# BIOGAS PRODUCTION FROM ANAEROBIC CO-DIGESTION OF GROUNDNUT SHELL AND SUGARCANE BAGGASE WITH COW DUNG

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**ABSTRACT**
The study analyzed the biogas production from anaerobic co-digestion of groundnut shell and sugarcane baggase with cow dung, the experiment was conducted under a batch process at thirty five days retention time. The proximate composition of the substrates before anaerobic digestion revealed digester B had the highest T.S (93.47), VS (85.59) and T.C (42.00). Digester A had highest T.N (2.25), digester C had highest C/N (112.2) digester A had the highest ash content (28.70) and digester A had highest moisture content (13.76), after the anaerobic digestion, digester B had the highest TS (86.5) and V.S (75.86), digester D (45.2), TC is highest in digester A (1.78), C/N ration is highest in digester C (156.26), ash content is highest in digester A(35.15) and digester E had the highest moisture content (25.23). Result of cumulative biogas production revealed that digester D had the highest biogas production (2850ml) after thirty five days retention time. The substrates are worthwhile venture and the substrates are best efficient in biogas production when co digested with cow dung.

**KEYWORDS: Anaerobic Co-digestion, Biogas, Cow dung, groundnut shell and sugarcane baggase.**

## 1.0 INTRODUCTION

There is an urgent need for alternative energy sources as a result of the dwindling energy resources which has become a global concern. This has made it imperative to search for new sources of domestic energy. The quest for wood as a source of domestic energy has led to deforestation and erosion in the southern parts and near desertification in the northern parts of the country (Ilochi and Nwachukwu, 1989). Raw materials for biogas production cover a wide range of feedstock including animal wastes, household wastes, crop residues, sewage sludge, food waste, and wastewater (Suneerat *et al.*, 2009). Manure component (carbohydrates, proteins, and lipids) carbon is ultimately transformed into methane ($CH_4$) and $CO_2$ (carbon dioxide) (Masse *et al*, 2011).

In Nigeria, identified feedstock substrate for an economically feasible biogas production includes water lettuce, water hyacinth, dung, cassava leaves and processing waste, urban refuse, solid (including industrial) waste, agricultural residues and sewage (Ubalua, 2008). It has been estimated that Nigeria produces about 227,500 tons of fresh animal waste daily. Since 1kg of fresh animal waste produces about 0.03 $m^3$ of biogas, then Nigeria can potentially produce about 6.8 million m3 of biogas every day from animal waste only. In addition, 20 kg of municipal solid waste (MSW) per capital has been estimated to be generated in the country annually (Mathew, 1982). Groundnut shell is found in large quantities as agricultural farm wastes in Northern parts of Nigeria such as Sokoto, Kebbi, Zaria, Borno and Yobe States (Sadaa *et. al*, 2013).

Co-digestion has been defined as the anaerobic treatment of a mixture at least two different substrates with the aim of improving the efficiency of the anaerobic digestion process (Neczaj *et al.*, 2012). The composition of biogas largely depends on the type of substrate used for its formation. Biogas is about 20 percent lighter than air. It burns without smoke and is non-toxic. It is also an odorless and colorless gas that burns with clear blue flame similar to liquefied petroleum gas (LPG) (Karki *et al.*, 2005). Anaerobic digestion of groundnut shell and sugarcane baggase is a technology that has been shown to effectively address many of the problems associated with groundnut shell and sugarcane baggase waste management such as waste accumulation which is not environmentally desirable as they take too long time to break down and air pollution which originates from uncontrolled burning.

## 1.2 AIM AND OBJECTIVES

The aim and objectives of this work are to:

1 determine the proximate composition of the substrates

2 produce biogas by anaerobic co-digestion of groundnut shell and sugarcane baggase with cow dung.

3 determine the cumulative volume of biogas produced.

## 2.0 MATERIALS AND METHOD

### 2.1 Sample collection

The agricultural wastes sample used for this research were, Cow dung collected from abattoirs in Kara, Groundnut shell obtained from groundnut Sheller plant and Sugarcane baggase, all substrate were collected from Argungu local government area of Kebbi state in a sac and transported to laboratory for processing.

### 2.2 Apparatus and Equipment

Five (1000ml) measuring cylinders, Hose pipe (which served as delivery tube for the gas), Araldite gum, five 6L digester cans, five plastic bowls, weighing balance, mercury-in glass thermometer (0-100$^0$C), digital pH meter (Hanna model 211), mortar and pestle, five retort stands were gathered.

### 2.3 Substrate treatment

The groundnut shell and sugarcane baggase were sun dried for about 3-4 days and crushed mechanically to smaller sizes while cow dung was ground using mortar and pestle. The substrates were then sieved, homogenized, packed and labelled in different plastic containers for further analyses.

### 2.4 Proximate composition of the substrates

Total solid (TS), Volatile Solid (VS), Carbon to Nitrogen (C:N) ratio, Ash Contents, Moisture Content (MC) and pH before and after the digestion process by the methods reported by Yavini *et al.*, (2014).

### 2.5 Experimental design

A hole was bored on the lid of the can by a machine (chissle). One end of the hose pipe (which served as a delivery tube for the gas) was inserted into the hole bored on the lid. Gum (Araldite) was then applied around the hole to ensure that no air was allowed to either seep into or out of the digester as described by Babatola (2008).

The feed stock (slurry) was then fed into the digester (Can) and covered with the lid which has already been connected to the hose pipe. Gum was applied around the circumference of the can lid to ensure an airtight condition which is necessary for anaerobic digestion. The plastic bowls were filled with water and measuring cylinder containing water was inverted in to the plastic bowls filled with water avoiding bubbles of air. The retort stand was used to hold the measuring cylinder vertically in the bowls.

The other end of the hose pipe was introduced into the water basin and passed through the measuring cylinder for the collection of gas produced. The volume of the water displaced is proportional to the volume of biogas generated.

The mode of loading was a discontinued feeding (batch feeding). This simply means loading the digester at once and maintaining a closed environment throughout the retention period. Five different digesters were prepared for loading. These digesters were labeled as follows:

Digester A: Cow dung only (A only)
Digester B: Groundnut shell only (B only)
Digester C: Sugarcane baggase only (C only)
Digester D: Groundnut shell with Cow dung (A & B)
Digester E: Sugarcane baggase with cow dung (A & C

## 3.0 RESULTS AND DISCUSION

### 3.1 Proximate composition

#### 3.1.1 Total Solid

Results in Table 1 show that the total solid were 86.24 and 93.47and 87.86 for substrates A, B and C respectively before the digestion. After the anaerobic digestion the values of total solid for the three substrates were 79.63, 86.51 and 80.04 respectively for digesters A, B and C. Digesters D and E with 82.32 and 74.77 (Table 2). This implies that there was a significant difference ($P<0.05$) between the set up digesters. This result is in line with the work of Latinwo and Agarry (2015) who reported a decrease in the value of Total Solid after anaerobic digestion.

#### 3.1.2 Volatile Solids

The values of volatile solids in Table 1 were 71.26, 85.51 and 78.95 for digesters A, B and C respectively, after anaerobic process the values of volatile solid were 64.85, 75.86, and 69.89 respectively for the digesters A, B and C. There was a significant difference ($P<0.05$) between the substrates. Digesters D and E had the values 68.52 and 65.10 respectively (Table 2). The reduction in these values was as a result of the volatile solid that has been converted into biogas.

#### 3.1.3 Total Carbon

Result in Table 1 show that total carbon values of the substrates were 31.50, 42.60, and 38.15 respectively before anaerobic digestion. After the anaerobic digestion, the values of total carbon were 28.51, 39.72 and 36.40 for the substrates respectively. Digesters D and E had values 45.2 and 43.7 respectively (Table 2), there was a decrease in these values as a result of the utilization of the substrate

#### 3.1.4 Total Nitrogen

The result in Table 1 shows the total Nitrogen values were 2.20, 1.07, and 0.34 for the substrates respectively before anaerobic digestion. After the anaerobic digestion, the values of total Nitrogen were 1.78, 0.96 and 0.23 respectively, digesters D and E with 1.02 and 41.73 respectively (Table 2). There was a significant difference ($P<0.05$) between the substrates. This result is in line with the work of Yavini *et al*. (2014) who stated that the main problem with anaerobic digestion of crop residues is that most of the agricultural residues are lignocelluloses with low nitrogen content.

### 3.1.5 Carbon/ Nitrogen (C/N) Ratio

The result in Table 1 shows the Carbon/ Nitrogen ratios of the substrates before the digestion were 14.3, 39.9, and 112.2 for digesters A, B and C respectively. After the anaerobic digestion, the values of C/N were 19.4, 50.13 and 181.43 digesters A, B and C respectively, digesters D and E with 44.3 and 141.0 respectively (Table 2). There was a significant difference (P<0.05) between digesters. This implies that the increase in C/N ration increases the biogas production this result is in line with that of Rabah *et al.* (2010) who noted that C/N ration in anaerobic digestion increase the biogas production

### 3.1.6 Ash Content

Ash Content of the substrates before the anaerobic co-digestion were 28.74 14.49 and 21.05 for digesters A, B and C respectively and after the anaerobic digestion, the values of ash content were 35.15, 25.14 and 30.11 for the substrate respectively. Digestates D and E have the following values: 31.48 and 24.90 respectively (Table 2)

### 3.1.7 Moisture Content

Moisture contents of the substrates before the anaerobic co-digestion were 13.76, 6.53 and 12.4 for substrates respectively and after the anaerobic digestion, the values of Moisture content were 20.37, 13.49 and 19.96 for digesters A, B and C respectively There was a significant difference at (P<0.05). Substrate A had the highest moisture content. The moisture contents were moderately low and were satisfactory for biogas production. Digesters D and E have the following values: 17.68 and 25.23 respectively (Table 2). This result is in line with the reports of Muzenda (2014).

**Table 1**: Proximate Analysis of the Substrates before the Anaerobic Co-digestion

| Parameters | Substrate A | Substrate B | Substrate C |
|---|---|---|---|
| Total Solid (%) | 86.24 | 93.47 | 87.86 |
| Volatile Solid (%) | 71.10 | 85.59 | 78.95 |
| Total Carbon (%) | 31.20 | 42.62 | 38.15 |
| Total Nitrogen (%) | 2.25 | 1.07 | 0.34 |
| Carbon /Nitrogen | 14.35 | 39.9 | 112.2 |
| Ash Content (%) | 28.70 | 14.49 | 21.05 |
| Moisture Content (%) | 13.76 | 6.53 | 12.14 |

**Table 2**: Proximate Analysis of the Digestate after the Anaerobic Digestion

| Parameters | Digester A | Digester B | Digester C | Digester D | Digester E |
|---|---|---|---|---|---|
| Total Solid (%) | 79.63 | 86.5 | 80.04 | 82.32 | 74.77 |
| Volatile Solid (%) | 64.85 | 75.86 | 69.89 | 68.52 | 65.10 |
| Total Carbon (%) | 28.51 | 39.72 | 36.40 | 45.2 | 43.70 |
| Total Nitrogen (%) | 1.78 | 0.96 | 0.23 | 1.02 | 0. 31 |
| Carbon/Nitrogen | 16.02 | 41.3 | 158.26 | 44.3 | 141.0 |
| Ash Content (%) | 35.15 | 24.14 | 30.11 | 31.488 | 34.90 |
| Moisture Content (%) | 20.37 | 13.49 | 19.96 | 17.68 | 25.23 |

### 3.8 Weekly cumulative biogas production (ml) for the digesters

Results in Table 3 show the cumulative biogas produced from all the digesters. Digester D has the highest cumulative production of 2850ml, digester E has total cumulative of 2515, digester A with a total cumulative of 2515ml, digester B with a total cumulative of 1475 and digester B with a total cumulative of 1085ml. The biogas yields from co-digestion are significantly higher than that of mono-digestions. This implies that co-digestion provided additional enzyme for utilization of the substrates. This results is in line with that of Iyagba *et al*. (2009) Also, Muzenda (2014) reported that co-digestion of energy crops can increase biogas recovery by 16-65%. This study shows co-digestion in digester D and E to be capable of improving the efficiency of biogas production than mono-digestion. This result supports the observation of Murto *et al*. (2004) who reported that co-digestion could improve biogas production by 50- 200%, depending on the operating condition and substrates used. The lower level of biogas produced by sugarcane baggase only is due to lower value of nitrogen which is needed to decompose its cellulose structure and also in mono-digestion of cow dung, sugarcane baggase and groundnut shell, the low production is due to the lower values of reducing sugars and soluble protein compared to those derived from the co-digestion.

**Table 4: Weekly Cumulative Biogas Production (ml) with Temperature ($^{o}$C) for the five digesters**

| Retention Time (weeks) | Temperature ($^{o}$C) | Digester A (ml) | Digester B (ml) | Digester C (ml) | Digester D (ml) | Digester E (ml) |
|---|---|---|---|---|---|---|
| 1 | 37 | 215 | 1005 | 225 | 2030 | 420 |
| 2 | 36 | 1230 | 1445 | 875 | 2640 | 2000 |
| 3 | 36 | 1470 | 1475 | 1080 | 2825 | 2440 |
| 4 | 37 | 1565 | 1475 | 1085 | 2850 | 2515 |
| 5 | 38 | 1570 | 1475 | 1085 | 2850 | 2515 |

## CONCLUSION

Considering the zero cost of the substrates in addition to controlling environmental pollution, the use of groundnut shell and sugarcane baggase as substrate for biogas production is concluded a worthwhile venture and substrates are best efficient in biogas production when used in its crude form.

**REFERENCES**

Babatola, J.O. (2008). Comparative study of biogas yield pattern in some animal and household wastes. *African Research Review,* 2 (4):54-68,

Ilochi E.E and Nwachukwu A (1989). Proc. Int. Symposium Biotechnology for Energy. Dec 1621.

Iyagba, E.I., Mangibo, I. A. and Mohammad, Y. S. (2009) The study of cow dung as co-substrate with rice husk in biogas production. Scientific Research Essays, 4 (9), 861-868.

Karki AB, Shresta J. N. and Bajgain S. (2005). *Biogas, As Renewable Source of Energy in Nepal, Theory and Development*, BSP-Nepal Publishing, Kathmandu, 1-12.

Massé D.I., Talbot G. and Gibert Y. (2011). In farm biogas production: A method to reduce GHG emissions and develop more sustainable livestock operations, *Animal Feed Sci. and Techn.,* 166: 436-445.

Matthew P. (1982). Gas production from animal wastes and its prospects in Nigeria *Nig. J. Solar Energ*y, 2(98): 103.

Murto M., Bjo¨rnsson L., and Mattiasson B. (2004). Impact of food industrial waste anaerobic co digestion of sewage sludge and pig manure. *Journal of Environmental Management*, 70(2), 101–107.

Muzenda E. (2014). Bio-methane Generation from Organic Waste: A Review. Proceedings of the World Congress on Engineering and Computer Science, Vol II, WCECS 2014, 22-24 October, 2014, San Francisco, US

Neczaj E., Bien J., Grosser A., Worwag M., and Kacprzak M. (2012). Anaerobic Treatment of Sewage Sludge and Grease Trap Sludge in Continuous Co-Digestion. *Global NEST J.*, 14(2): 141-148.

Rabah A. B., Baki A. S., Hassan, L. G., Musa M. and Ibrahim, A. D. (2010) Production of biogas using abattoir waste at different time. Science World Journal, 5, 4

Sadaa, B.H., Amarteyb Y.D. and Bako S. (2013). An investigation into the use of groundnut shell as fine aggregate replacement. *Nigerian Journal of Technology (NIJOTECH)*Vol. 32 (1), pp. 54–60

Suneerat P, Sommas K and Tharapong V. (2009). Economic assessment of biogas-to-electricity generation system with $H_2S$ removal by activated carbon in small pig farm *Scientific Res. And Essay,* 4(9):861-886.

Ubalua A.O. (2008). Cassava wastes: Treatment options and value addition alternatives. *Afr. J. Biotechn*., 6: 2065-2073.

Yavini D. T., Taura H. U., Mohammed N. and Namo M. J. (2014). Comparative Study of Mesophilic Biogas Production Potentials of Selected Agro-Wastes. *The International Journal of Engineering and Science (IJES)* 3(2), Pp.1-6.