS

The flame test was used to prove that biogas was produced in the experiment. The gas generated from the bio digesters containing the substrates (cow dung, pig feces and poultry droppings) respectively was used for the test. The hose connecting the bio-digesters and the small bottles was detached and attached to the Bunsen burner and ignited. The gas burned but with little flame. This result is consistent with the study of [11] and [23]. Findings of the study also showed that there was an initial decrease in pH which might have been caused by the methanogens acting on the substrates. It increased after the 11th day and continued and also fluctuated. This finding is corroborated by the results of the study of [24].

Findings of the study further revealed that the amount of gases generated from the different substrates were in different proportions. The amount of methane generated from this study showed that poultry droppings generated most, followed by pig feces and then cow dung respectively. This finding is also consistent with the study of [24]. Also, the volume of carbon dioxide generated differed among substrates. The result showed that cow dung generated most followed by pig feces and finally poultry droppings respectively.

The results of this study distinctly showed that biogas can be generated from cow dung, pig dung and poultry droppings through fermentation using fresh substrates as inoculum. This is in conformity with the work of [25]. The result also showed how locally made bio digesters were used as biogas production models. The remaining slurry in the bio digester after biogas production was also found to be rich in compost which can be used in improving agricultural soil nutrients and productivity. Studies have shown that biogas can also be produced from plant wastes as a substitute for fossil fuels [26].

Biogas generated from animal wastes (cow dung, pig dung and poultry droppings) as revealed in this study, produces an energy resource that can be purified and stored in gas cylinders and used efficiently for direct heat conversion. The process also creates an excellent residue that retains the fertilizer value of the original waste products. The increasing cost of conventional fuel in urban and peri-urban settlement necessitates the exploration of these energy sources. Moreover, the search for alternative sources such as biogas should be intensified so that ecological disasters like deforestation, desertification can be arrested and can also help to potentially reduce climate change as it is environmentally friendly. The methane contents for all the substrates digested were within the range given in literature. The pH values of the three substrates inside the digester were very stable and always in the optimal range between 6.5-8.0 and also the temperature inside the digesters were stable fluctuating around 32+1^{o}C which is within the mesophilic range. These findings are consistent with the work of [1].

This study showed that the various substrates generated carbon dioxide and methane gases at different quantities within the same stipulated time. Cow dung produced about 25ml of CO_2 and 50ml of CH_4, pig feces generated about 20ml of CO_2 and 60ml of CH_4 while poultry droppings generated about 18ml of CO_2 and 62ml of CH_4 respectively.

V. CONCLUSION AND RECOMMENDATIONS

This study has shown that cow dung, pig feces and poultry droppings can be used to produce biogas which could be used to some extent to address the energy challenge (renewable energy) and environmental problems in Nigeria urban and peri-urban settlements. From the correlation analysis, the result showed that there was a statistically significant variation in the amount of gases generated by substrates. Also, there was a statistically significant relationship between temperature and pH on the amount of gas generated by substrates. Arising from the research findings, it is obvious that the best substrate to be used for biogas technology is the cow dung because more gas was generated; thus, more research should be conducted in this area in order to ascertain the effectiveness of the use of cow dung The residue generated from these substrates should be used as fertilizer since it helps reduce the excessive amount of nitrogen, phosphorus and potassium (NPK) released into the environment. Finally, the use of alternative source of energy such as biogas should be adopted by the Nigerian government as a sure way of arresting or mitigating ecological disasters such as deforestation, desertification and climate change.

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Dr. Wizor has been lecturing both graduate and undergraduate students in the University since 2006 till date and consulting for several industries, ministries, departments and agencies (MDA's) on environmental related issues and urban developments. He has acquired relevant industry knowledge over the years especially in the area of data analysis, project management, disaster risk reduction (DRR) skills, remediation and restoration of impacted soil, social media amongst others.

Dr. Wizor is very good in research, quality assurance skills, Microsoft office and customer service. He is a Team player, loves teaching and public speaking; leadership and management. Dr. Wizor's interests are in the area of urbanization in developing countries, Greater Port Harcourt city development, housing studies, contemporary urban plans implementation in sub-Saharan Africa, urban agriculture in the global south and disaster risk

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Dr. Wizor has been awarded certificates for participating in several workshops and conferences in Nigeria and diaspora. He is a Fellow of the Institute of Corporate Administration of Nigeria (FCAI) and a Member of other reputable professional bodies including; Association of Nigerian Geographer (ANG), Nigerian Environmental Society (NES) and Institute of Certified Geographers of Nigeria (ICGN). He has published widely both in reputable local and International Journals.