# Qualitative and Quantitative Means of production of Biogas from Biodegradable Waste (Cow dung) For Sustainable Energy.


## ABSTRACT

**Aims:** This study was carried out by analyzing the quantitative and qualitative of the biogas produced from cow dung by degrading mechanism. 32L of bioreactors was used for the study.
**Methodology:** The bioreactors were constructed to imitate the fixed batch prototype. The study lasted for 30 days and it was carried out at the National Centre for Energy Research and Development, University of Nigeria,Nsukka. Slurry was prepared in bioreactors. The substrates in the bioreactors were water and cow dung (intestinal and abdominal waste). The pH, the total solids (TS), volatile solids (VS) and total volatile fatty acid (VFA) characteristics of the substrate before and after digestion were determined using standard method. Quantitative and qualitative analysis of biogas production was by liquid displacement and gas Analyzer methods
**Results:** The results of the TS, VS and VFA were 400 mg/l, 92mg/l and 16.7 mg/l respectively in the predigested samples and 92 mg/l, 17.4mg/l and 28.3mg/l respectively in the post digested samples. The quantity of biogas produced at the first week was 8.5liters, 7.5litre and 6.1liter from the $4^{th}$ day,$5^{th}$ day and $8^{th}$ days. The qualitative analysis showed that the prominent biogas produced was methane.
**Conclusion:** The results of the research concluded that high quantity of biogas can be produced using cow dung. Approaches and technology for more efficient biogas producing consortia are proposed.



Keywords: Biogas, biodegradable waste, qualitative, quantitative, bioreactor, methane, $co^2$.


## 1. INTRODUCTION

The production of biogas from renewable resources is becoming a prominent feature of most developed and developing countries of the world. It is agreed that biogas plays an important role in the domestic and agricultural life of the rural dwellers in countries like India, China, Korea, Malaysia and West Africa like Nigeria. It also has the advantage of contributing to the solution of environmental problems, because of it is a substitute to fossil fuels [1]. Fossil fuels have long been the major source of global energy. These fuels are generally used as sources of energy in combustion engines and in some instances as raw materials for the petrochemical industries. Although fossil fuels play a key role in the global economic and political situations, they have numerous challenges such as environmental pollution, global warming, oil spills and gas flares [2].

The local manure from animal herds, other agricultural and industrial wastes that are largely generated in Nigeria on a daily basis could be employed as raw material for both small and large-scale biogas production. Nigeria produces about 227,500 tons of fresh waste each day [3] Cow dung can be defined as the undigested residue of consumed food material being excreted by herbivorous bovine animal species. Biogas is produced when bacteria degrade biological materials in the absence of oxygen, in a process known as anaerobic digestion [4]. Anaerobic treatment is the use of biodegradable waste, in the absence of oxygen, for the breakdown of organic matter and the stabilization of these materials by conversion to methane and carbon dioxide gases and a nearly stable residue [5]. Biodegradable wastes can be use as sources of nutrient, feed ingredients to microorganisms and as fuel energy source, they contain high level of organic matter that could be converted into energy as supplement for fossils.

Animal wastes are abundant all over the world with Nigeria newly producing about 327,800 tons of fresh waste each day, that 1kg of fresh animal waste produce about $0.08m^3$ of gas per day. This shows theoretically that Nigeria can produce 8.8 million M3 of biogas daily, which in terms of energy is equivalent to about 4.9 million liters of petroleum [6]. The use of biogas is capable of providing a special impetus in both rural and urban areas. Biogas plant can be built by using materials which are locally available in most developing countries [7]. The solid or liquid residue can further be used as feed or as biomass briquette for cooking [7]. The abundant availability of animal manure in Nigeria (particularly from poultry enterprises), which could cause health hazards during decay could be turned to biogas for utilization by the rural communities and later in future be commercialized for sale to urban dwellers. This implies that these wastes can be turned to wealth. There is yet another wave of renewed interest in biogas usage due to increasing concerns of climate change, indoor air pollution and increasing oil prices[8]. The aim of this research is to generate biogas from Biodegradable waste ( cow dung) and the Specific objectives include: To optimize the quantity and quality of biogas produced from the anaerobic fermentation of Biodegradable waste, determination of the pH and temperature at which biogas is produced at optimum, determine the best ratio of Biodegradable waste (Cow dung) for optimum biogas production.

## 2. MATERIALS AND METHODS

### 2.1. Sample Collection

Fresh cow dung (intestinal and abdominal waste) was obtained at new community market Ikpa in Nsukka, Enugu State of Nigeria. The sample was collected in a large clean plastic container and transported within 24 hours to the laboratory for analysis.

### 2.2. Preparation of Waste

Varied quantities of both intestinal cow dung waste and abdominal cow dung waste were weighed out and thoroughly mixed in a calibrated plastic bowl before charging into a 32-litres bioreactor. An appropriate quantity of water was used, which was determined by the moisture content of the waste used.

### 2.3. Experimental Design

A set of Two batch bioreactors (labeled A and B) of 32-litre capacity was charged up to ½ of the bioreactor volume, varying the amount of cow dung while the volume of water remained constant as shown below:
Bioreactor A (1:2): consisted of 8kg of cow dung to 16litres of water only.
Bioreactor B (1:0:2): consisted of 4kg of cow dung to 16litres of water
These digestion processes was carried out for the period of 30 days retention time.

### 2.4. Proximate Analysis

#### 2.4.1. Determination of Moisture Content of the substrates using the Method [9]. Procedure

A clean crucible was ignited and cooled in a desiccator and the weight taken. Exactly 2g of the sample was placed in the crucible and the weight of the crucible + sample was taken. The crucible was then dried in the oven at 100$^{o}$C for 24 hours to constant weight (by reweighing after every 4 hours then after 30 minutes until a constant weight was obtained). The weight was taken and the % moisture content calculated as shown; % moisture content =

$$\frac{\text{Weight of sample – Weight of crucible + Sample after drying}}{\text{Weight of sample taken}} \times 100$$

#### 2.4.2. Determination of Fat Content of the Substrate, using Soxhlet Extraction Method[10]. Procedure

A clean flask was dried in an oven at 100 $^{o}$C and was cooled in a desiccator before weighing. Five (5g) gramme of the sample were transferred into the flask. The sample was then ground with electric blend to pass 1-mm sieve in a thimble, plugged with cotton wool and was placed into the extractor. The extraction was done with petroleum spirit for 4 hours first. Thereafter, the residue was transferred into a small mortar, ground lightly and was then returned to the extraction apparatus. The mortar was washed and rinsed with small quantity of petroleum spirit, and transferred into the flask. The extraction was continued for additional 1 hour until most of the solvent had distilled from the flask into the extractor. It was then placed in an oven for 2 hours. This was cooled and weighed. The percentage oil was calculated as follows :

$$\text{\% oil (w/w)} = \frac{\text{Initial weight of the sample-final weight of the sample after extraction}}{\text{Initial weight of the sample taken}} \times 100$$

### 2.5. Pre and Post Digestion Characteristics of Cow dung

#### 2.5.1. Total solid analysis

A clean evaporating (porcelain) dish was washed and dried in a hot air oven at 105$^{o}$C for one hour. The empty evaporation dish was weighed in an analytical balance and the weight measured denoted as (Wdish). Using a pipette, 75ml of the sample was transferred into the porcelain dish, weighed and denoted as (Wsample). The oven was switched on and allowed to reach 105$^{o}$C. The weighed sample (Wsample) was then placed in the oven and dried for 1 hour, then cooled in desiccators. The dish was weighed as soon as it has cooled to avoid absorption of moisture. The weight with residue was noted as (Wtotal) and % total solids was calculated as shown below:

$$\text{\% total solid} = \frac{\text{Wtotal-Wdish}}{\text{Wsample-Wdish}} \times 100$$

Where: Wdish is weight of dish (mg)

Wsample is weight of wet sample and dish (mg)

Wtotal is weight of dried residue and dish (mg)[11]

#### 2.5.2. Volatile solid and volatile fatty acid analysis

The evaporating dish containing the dried residues was transferred to an oven which has been heated to 550$^0$C and ignited for 2hrs then Cooled in a desiccator the residue weighed and recorded as Wvolatile. The % volatile solids was calculated as shown below:

$$\% \text{ volatile solids} = \frac{\text{Wtotal - Wvolatile}}{\text{Wtotal – Wdish}} \times 100$$

Where:
Wdish is weight of dish (mg)
Wtotal is weight of dried residue and dish (mg)
Wvolatile is weight of residue and dish after ignition (mg)

### 2.6. Quantitative analysis of biogas produced

Quantification of biogas production was analyzed through gas collection by downward displacement of water by biogas produced on daily basis and the volume of displaced water recorded as the volume of gas produced.

### 2.7. Qualitative analysis of biogas produced

Qualitative analysis of flammable biogas produced in each of the reactors was determined using BACHARACH Gas Analyzer (PCA2) which shows composition of methane, carbon monoxide, hydrogen sulphide and oxygen. The inlet pot of the BACHARACH Gas Analyser was taken close to the biogas outlet pipe and the gas was allowed to flow into the analyzer which analyzes the quantity of methane and carbon dioxide produced in percentage, while the quantities of hydrogen sulphide and oxygen are given in ppm.

### 2.8. Determination of pH of the Slurry, Ambient and Slurry Temperature in the Bioreactor

The pH of the slurry were determine using pH meter (Search Tech, model PHS 3C). Samples of the slurry were collected on the first day of charging the digester and pH determined. This was repeated 3times a week after stirring for four weeks. The ambient and slurry temperatures of the bioreactor(s) were also monitored at 24 hours interval throughout the retention period after charging of the bioreactors with mercury in glass thermometer (0-100$^0$C). The slurry temperature was determined by immersing the mercury bulb into the slurry and it was held at the tip of the thermometer. The temperature was taken when the mercury reading in the glass had been steady.

### 2.9. Determination of Biogas Flammability

The flammability of the biogas produced was determined using a fabricated gas burner. The fabricated gas burner was connected to the bioreactor’s valve (tap); with a pipe hose, the valve was then open to allow the flow of gas through the hose to the gas burner, and was ignited.

## 3. RESULTS

### 3.1. Proximate Analysis of Cow Dung.

Table 1 shows the result of the proximate analysis of cow dung. In cow dung the moisture of about 83.55% and fat content of 0.15% were obtained. The cow dung contained higher moisture content due to the nature of the waste and there was low fat content in cow dung.

Table 1: Proximate Analysis of Cow dung

| PARAMETER | COWDUNG |
|---|---|
| **Moisture content ( % )** | 83.55 |
| **Fat content ( % )** | 0.15 |

**3.2. Pre and Post Digestion Characteristics of the Substrates**
The TS and VS characteristics of the cow dung showed high values in the pre digestion analysis with TS giving 400mg/l. The results of the post digested samples showed reduction which denotes adequate utilization of the substrate. The TS was reduced to 92mg/l (Fig. 1). The VFA increased in the post digested sample as against the predigested in which 18.7mg/l and 28.3mg/l were reported respectively. The average pH of the substrate during the period of the study was 6.7.

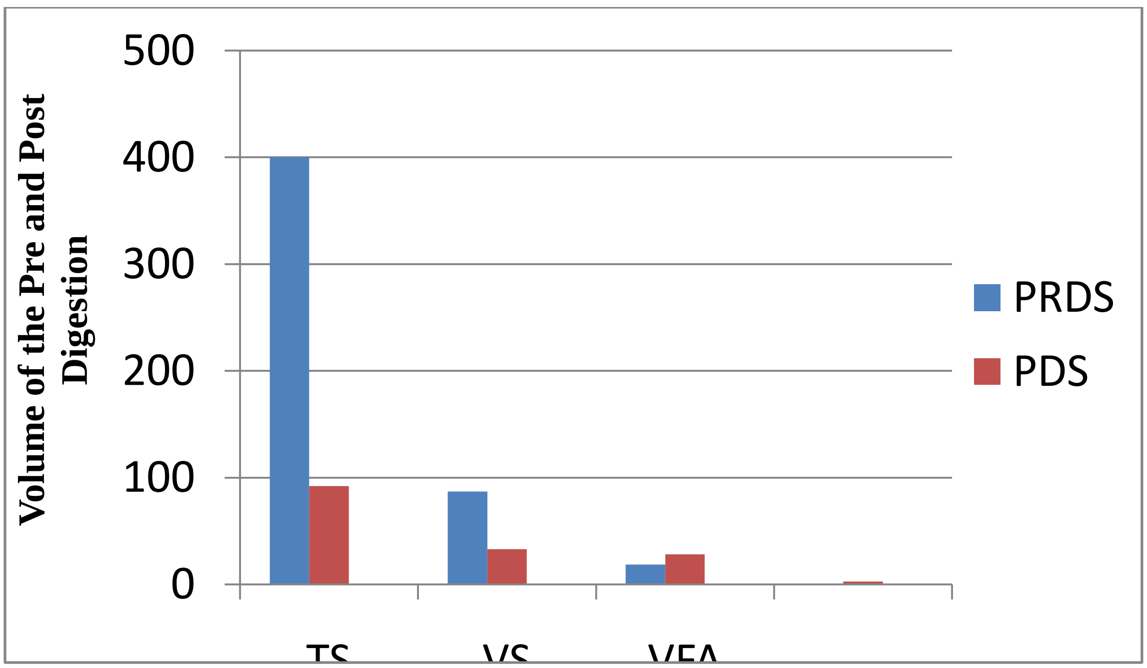


**Fig. 1**: Pre and Post digestion characteristics of cow dung. Key: PRDS= Pre-digestion sample, PDS=Post digestion sample. TS=Total solid, VS=Volatile solid, VFA = Volatile Fatty Acids

**3.3. The Quantity of Biogas Produced Daily in Bioreactor .**
Figure 2 shows the quantity of biogas produced daily in bioreactor (1:2). From the graph, the regression line shows a shallow slope which was accompanied by a large change in X and a small change in Y. The trend indicates co-vary relationship between the day and the biogas produced, the regression line shows a downward displacement which shows that as the day progresses, the quantity of biogas produced reduces.

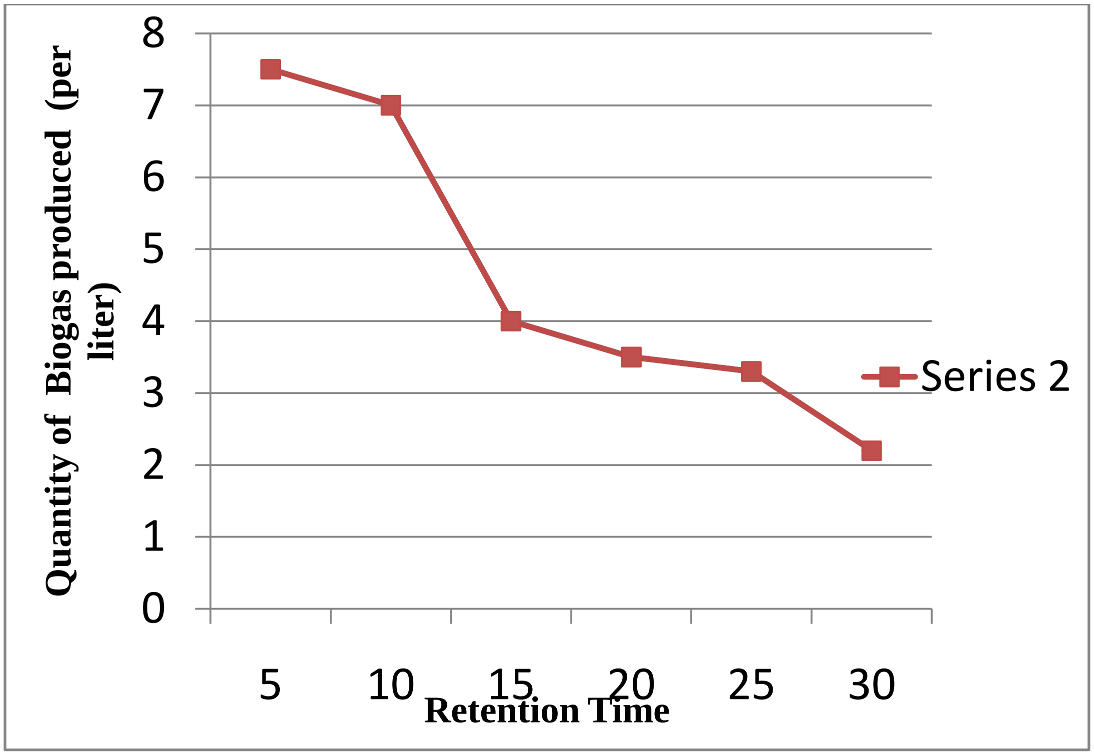


**Fig.2**: The quantity of gas produced daily in a bioreactor

**3.4. Quality of Biogas Produced in the Bioreactor.**

The result in table 2 shows the composition of biogas produced from the mixture in the bioreactor. The mixture of cow dung (A) 1:2 ratio had a higher percentage of methane (82.2%) with the least quantity of carbon dioxide composition of 17.8%,using Bacharach gas analyzer ( $PCA_2$)

**Table 2**: Composition of Biogas Produced in a Bioreactor

| PARAMETER | COMPOSITION PERCENTAGE |
|---|---|
| **Methane ( % )** | 82.2 |
| **Carbon dioxide ( % )** | 17. 8 |

**3.5. Ambient Temperature, Slurry Temperature, PH and Cumulative Biogas volume/Yield**

The anaerobic digestion of cow dung generated some volume of biogas over the Four-week digestion period. There was biogas production in the first two days of anaerobic digestion. The highest biogas yield of 8.5 L/TS was observed in the $4^{th}$ day while the least was observed in the 22nd day. The biogas yield decreases as the day increased. Details of the result are shown in Table3.

**Table3: Ambient Temperature, Slurry Temperature, PH and Cumulative Biogas volume/Yield**

| Days | Ambient temperature ($^oc$) | Slurry temperature ($^oc$) | PH | Volume (l/ts) |
|---|---|---|---|---|
| **0** | 30 | 35 | 6.81 | 3.5 |
| **2** | 33 | 37 | 6.80 | 5.0 |
| **4** | 33 | 39 | 6.80 | 8.5 |
| **6** | 31.5 | 41 | - | 7.5 |
| **8** | 28 | 37 | 6.79 | 6.1 |
| **10** | 32 | 40 | - | 7.0 |
| **12** | 30.5 | 39 | 6.80 | 6 .0 |
| **14** | 31 | 35 | 6.80 | 4.3 |
| **16** | 29.5 | 38 | 6.78 | 3.2 |
| **18** | 32 | 37 | 6.76 | 4.0 |
| **20** | 32 | 36 | - | 3.5 |
| **22** | 27 | 34 | 6.81 | 2.0 |
| **24** | 29 | 35 | 6.80 | 3.3 |
| **26** | 34 | 39 | 6.80 | 2.1 |
| **28** | 27.5 | 33 | 6.85 | 2.2 |
| **30** | 28.5 | 32 | 6.80 | 2.2 |


**Fig 3:** Flammability check using a gas burner

## 4. DISCUSSION

In this study the amount of gas produced varies with biochemical characteristics of organic wastes, pH, temperature, etc. The solids reported in the study were digestible and degradable; hence, the values of the TS and VS in the post digested sample (PDS) were much lower than the predigested sample (PRDS). These findings were similar to the report of [12] who reported lower TS and VS in the post digestion sample and higher pre-digestion samples(PRDS) The results on total solids were correlated to the quantity and quality of biogas in the cow dung This observation is correlated to the report of [13-14] who reported higher quantity of biogas yield from reactors with TS 7.4% and 9.2% as against rectors with TS 2.65%, 4.6% and 6.2% .This study was carried out to investigate the best ratio of water to cow dung (based on the moisture content of the cow dung) for biogas production. The production of flammable biogas commenced within 78 hours of charging. The high production of biogas observed in Bioreactor (1:2) could be attributed to the water ratio added to the cow dung, which provided the medium for maximum activities of the extracellular enzymes and mass transfer of the anaerobes within the reactor.

However, because of the high water ratio content during slurry charging thus increased the biogas yield . The study showed declines in the cumulative biogas yield at third week, the decline could also be as a result of the properties of the cow dung such as the moisture content as shown in table 1 and reduction in the bacterial load which help in the degradability property thereby leading to low yield of biogas. This implies that the mixture in Bioreactor (1:2) with 8kg of cow dung and 16 litres of water was the best mixture for flammable biogas production.

However, [15] further analysis of the result obtained in Bioreactor shows the onset of flammable of biogas as observed in Bioreactor could also be as a result of the less fat content of the waste as shown in table 1 and microbial action on the waste which converted the fatty acid into acetate, thereby improving the pH of the slurry for methogenic activities The results from this study showed *Bacillus* species appears to overlap from one stage to another during biogas production, suggesting a succession in species of bacteria during the process of gas production.

## 5. CONCLUSION

Biogas is a gas from anaerobic decomposition technology of biochemical reaction carried out by several types of microorganisms that require little or no oxygen to survive. After this process a gas that is mainly composed of methane and carbon dioxide is produced. Biodegradable waste (Cow dung) are largely generated in Nigeria on a daily basis and could be employed as raw material for both small and large-scale biogas production. The high quantity of methane produced from cow dung can be technologically harnessed and made a viable renewable energy source especially for developing countries. The production of this biogas will reduce over dependent on gas gotten from fractional distillation of fossil fuel. Also bear in mind that this fuel could get exhausted any time soon, hence need for degradable waste as a renewable Energy Source.


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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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**APPENDIX**

A B

**App.1A**:  Quantitative analysis using downward displacement and **1B**: Quanlitative Analysis using Bacharach pca2 gas analyzer .