

# Evaluation of Performance of Fixed Dome Biogas Digester Surface Insulated with Mud

**Nwoke Oji Achuka, Ozioko Ifeanyi Chijindu, Ime Chukwuemeka, Ugwu Samson**

**Nnaemeka, Ezenne Gloria Ifeoma, Ogwo Vintus**  
Department of Agricultural and Bioresources Engineering  
University of Nigeria Nsukka, Enugu State Nigeria.  
nwoke.oji@unn.edu.ng

**Chukwuma Chibundo Emmanuel**

Department of Agricultural and Bioresources Engineering, Nnamdi Azikiwe University Awka,  
Anambra State Nigeria

## Abstract

The aim of the study is to exploit the potential of mud beyond its current applications in construction industries, to insulate bio-digesters against temperature fluctuations. To achieve this, six identical fixed dome biogas digesters (32 Liters) were designed, constructed and used to carryout anaerobic digestion of three feedstocks namely cow abdominal waste, poultry droppings and 1:1 mixture of cow abdominal waste and poultry droppings. Three digesters were charged and surface covered with mud for insulation while the remaining three were charged and kept on the surface uninsulated. The ANOVA result indicates that Mud insulation of digester and feedstock have significant effect on the performance of the fixed dome biogas digesters ( $\alpha = 0.05$ ). The range of pH, Volume of biogas and slurry temperature (ST) in all the feedstocks (Cow abdominal waste, poultry droppings and 1:1 mixture of Cow abdominal waste and poultry droppings) were 6.948-7.170, 3.643-3.865 liters and 29.917-30.242°C, respectively. The highest volume of biogas was produced by mud insulated surface fixed dome biogas digester with cow abdominal waste feedstock. The highest temperature evolution was from 1:1 Mixture of Cow Abdominal Waste and poultry droppings feedstock.

## Keywords

Fixed dome digester, biogas, Mud Insulation, Feedstock, Cow abdominal Waste and Poultry Dropping.

## 1.Introduction

The biogas industry is constantly innovating ways of improving energy recovery from a variety of biomass resources. While there are several attempts in this direction, more focus has been placed on bio-digester chemical reactions with little attention to system sustainability for long-life performance. The factors affecting uptake of biogas systems were investigated by Kahubire et al. (2010), Mittal et al. (2018), Mulinda et al. (2013), Mwirigi et al. (2014), Walekhwa et al. (2009) and Roopnarain and Adeleke (2017), who ruled out economic barriers to investment as major inhibitor to adoption. Most biogas installations have not sustained gas production (Tumusiime et al. 2019; Nabuuma and Okure, 2006; Kariko-Buhwezi et al. 2011), this has partly been due to poor digester operating conditions such as low digester temperatures and poor quality of digester feed (Kariko-Buhwezi et al., 2011; Mwakaje, 2008). Most biogas digesters operate between 18–25 °C (Kariko-Buhwezi et al. 2011), which is far below optimum of 30–40 °C (Kumar et al. 2013; Al Seadi et al. 2008), with uncontrolled fluctuations which are inhibitory to biogas production. According to Al Seadi et al. (2008), methanogenic microorganisms are very sensitive to temperature changes, and can only tolerate temperature fluctuations of up to  $\pm 3$  °C. It should be noted that adoption and sustainability are not directly related. For example, studies by Mulinda et al. (2013), Kabir et al. (2013) and Mwirigi et al. (2009), indicate that the household's socioeconomic status influences adoption but it does not significantly influence the long term utilization of a biogas system. On the other hand, (Puzzolo et al., 2016) revealed that other factors including optimal operation of renewable energy technologies directly influence their sustainability.

Although productive biogas systems have the ability to overcome several bottlenecks to adoption such as high installation & operation costs, technical & socio-cultural impediments, and lack of sustainable supply of digester feedstock (Kahubire et al. 2010; Mittal et al. 2018; Walekhwa et al. 2009; Lwiza et al. 2017), as indicated by Tumusiime et al. (2019), their operations have got to be optimal. The ultimate goal of a productive biogas installation is to produce biogas for economic gain Wehkamp (2013), and thus, such a system must maximize energy outputs in order to realize high economic returns. Digester temperature is one of the key influence parameters for optimal biogas recovery, and thus its optimization and stability are key requirements for every productive biogas plant. Studies have described biogas production as a very intricate process with methanogenesis; the stage responsible for methane generation, being the most affected by temperature fluctuations (Al Seadi et al. 2008; Athanasoulia et al. 2012; Nizami, 2012). According to Al Seadi et al. (2008), large temperature fluctuations lead to system imbalance with consequent low gas yield, and in worst cases to complete process failure. Low gas yield greatly derails expectations of biogas plant owners, and is a precursor to dis-adoption. In order to circumvent this, digester wall insulation is a necessary requirement. A study by Zhang et al. (2016) indicated that application of insulation mortar and glass fiber reinforced plastic (GRP) material on the outside walls of the digester, improved and maintained a stable digester slurry temperature with consequent increase in biogas production and economic benefits. However, GRP has a higher embodied energy and hence costly. Small temperature fluctuations were also achieved by Odekanle et al. (2020) using automated anaerobic digesters (Edibon PDANC 0007/144) operating on batch mode. Even though digester insulation provides material benefits, it must be undertaken at least cost in order to avoid accelerating the effects of economic barriers to investment in biogas system. Utilization of cost-effective raw materials for this purpose such as mud, provides tangible benefits in this direction since they can easily be locally sourced, thereby offsetting the importation and custom duty expenses. Renewable energies play an important role in solving the current and future energy needs of Nigeria and in particular biomass. Biomass is very significant because it is a “carbon neutral” fuel (Fantozzi and Buratt 2009). The constant use of fossil fuels as primary energy source has led to global climate change, environmental degradation, and human health problems (Budiyno et al. 2010). Human beings are now using anaerobic digestion of waste organic materials to generate biogas (Patil et al. 2011). Biogas is mixture of gases, predominantly methane and carbon dioxide, produced by anaerobic digestion. In biogas production temperature of the slurry is an important parameter that affects the rate of biogas production.

In nature, methane is formed over a wide range of temperature from 0 to 97°C (Dhaked et al. 2010). An increase in ambient temperature generally increases the rate of reaction and therefore the rate of biogas production. Temperature is one of the most important factors affecting microbial activity within an anaerobic digester, and methane production is strongly temperature dependent. In general temperature influences three aspects of digester heat requirements; heat loss through digester walls, heat loss through the digester cover and heat required to heat incoming manure to the digester operating temperature (Chen 2007). Fluctuation in digester temperature affects the activity of methane-forming bacteria (Fulford 2001, Nijaguna 2002). Temperature influences not only methane-forming bacteria but also volatile acid-forming bacteria. A 10°C temperature increase or decrease can stop methane production or methane-forming bacterial activity. Changes in the quantities of organic acids and alcohols that are used directly and indirectly as substrates by methane-forming bacteria affect overall digester performance (Gerardi 2003). Over the past years researchers on biogas production all over the world have put a great effort in improving methane yield by evaluating all kinds of wastes in order to enhance synergies between different substrates and have shown that performance of the biogas digesters depends on the type and composition of material fed into the digester. In addition, temperature, pH, retention time, inocula type and loading rate affect biogas production. And furthermore, biogas production is also affected by the digester geometry. In Nigeria, there is little public awareness of the importance of biogas production as an alternative source of energy although there would be an increment in the number of anaerobic digesters in the next future years due to research work on biogas technology. Anaerobic digestion of organic wastes to produce renewable energy in form of biogas could be one of the solutions to eradicate energy poverty especially in the rural areas of Nigeria. Hence, experimental studies on how to improve methane production from fixed dome biogas digester by insulation, mono-digestion and co-digestion are of significant importance.

### 1.1 Objectives

The aim of the study is to exploit the potential of mud beyond its current applications in construction industries, to insulate bio-digesters against temperature fluctuations. The specific objectives are to design and construct fixed dome biogas digesters. (ii) carry out anaerobic digestion with the biogas digester uninsulated and surface insulated with mud using different feedstocks namely cow abdominal waste, poultry droppings and 1:1 mixture of cow abdominal waste and poultry droppings and (iii) determine the effect of mud surface insulation of digester and feedstock on the performance of the biogas digester.

## 2. Materials and Methods

### 2.1 Design and Construction of Fixed Dome Biogas Digester

Design of thermal insulation thickness for a cylindrical biodigester preceded experimental investigations using relevant guiding heat transfer equations as published by Kumar (2007), whereby the optimal thickness of insulation formed the main design criteria. An effective insulator should have a thickness such that the radius of the shell being insulated is greater than the critical radius  $r_c$  where  $r_c$  is the ratio of insulation material thermal conductivity ' $k$ ' to convective heat transfer coefficient ' $h_o$ '. Otherwise, addition of insulation would result into increase in heat loss. This thus informed the design of the optimal thickness of insulation to limit digester temperature fluctuations. The design commenced with material selection for the prototype digester, and digester operating temperature and the surrounding conditions. Mesophilic digestion (38 °C) was considered for this study since it provides a stable environment for the functioning of anaerobic microorganisms (Wehkamp 2013, Boogman 2014).

Moreover, thermophilic reactors are more prone to temperature fluctuations and since temperatures are far above ambient, maintaining a stable temperature in thermophilic reactors is a costly endeavor compared to mesophilic digestion. 38 °C was thus used as design temperature for the digester while the surrounding atmosphere was taken at 18 °C to accommodate low ambient temperatures at night and during rainy seasons.

### 2.2 Collection and Preparation of Feedstock

The cow abdominal waste was obtained from abattoir at Ikpa Market Nsukka (latitude: 6°51'33.41" and longitude: 7°23'52.51"), Enugu state Nigeria while the poultry droppings was collected in bags from the National Centre for Energy Research and Development, University of Nigeria Nsukka (latitude: 6°51'33.41" and longitude: 7°23'52.51"). The substrates respectively were mixed in the ratio of 1:2 (Feedstock:Water). The operational mode was the batch method using an operational mesophilic temperature. Biomethanation of these slurries was carried out for energy production in a fixed dome reactor and cumulative biogas production; slurry temperatures were monitored throughout the study. The digester was tightly corked with rubber stopper to create anaerobic condition and connected to a gasometrical chamber.

### 2.3 Experimental Set up

The anaerobic experiment was set up the premises of the National Centre for Energy Research and Development, University of Nigeria Nsukka. Three of the developed fixed dome biogas digesters (32 Litres) were recharged with each of the three feedstocks respectively and were covered with mud to insulate the digester while the remaining three digesters were also fed with the three feedstocks respectively and kept on the surface without insulation (Figure 1). The six digesters each 32 litres were allowed to run concurrently under the same ambient temperature for a period of 30 days. To ascertain the performance of the digester's physicochemical properties of the biogas production process were determined using standard procedures. Each experimental digester was fed through the inlet with 14 kg of fresh dairy cow dung thoroughly mixed with tap water to bring the weight of slurry to 20 kg. Mixing of dung and water was provided by manual mixing in a water bath by hand. The loading rate was determined using the procedure described by FARMESA (1996). The inlets were securely sealed and the complete assemblies of digesters carried and placed in trenches, which were dug in an open space in National Center for Energy Research and Development, University of Nigeria Nsukka and natural conditions (NC) to accommodate them. Provision for the agitation of the digester contents during the digestion process was not made because its effect on small-scale digesters is considered minimal (Barnett et al., 1978). Emptying of sludge was done through the inlet opening after elapse of a given hydraulic retention time.



Figure 1. Experimental Set Up of Fixed Dome Biogas Digesters (A)Mud Insulated Surface (B) uninsulated Surface

## 2.4 Laboratory Analysis of Samples

Three digester were charged and the surface insulated with mud while the remaining three were charged and kept on the surface uninsulated. The experiment lasted for 30 days. The laboratory analysis were based on standard procedures. In a batch digester the waste is put into the plant with a starter, if available, and the gas collected as it is given off. The time in which biogas production was simply negligible or equal for both sites was considered the hydraulic retention time. At this point the experimental digesters were stopped and their contents discharged. The daily gas yields were measured using jar displacement method and the corresponding temperature using Delta-T logger device. The pH was measured using hand held digital pH meter.

## 2.5 Statistical Analysis

One way ANOVA was used to determine the effect of the treatment on the response of the biogas production parameters. Multiple comparison of means was carried out using Duncan Multiple Range Test at 5% Probability. Statistical analysis and Graphical Plots were carried out using statistical Package for Social Sciences(SPSS) Version 21.0.

## 3. Results and Discussion

### 3.1 Variation of Slurry Temperature, pH and Volume of Biogas produced in different feedstocks

The variation of Slurry temperature, pH and volume of biogas produced in different feedstocks during the 30 days anaerobic digestion are presented in Figure 2A, Figure 2B and Figure 2C respectively. The ambient temperature during the anaerobic digestion process is as shown in Figure 3.

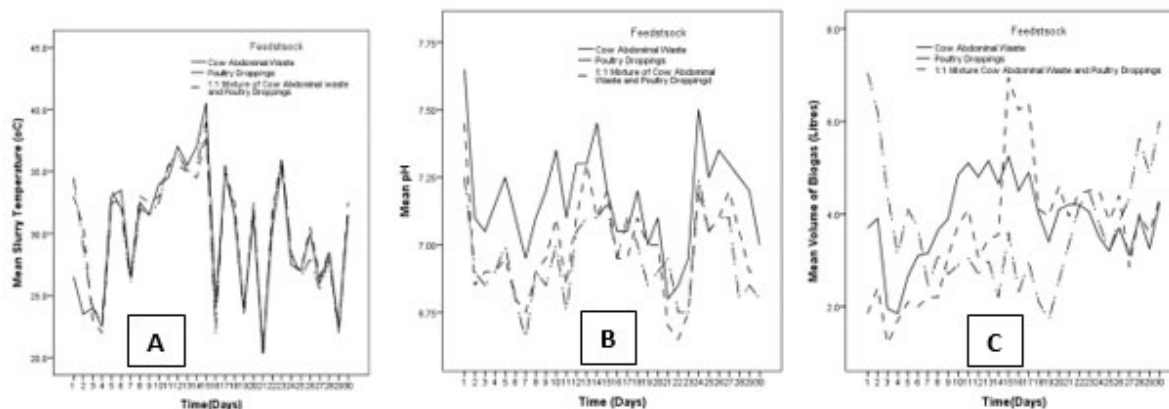


Figure 2. Variation of (A) Slurry Temperature, (B) pH and (C) Volume of Biogas produced in different feedstocks

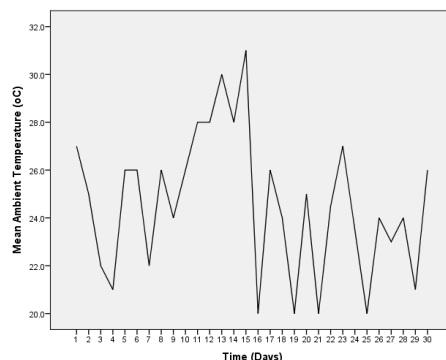


Figure 3. Variation in Ambient Temperature During the 30 Days Anaerobic Digestion Process.

### 3.2 Graphical Comparisons of the Effects of Mud Surface Insulation of Digester and Feedstock on Slurry Temperature, pH and Volume of Biogas

The comparison of the effects of mud Surface insulation of digester and feedstock on slurry temperature, pH and volume of biogas produced are presented in Figure 4A, Figure 4B and Figure 4C respectively.

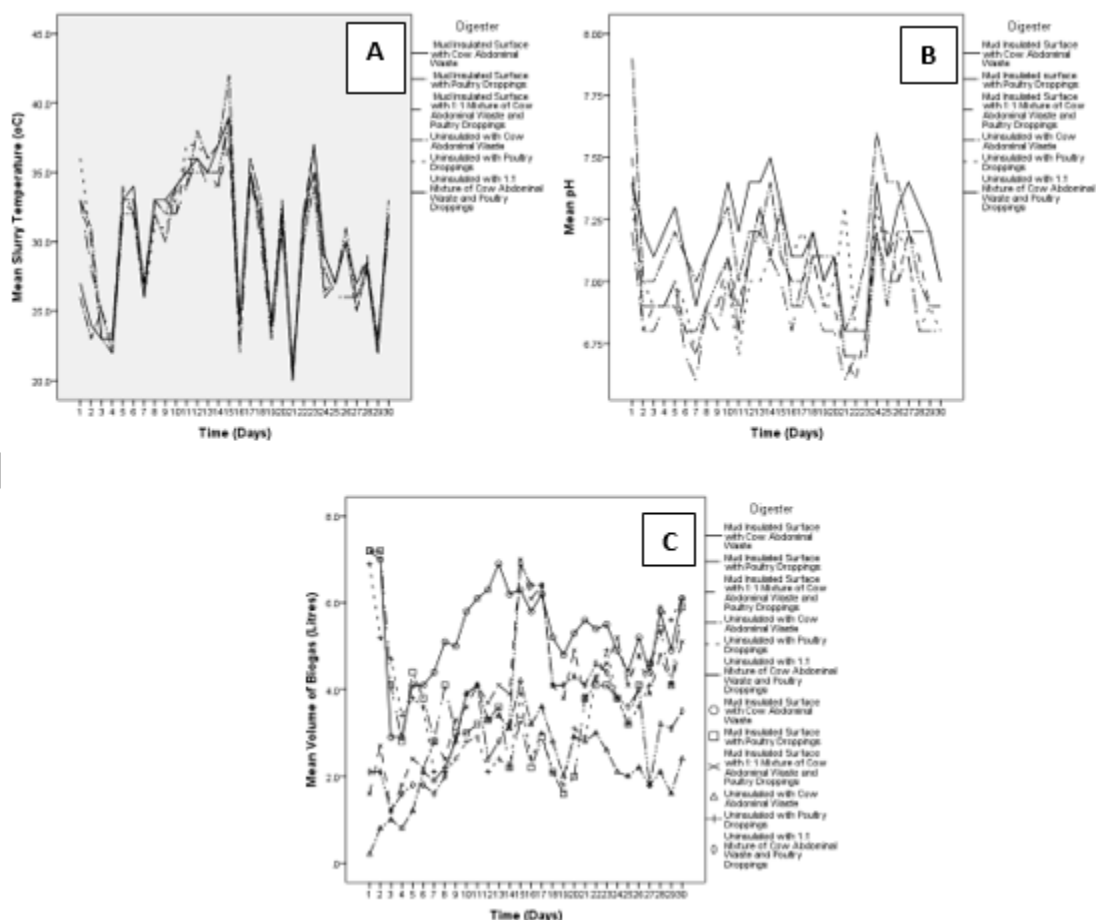


Figure 4. Comparison of the Effects of Ground Insulation of Digester and Feedstock on Measured Parameters During the 30 Days Anaerobic Digestion (A)Slurry Temperature (B)Slurry pH (C) Volume of Biogas Produced.

### 3.3 Statistical Analysis Results

#### 3.3.1 Descriptive Statistics of the Performance of the Mud insulated Surface and Uninsulated fixed dome biogas digesters with Different Feedstocks

The descriptive statistics of the performance of the mud insulated surface and uninsulated fixed dome biogas digesters with Different Feedstocks is presented in Table 1. Table 1 showed that the range of values for pH, volume of biogas and slurry temperature were 6.897-7.177, 2.404-5.327 liters and 29.667-30.467 °C, respectively.

Table 1. Descriptive Statistics of the Performance of the Mud Insulated Surface and Uninsulated Fixed Dome Biogas Digesters with Different Feedstocks

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
ST	1	30.050	5.1701	.9439	28.119	31.981	20.0	39.0
	2	29.667	4.8018	.8767	27.874	31.460	21.0	39.0
	3	30.150	4.8692	.8890	28.332	31.968	20.0	37.0
	4	29.783	5.2845	.9648	27.810	31.757	21.0	42.0
	5	30.467	5.3994	.9858	28.450	32.483	20.0	39.0
	6	30.333	4.9781	.9089	28.474	32.192	20.0	39.0

pH	Total	180	30.075	5.0249	.3745	29.336	30.814	20.0	42.0
	1	30	7.177	.1924	.0351	7.105	7.249	6.8	7.5
	2	30	6.897	.1712	.0313	6.833	6.961	6.6	7.2
	3	30	6.983	.1913	.0349	6.912	7.055	6.6	7.5
	4	30	7.163	.2173	.0397	7.082	7.244	6.8	7.9
	5	30	7.000	.1762	.0322	6.934	7.066	6.7	7.3
	6	30	6.990	.1863	.0340	6.920	7.060	6.7	7.4
Volume	Total	180	7.035	.2128	.0159	7.004	7.066	6.6	7.9
	1	30	5.327	1.0566	.1929	4.932	5.721	2.9	7.2
	2	30	3.730	1.3509	.2466	3.226	4.234	1.6	7.2
	3	30	3.893	1.3751	.2511	3.380	4.407	1.2	7.0
	4	30	2.403	1.0029	.1831	2.029	2.778	.2	4.2
	5	30	3.573	1.3595	.2482	3.066	4.081	1.8	6.9
	6	30	3.393	1.4669	.2678	2.846	3.941	1.2	6.9
Total		180	3.720	1.5309	.1141	3.495	3.945	.2	7.2

1= **Mud Insulated Surface** Digester with Cow Abdominal Waste Feedstock;2= **Mud Insulated Surface** Digester with Poultry droppings Feedstock;3= **Mud Insulated Surface** Digester with 1:1 Mixture of Cow Abdominal Waste and Poultry Droppings;4= Uninsulated Digester with Cow Abdominal Waste Feedstock; 5= uninsulated Digester with Poultry Droppings Feedstock; 6=Uninsulated Digester with 1:1 mixture of Cow Abdominal Waste and poultry Droppings

### 3.3.2 The ANOVA Results of the effect of mud surface insulation and feedstock on fixed dome biogas digester performance

The ANOVA Table of the Effect of mud surface insulation and feedstock on fixed dome biogas digester performance at 5% Significant Level is also Presented in Table 2. Table 2 showed that mud insulation of digester and feedstock have significant effect on the performance of the fixed dome biogas digesters. Table 2 indicates that there are significant differences in the mean values of volume of biogas produced and slurry pH for the six different biogas digesters at 5% significant levels. Table 2 also showed that the mean slurry temperature of the six different digesters are statistically the same at 5% significant level..

Table 2. ANOVA Table of the Effect of Mud Surface Insulation and Feedstock on Fixed Dome Biogas Digester Performance at 5% Significant Level

		Sum of Squares	df	Mean Square	F	Sig.
ST	Between Groups	14.346	5	2.869	.111	.990 <sup>NS</sup>
	Within Groups	4505.392	174	25.893		
	Total	4519.738	179			
pH	Between Groups	1.848	5	.370	10.270	.000*
	Within Groups	6.262	174	.036		
	Total	8.110	179			
Volume	Between Groups	134.201	5	26.840	16.369	.000*
	Within Groups	285.307	174	1.640		
	Total	419.508	179			

\*= Statistically significant at 5% probability( $\alpha=0.05$ ); <sup>NS</sup>=Not Significant at 5% probability( $\alpha=0.05$ )

### 3.3.3 Multiple Comparison of the Mean of Measured Digester parameters Using Duncan Multiple Range Test (DMRT)

The multiple comparison of the mean of measured digester parameters using Duncan Multiple Range Test at 5% significant level is presented in Table 3.

Table 3. Multiple Comparison of the Mean of Measured Digester parameters Using Duncan Multiple Range Test at 5% significant Level

S/No.	Insulation	Feedstock	pH	Volume of Biogas (Litres)	Slurry Temperature(°C)
1	Mud Surface Insulation	Cow Abdominal waste	7.177b	5.327a	30.050a
2	Mud surface Insulation	Poultry Droppings	6.897a	3.730b	29.667a
3	Mud Surface Insulation	1:1 Mixture of Cow Abdominal Waste and Poultry Droppings	6.983a	3.893b	30.150a
4	Uninsulated	Cow abdominal Waste	7.163b	2.403a	29.783a
5	Uninsulated	Poultry Droppings	7.000a	3.573b	30.467a
6	Uninsulated	1:1 Mixture of Cow Abdominal Waste and Poultry Droppings	6.990a	3.393b	30.333a
Mean values followed by the same lower case letters are significantly the same at 5% probability level.					

### 3.3.4 The mean plots of volume of biogas produced, slurry temperature and pH for the six different digesters

The mean plots of volume of biogas produced, slurry temperature and pH for the six different digesters studied are presented in Figure.5A, Figure 5B and Figure 5C, respectively. The highest volume of biogas and slurry pH were produced by digester 1 (Figure 5A and Figure 5C), indicating that the highest volume of biogas and slurry pH were produced by mud insulated surface fixed dome biogas digester with cow abdominal waste feedstock. The highest slurry temperature was produced by digester 5(Figure 5B), indicating that the highest pH evolution was from uninsulated fixed dome biogas digester with poultry droppings feedstock. The results generally indicates that the mud insulated fixed dome biogas digester with cow abdominal waste performed better than the uninsulated fixed dome biogas digester with respect to the volume of gas produced and pH evolution.

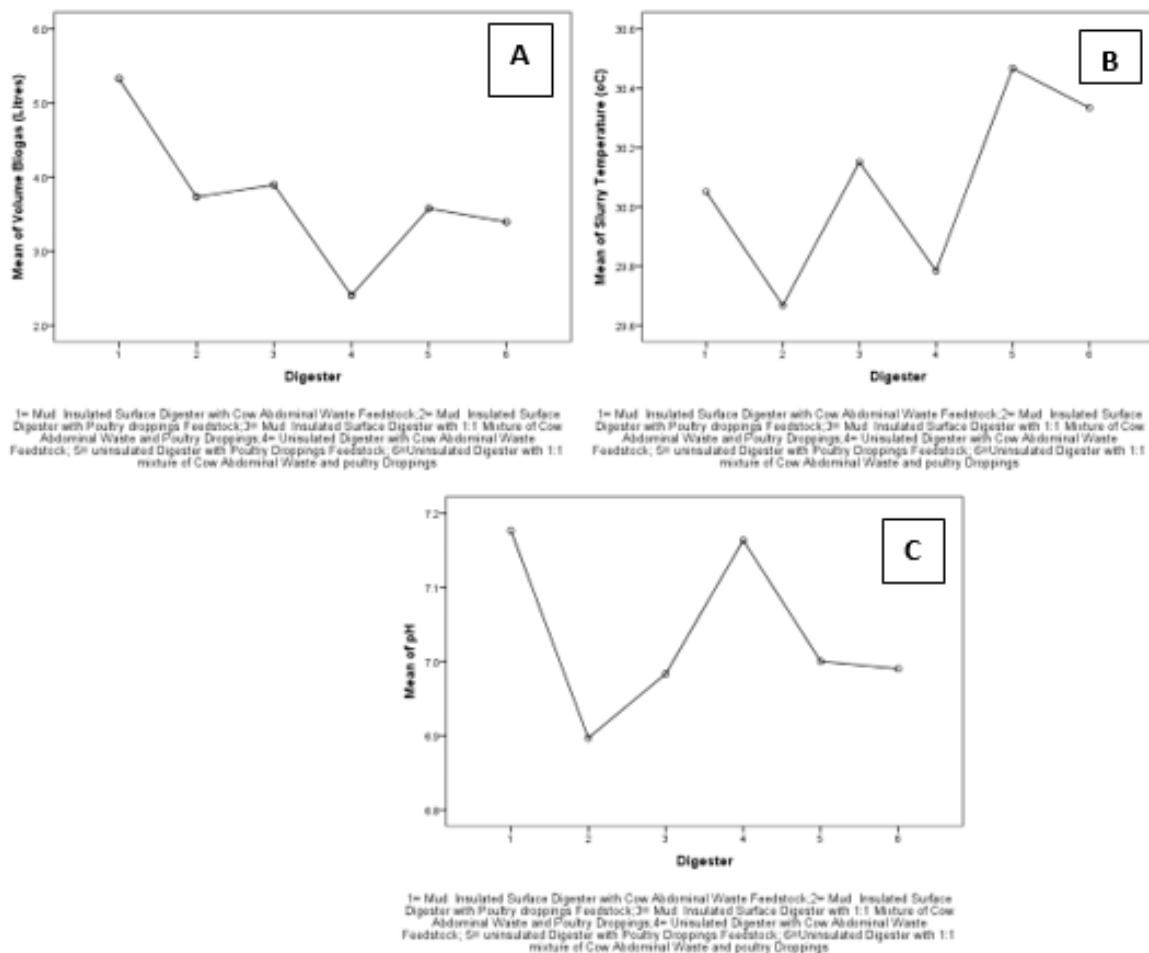


Figure 5. Mean plots of parameters for the six different digesters studied (A) volume of biogas produced (B) slurry temperature evolution (C) pH evolution

### 3.3.5 The Descriptive Statistics of the Performance of the fixed dome biogas digester due to the Different Feedstocks

The Descriptive Statistics of the Performance of the fixed dome biogas digester due to the Different Feedstocks is presented in Table 4. The range of pH, Volume of biogas and slurry temperature (ST) in all the feedstocks( Cow abdominal waste, poultry droppings and 1:1 mixture of Cow abdominal waste and poultry droppings) were 6.948-7.170, 3.643-3.865 liters and 29.917-30.242°C, respectively (Table 4).

**Table 4. Descriptive Statistics of the Performance of the fixed dome biogas digester due to the Different Feedstocks**

Acidstocks									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
pH	1	60	7.170	.2036	.0263	7.117	7.223	6.8	7.9
	2	60	6.948	.1799	.0232	6.902	6.995	6.6	7.3
	3	60	6.987	.1873	.0242	6.938	7.035	6.6	7.5
	Total	180	7.035	.2128	.0159	7.004	7.066	6.6	7.9
Volume	1	60	3.865	1.7933	.2315	3.402	4.328	.2	7.2



ST	2	60	3.652	1.3460	.1738	3.304	3.999	1.6	7.2
	3	60	3.643	1.4320	.1849	3.273	4.013	1.2	7.0
	Total	180	3.720	1.5309	.1141	3.495	3.945	.2	7.2
	1	60	29.917	5.1849	.6694	28.577	31.256	20.0	42.0
	2	60	30.067	5.0819	.6561	28.754	31.379	20.0	39.0
	3	60	30.242	4.8829	.6304	28.980	31.503	20.0	39.0
Total		180	30.075	5.0249	.3745	29.336	30.814	20.0	42.0

### 3.3.6 The ANOVA of the Effect of Feedstock on Fixed Dome Biogas Digester Performance at 5% Significant Level

The ANOVA Table of the Effect of Feedstock on Fixed Dome Biogas Digester Performance at 5% Significant Level is presented in Table 5. Table 5 indicates that Feedstock has significant effect on pH of the fixed dome biogas digester ( $\alpha=0.05$ ) but has no effect on both volume of biogas and slurry temperature(ST) at 5% significant levels.

Table 5. ANOVA Table of the Effect of Feedstock on Fixed Dome Biogas Digester Performance at 5% Significant Level

		Sum of Squares	df	Mean Square	F	Sig.
ST	Between Groups	3.175	2	1.588	.062	.940 <sup>NS</sup>
	Within Groups	4516.563	177	25.517		
	Total	4519.738	179			
pH	Between Groups	1.684	2	.842	23.200	.000*
	Within Groups	6.425	177	.036		
	Total	8.110	179			
Volume	Between Groups	1.894	2	.947	.401	.670 <sup>NS</sup>
	Within Groups	417.614	177	2.359		
	Total	419.508	179			

\*= Statistically significant at 5% probability( $\alpha=0.05$ ); <sup>NS</sup>= Not Significant at 5% probability( $\alpha=0.05$ )

### 3.3.7 Multiple Comparison of The Mean Response Of Parameters Due to Treatment of The Digesters With Different Feedstocks Using Duncan Multiple Range Test

Table 6 showed the multiple comparison of the mean response of parameters due to treatment of the digesters with different feedstocks using Duncan Multiple Range Test at 5% significant level.

Table 6. Multiple Comparison of the Mean Response of parameters due to Treatment of the Digesters with Different Feedstocks Using Duncan Multiple Range Test at 5% significant Level

S/No.	Feedstock	pH	Volume of Biogas (Litres)	Slurry Temperature(°C)
1	Cow Abdominal waste	7.170b	3.865a	29.917a
2	Poultry Droppings	6.948a	3.652a	30.067a
3	1:1 Mixture of Cow Abdominal Waste and Poultry Droppings	6.987a	3.643a	30.242a
Mean values followed by the same lower case letters are significantly the same at 5% probability level				

### 3.3.8 The Mean Plots Of Volume Of Biogas Produced, Slurry Temperature And Ph For The Three Feedstocks Studied

The mean plots of volume of biogas produced, slurry temperature and pH for the three feedstocks studied namely Cow Abdominal waste, Poultry Droppings and 1:1 Mixture of Cow Abdominal Waste and Poultry Droppings are presented in Fig.6A, Fig.6B and Fig.6C, respectively. The highest volume of biogas and pH were produced by

feedstock 1 (Fig.6A and Fig.6C), indicating that the highest volume of biogas and pH were produced by Cow Abdominal Waste feedstock. The highest slurry temperature was produced by feedstock (Fig.6B), indicating that the highest temperature evolution was from 1:1 Mixture of Cow Abdominal Waste and poultry droppings feedstock. The results generally indicates that the Cow Dung Abdominal Waste feedstock performed better followed by the 1:1 mixture of cow abdominal waste and poultry droppings feedstock in the biogas production Process of mud insulated surface fixed dome biogas digester.

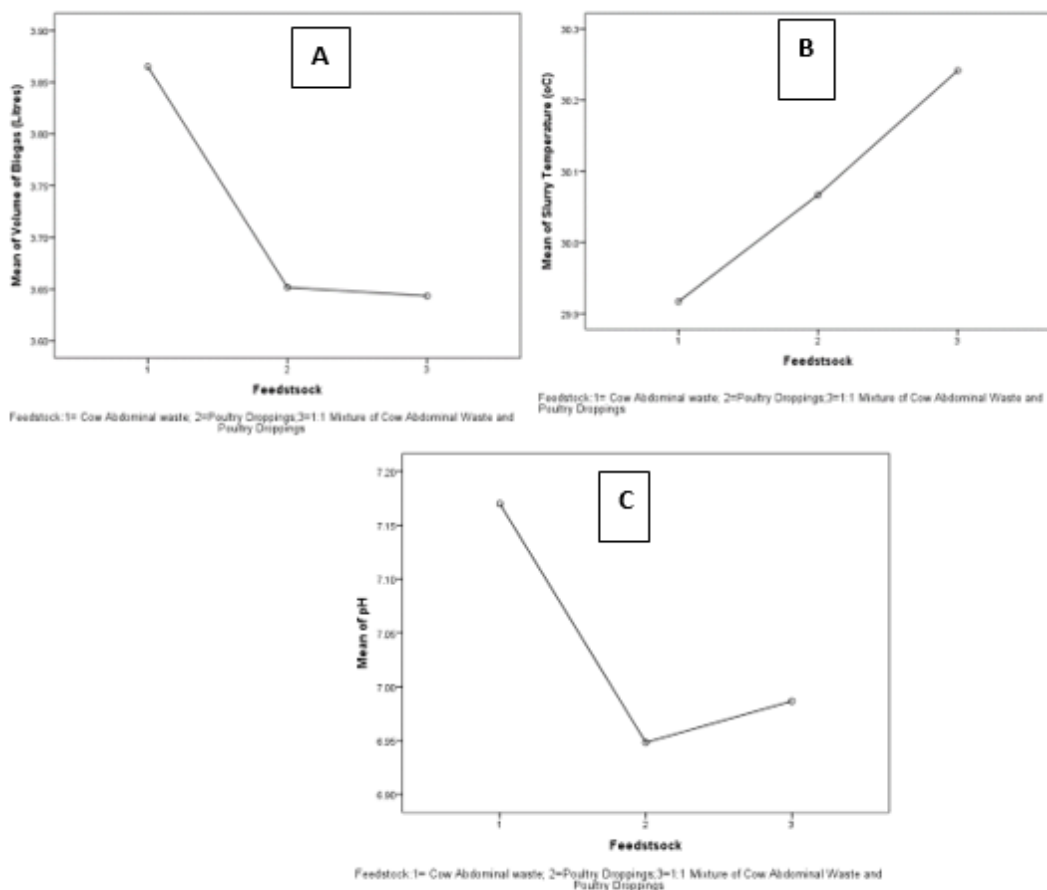


Figure 6. The mean plots of parameters for the three feedstocks studied namely Cow Abdominal waste, Poultry Droppings and 1:1 Mixture of Cow Abdominal Waste and Poultry (A) volume of biogas produced, (B) slurry temperature and (C) Slurry pH

#### 4. Conclusion

Digester temperature and feedstock are some of the key influence parameters for optimal biogas recovery, and thus its optimization and stability are key requirements for every productive biogas plant. The study aimed to exploit the potential of mud beyond its current applications in construction industries, to insulate bio-digesters against temperature fluctuations. The results showed that the range of values for pH, volume of biogas and slurry temperature were 6.897-7.177, 2.404-5.327 liters and 29.667-30.467 °C, respectively. Mud insulation of digester and feedstock have significant effect on the performance of the fixed dome biogas digesters ( $\alpha = 0.05$ ). There are significant differences in the mean values of volume of biogas produced and slurry pH for the six different biogas digesters at 5% significant levels. The mean slurry temperature of the six different digesters were statistically the same at 5% significant level. The highest volume of biogas and slurry pH were produced by mud insulated surface fixed dome biogas digester with cow abdominal waste feedstock. The highest pH evolution was from uninsulated fixed dome biogas digester with poultry droppings feedstock. The results generally indicates that the mud insulated fixed dome biogas digester with cow abdominal waste performed better than the uninsulated fixed dome biogas digester with respect to the volume of gas produced and pH evolution. The range of pH, Volume of biogas and

slurry temperature (ST) in all the feedstocks (Cow abdominal waste, poultry droppings and 1:1 mixture of Cow abdominal waste and poultry droppings) were 6.948-7.170, 3.643-3.865 liters and 29.917-30.242°C, respectively. Feedstock has significant effect on pH of the fixed dome biogas digester ( $\alpha=0.05$ ) but has no effect on both volume of biogas and slurry temperature (ST) at 5% significant levels. The highest volume of biogas and pH were produced by Cow Abdominal Waste feedstock. The highest temperature evolution was from 1:1 Mixture of Cow Abdominal Waste and poultry droppings feedstock. The results generally indicate that the Cow Dung Abdominal Waste feedstock performed better followed by the 1:1 mixture of cow abdominal waste and poultry droppings feedstock in the biogas production Process of mud insulated surface fixed dome biogas digester. We therefore recommend the insulation of fixed dome biogas digester and appropriate feedstock for improved biogas production.

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### Biographies

**Nwoke, Oji Achuka** Ph.D., M.Eng., B.Eng., R.Engr.(COREN), MNSE, MNIAE, Senior Lecturer, Structures and Environmental Engineering, Department of Agricultural and Bioresources Engineering, Faculty of Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria. RG Score: <https://www.researchgate.net/profile/Oji-Nwoke-2>.

**Ozioko, Ifeanyi Chijindu** B.Eng. Department of Agricultural and Bioresources Engineering, Faculty of Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria.

**Ugwu, Samson Nnaemeka**, Ph.D., Lecturer I, Department of Agricultural and Bioresources Engineering, Faculty of Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria.

**Ezenne, Gloria Ifeoma** Ph.D., Associate Professor, Department of Agricultural and Bioresources Engineering, Faculty of Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria.

**Ime, Chukwuemeka**, B.Eng. Graduate Assistant, Department of Agricultural and Bioresources Engineering, Faculty of Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria.

**Ogwo, Vintus** M.Eng , Lecturer I, Department of Agricultural and Bioresources Engineering, Faculty of Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria.

**Chukwuma, Chibundo Emmanuel**, Ph.D., Senior Lecturer, Department of Agricultural and Bioresources Engineering, Nnamdi Azikiwe University Awka, Anambra State Nigeria.