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*Full Length Research Paper*

# Comparative analysis of biogas produce from tannery effluent and groundnut waste

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**A comparative analysis of biogas produced from tannery effluent and groundnut waste was examined. The bacteria isolated and identify are; *Bacillus laterosporus*, *B. alvei*, *B. lentus*, *B. subtilis*, *B. cereus*, *Pseudomonas aeroginosa*, *Yersinia enterocolitica*, *Proteus mirabilis*, *Vibrio parahaemolyticus*, *Listeria monocytogenes*, *Serratia marcescens* and *Citrobacter diversus*. A volume of 306cm$^3$ of biogas was produced from tannery effluent, while 317cm$^3$ was produced from groundnut waste for a period 30 days. There was no significant difference in the amount of biogas produced from tannery effluent and groundnut waste, ($P \leq 0.05$). Therefore both tannery effluent and groundnut waste can be utilized for biogas production.**

**Keyword**: Biogas, comparative analysis, tannery effluent, groundnut waste,

## INTRODUCTION

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen (Aliyu *et al*, 1995). It is a flammable gas produced by anaerobic fermentation of organic waste materials. Biogas originates from biogenic material and is a type of biofuel. (Zuru, 2006). Depending on where it is produced, biogas can also be called swamp, marsh, landfill or digester gas. A biogas plant is the name often given to an anaerobic digester that treats farm waste or energy crops. (Wikipedia, 2008).

The composition of biogas is typically; methane 50-75%, carbondioxide 25-50%, nitrogen 0-10%, Hydrogen, 0-1%, Hydrogen sulfide 0-3% and oxygen 0-2% (Wikipedia, 2007). Biogas can be utilized for electricity production, space heating, water heating and process heating. If compressed, it can replace compressed natural for use in vehicles, where it can fuel an internal combustion engine or fuel cells. Compressed biogas is becoming widely used in Sweden, Switzerland and Germany. A biogas-powered train has been in service in Sweden since 2005. methane within biogas can be concentrated to the same standards as natural gas, when is, it is called biomethane (Cheremisinoff and Ellerbush, 1980) Bioenergy already accounts for nearly 10percent of total world energy supplies. It accounts for more than 60 percent of final energy used in Africa, 34 percent in Asia and 25 percent in Latin America. (Oyeleke, 2007). A variety of factors affect the rate of digestion and biogas production, the most important include pH temperature and nutrient content. Optimum biogas production is achieved when the pH value of input mixture in the digester is between 6 and 7 (Oyeleke *et al*, 2003).

Tannery effluent refers to the waste water resulting from the process of converting skin and hide into leather. Tanning involves the use of alum, gall nuts, tree barks, pods and leaves of certain plants used for tanning process (Mann, 1996). Tannery effluents contain vegetable tannins and non-tannins which exert oxygen demand. The discharge of untreated waste water into water bodies may affect the physical, chemical and biochemical characteristics of the water and deplete dissolved oxygen in water bodies. The high oxygen demand of tannery waste is due to protein fatty matter and tannins (Ajayi, 1996).

High pH, excessive alkalinity, suspended matter, sulphides in tannery waste water react with iron and other metal causing black precipitate rendering water unfit for industrial uses, fishes and other aquatic life in streams are also affected (Somanath, 1990). Nitrogen and phosphorus from tannery effluent encourages uncontrolled growth of algae and other aquatic plants in water bodies (Madhappen and Herbert, 1994).

Groundnut *Arichia hypogaea* is one of the important oil seed crops. It has an oil content of 50% as compared to 40% of sunflower, 20% of soyabean and

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50% sesame crop. The aim and objective of the study is to comparatively analyze the biogas produced from tannery effluent and groundnut slurry waste in respect to volume/amount of biogas produced, retention time, physical and biological condition necessary for maximum production and substrate availability in order to advice prospective or biogas producing companies on the best condition and substrate to use for biogas production.

## MATERIAL AND METHODS.

### Sample collection

Tannery effluent sample was collected from Ungwan rogo "majaima", a local tannery industry in Sokoto metropolis. While groundnut waste was collected from groundnut oil cooperative 'yarojoriba, a local groundnut oil extract company in Sokoto metropolis.

### Digester design

### Material needed

A hole was bored on the cover of the Can by a machine, and hose pipe (which serves as a delivery tube for the gas) was then derived into the hole bored on the cover. Areldyte was then applied around the hole to ensure that no air is allowed to either seep into or out of the digester. The feed stock (slurry) was then fed into the digester (Can) and covered with the cover which has already been connected to the hose pipe. Areldyte was also applied around the circumference of the Can cover ensuring an airtight condition which is necessary for anaerobic digestion. The water basin was filled with water and measuring cylinder containing water was inverted into the water filled basin avoiding bubbles of air. The retord stand was used to hold the measuring cylinder vertically in the basin. The hose pipe which have been connected to the digester was introduced into the water basin and passed through the measuring cylinder for the collection of gas produced.

### Slurry preparation and installation

From the groundnut waste sample, 100g was weighed and mixed with 400ml of water to produce a groundnut slurry waste 1:4w/v. while 400ml of tannery effluent with equal amount of solid particles was also measured and fed into the digester. The pH of both the slurry was determined. The samples were replicated three times giving a total of six digester (i.e. three for groundnut waste and three for tannery effluent) and was allowed to stand for 30days for biogas production. During the period of biogas production, daily reading of the amount of biogas produced and temperature was, measured and recorded at about 12:00pm (Daily). After the biogas production 5ml of the sample from groundnut and tannery sludge was collected for biochemical determination of microorganism responsible for biogas production, also the same slurry was prepared and 5ml was collected from both groundnut and tannery waster for biochemical determination of microorganism before biogas production. The slurry was then sterilized by autoclaving of 121$^{o}$C for 15 minute, after which a known microorganism isolated after biogas production was inoculated into the slurry for biogas production.

### Media preparation

### Nutrient Agar Medium

The following media was prepared according to manufacture's instructions, 28g of nutrient agar was weighed and dispensed into a conical flask containing 1000ml of distilled water and was sterilized by autoclaving (Cheesbrough, 2003)

### Serial Dilution and Inoculation

Serial dilution of the sample of groundnut waste and tannery effluent was carried out and dilution factor of $10^{-4}$ and $10^{-5}$ was inoculated into nutrient agar by spread plate method.

### Charaterization and identification of bacteria isolate

The isolates were characterized and identified following standard procedures of Gram staining, catalase test, spore staining, indole test, citrate test, urase test, carbohydrate utilization test, methyl red voges proskaver test, and hydrogen sulphide gas production, described by cheesbrough (2003) and Oyeleke and Manga (2008).

## RESULTS

The pH of slurry as was measured using a pH meter before biogas production. The pH of each of the digester of both groundnut waste and tannery effluent were determined

#### Statistical analysis

#### Mean separation

Standard Error (SE) = 969.8
Standard Error of Difference (SED) = 1371.5
Coefficient of variation (CV) = 495.6%
Least significant Difference (LSD) = 2988

**Table 1.** pH of slurry before biogas production

| Digester | Tannery effluent (pH) | Groundnut waste (pH |
|---|---|---|
| 1 | 4.6 | 5.6 |
| 2 | 4.6 | 5.7 |
| 3 | 4.7 | 5.6 |

The pH of slurry as was measured using a pH meter after biogas production. The pH of each of the digester of both groundnut waste and tannery effluent were determined

**Table 2.** pH of slurry after Biogas production

| Digester | Tannery effluent (pH) | Groundnut waste (pH) |
|---|---|---|
| 1 | 5.7 | 5.6 |
| 2 | 5.5 | 6.1 |
| 3 | 5.6 | 5.8 |

The total viable microbial count obtained from groundnut waste and tannery effluent.

**Table 3.** Total microbial count (cfu/ml)

| Digester | Tannery effluent (cfu/ml) | Groundnut waste (cfu/ml) |
|---|---|---|
| 1 | $11.2x10^3$ | $9.2x10^3$ |
| 2 | $8.8x10^4$ | $8.1x10^3$ |
| 3 | $7.4x10^4$ | $8.0x10^3$ |

The record of both temperature and volume of biogas produced from each replicate treatment of tannery effluent over a period of 30 days as recorded at 12:00pm daily.

**Table 6.** Biogas production from tannery effluent

| Day | Average room | Volume of gas produced ($CM^3$) | | |
|---|---|---|---|---|
| | Tem.($^0$C) | $T_1$ | $T_2$ | $T_3$ |
| 1 to 5 | 29 | 310 | 120 | 300 |
| 6 to 10 | 29 | 40 | 70 | 50 |
| 11 to 15 | 29 | 00 | 00 | 00 |
| 16 to 20 | 30 | 10 | 00 | 15 |
| 21 to 25 | 30 | 00 | 00 | 05 |
| 25 to 30 | 30 | 00 | 00 | 00 |

The record of both temperature and volume of biogas produced from each replicate of groundnut waste over a period of 30 days as recorded at 12:00pm daily

**Table 7.** Biogas production from groundnut waste

| Day | Average ambient Temp. ($^0$C) | Volume of gas produced ($Cm^3$) | | |
|---|---|---|---|---|
| | | $G_1$ | $G_2$ | $G_3$ |
| 1 to 5 | 29 | 20 | 70 | 10 |
| 6 to 10 | 29 | 310 | 00 | 24 |
| 11 to 15 | 29 | 50 | 188 | 190 |
| 16 to 20 | 30 | 00 | 00 | 25 |
| 21 to 25 | 30 | 10 | 00 | 00 |
| 26 to 30 | 30 | 00 | 00 | 00 |

The gross average record of biogas produced from both tannery effluent and groundnut waste as recorded over a period of 30 days

**Table 8.** Average gas production

| Day | Tannery effluent ($CM^3$) | Groundnut waste ($CM^3$) |
|---|---|---|
| 1 to 5 | 243 | 33 |
| 6 to 10 | 53 | 275 |
| 11 to 15 | 00 | 143 |
| 16 to 20 | 13 | 25 |
| 21 to 25 | 05 | 10 |
| 26 to 30 | 00 | 00 |

## DISCUSSION

The bacteria isolated and identified are *Bacillus laterosporus, Bacillus alvei,Pseudomonas aeruginosa, Yersinia enterocolitica, proteus mirabilis, Bacillus lentus, Listeria monocytognes, Vibrio parahaemolyticus, Serratia marcesens, Citrobacter diversus, Bacillus subtilis, Salmonella species* and *Bacillus cereus* (as presented in table 4 and 5) *Bacillus laterosporus, Proteus mirabilis* and *Pseudomnas aeruginosa,* were isolated from the waste material both before and after biogas production. They are members of falcultative anaerobes since they were viable in both aerobic and anaerobic condition. However, *Listeria monocytogenes, Yersinia enterocolitica* and *Bacillus lentus* were present in the waste material before biogas production but absent after the production. They were probably inhibited or killed due to changes in growth parameters of pH and temperature or they are aerobic bacteria.

The pH determined before biogas production from table 1 do not reach the optimum pH required for biogas production which is between 6 and 7. From table 2, there has been no any appreciable increase in pH value. This low pH value before and after biogas production has reduced the activity of biogas producing microorganism since methanogenic bacteria are very sensitive to pH and do not thrive below a value 6.5, Fernando and Dangogo (1986).

The average temperature range (from table 6 and 7) is 29-30$^0$c which is optimum for biogas production; this also validates the temperature range cited by Oyeleke (2007). At low temperature, microorganisms become inactive and rate of gas production drops but resumes when the temperature is favorable.

Tannery effluent has less retention time compared to groundnut waste (as shown in figure 1 and 2) that has the highest production within the first 5 days. This can be attributed to the water content, of tannery effluent which gives the microorganism high water activity. Water is one of the growth factor required by microorganisms and since tannery effluent is always

**Table 9.** Groundnut waste Vs Tannery effluent

| Waste material | Gas yield |
|---|---|
| Groundnut waste | 371[a] |
| Tannery effluent | 306.7[a] |

371-306.7 = 64.3
64.3 < 2988 (LSD)
Not significantly different.

in liquid form, microorganisms in tannery effluent are always viable and active. Methane must have been produced from tannery effluent even before anaerobic digestion but at slow rate and it seep in to the

Atmosphere as in landfill gas according to Oberbeck (2005). The production increase however in anaerobic digester. Therefore tannery effluent is a good substrate to be used for immediate gas production. Groundnut waste on the other hand, has its highest production after the first 10 days. This is due to the low moisture content in groundnut waste that requires ample time for hydrolysis before gas production.

There was no significant difference in gas yield from groundnut waste and tannery effluent (as presented in table 9). That is both substrate produce the same amount of biogas under the same physical condition, P ≤ 0.05. Groundnut waste (husk) is readily available in large quantity especially in Northern part of Nigeria where groundnut is cultivated. It's of less economic importance and is not use as livestock feed, it even pose disposal difficulties. It is a good source of substrate for large scale biogas production as was suggested by Nguyen *et al* (2007). On the other hand, tannery effluent is at zero value with a disagreeable odour causing underground water contamination and contamination of large water bodies. Tannery effluent used for biogas production is a good source of fertilizer because of its high nitrogen content.

There was no gas production after sterilization of the substrate. The *Citrobacter diversus* that was inoculated was inhibited by low pH. In practical, fermentation processes involves the synergic metabolic action of various bacteria. No single bacterium is able to produce fermentation product alone, Lung *et al* (1996).

## CONCLUSION

This study revealed that there is no significant difference in the amount of biogas produced from tannery effluent and groundnut waste (p ≤ 0.05). Considering the zero cost of both tannery effluent and groundnut waste in addition to controlling environmental pollution, The use of groundnut waste and tannery effluent as substrate for biogas production is concluded a worthwhile venture. And substrate is best efficient in biogas production when used in its crude form.

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