# Production of Biogas from Cassava Peels Blended with Goat Manure

**K.C. Onyeneho[1*]; Okoh Promise Emeka[2]; Audu Ibrahim Ali[3]; I.C. Iloani (M.Eng In View)[2]; and Ajibili Edibo Haruna[3]**

[1] Department of Mechanical Engineering Technology, Akanu Ibiam Federal Polytechnic Unwana,
[2]Projects Development Institute (PRODA), Enugu, Nigeria.
[3]Department of Mechanical Engineering, The Federal Polytechnic, Idah, Nigeria.

E-mail: emmychyugwuoke@yahoo.com *

## ABSTRACT

Most cassava producing nations have many tonnes of cassava peels produced during the processing period. Waste generation will continue to be on the increase since there is an ongoing expected increase in cassava production. There is an urgent need to manage these waste products in order to reduced environmental pollution in the affected nations of the world. The most efficient management of this environmental waste is through anaerobic digestion which produces biogas.

This work examined the volume of biogas generated from three 50 L digester used for anaerobic digestion of cassava peels. Three digesters were used for the biogas production, digester A containing cassava peels, digester B containing cassava peels blended with goat dung, and digester C containing the cassava peels with goat dung and Inoculum. The Inoculum used was digested cassava peels with goat dung which contain rich anaerobic bacteria. The ratio of water to cassava peel in the three digesters was 2:1. The pH of the anaerobic reaction varied from 5.6 to 7.8. The maximum cumulative biogas yield recorded in the first batch of the experiment was 158.9 liters in digester C. The highest atmospheric temperature recorded during the experiment was 30°C. The batch C of the biogas production recorded the highest cumulative biogas yield of 216.4 liters in digester C.

(Keywords: Cassava peels, goat dung, biogas, waste management, inoculum)

## INTRODUCTION

The dependence on fossil fuels as primary energy source has led to global climate change, environmental degradation, and human health problems. Eighty percent of the world's energy consumption still originates from fossil fuels [1].

Bio-energy (energy produced from biomass) can be seen as one of the key options to fossil fuels. Among the many bio-energy related processes being developed, those processes involving microorganisms are especially promising, as they have the potential to produce renewable energy on a large scale, without disrupting the environment or human activities [2].

With the aid of technology, one can gain an access to efficient utilization of agro-industrial products aimed at obtaining value added products like biofuels, biochemicals, and biomaterials. Bioprocessing of agro-industrial residues can help solve environmental problems associated with the disposal of these materials. Methane production from the crop residues could be an interesting option for disposing these materials and also for increasing the domestic biofuel production [3].

Biogas is the product of organic matters decomposition under oxygen-free condition with microbial participation especially Methanogens [4]. Biogas formation can occur naturally in swamps, marine sediments, and water-logged soils, rice fields, deep bodies of water, sanitary landfills and even in the digestive system of ruminants; and termites. It can also be recovered from lagoons used for waste treatment. Biogas is also called; swamp gas, sewer gas, marsh gas, gobar gas, digester gas, 'will O the wisp gas, natural gas, landfill gas, and sewage gas.

Biogas, a mixture of gasses consisting of 50 – 70%, methane, 30 – 40% carbon dioxide, 5 – 10%, hydrogen, 1 – 2% nitrogen, 0 – 3% water vapor, and traces of hydrogen sulfide, carbon monoxide, and oxygen [4].

Generally, four different stages have been recognized in the production of biogas with several other intermediate products. These include; hydrolysis, acidogenesis, acetogenesis, and methanogenesis. The efficiency, effectiveness and stability of anaerobic digestion and consequently biogas generation can vary significantly based on various operational factors such as; type of waste streams, digester design , temperature, moisture content, retention time, pH, agitation or mixing, bacterial species and organic loading rate. Presence of toxicants can also influence biogas production. Positive implications of biogas include; the reduction in environmental pollution, odor [5, 6], and in the destruction of most pathogenic organisms, worms, ova, etc. Biogas can also serve as a clean alternative to fuel energy source to oil, electricity and wood.

In Nigeria, cassava is mostly produced and processed by small-scale farmers at the family or village level [7]. Cassava provides a reliable and inexpensive source of carbohydrates for people in Sub-Saharan Africa, especially in Nigeria, where its production, processing, and consumption is most predominant and significant on a global scale [8, 9]. It also provides different job opportunities for both men and women from the production stage until it gets to the final stage.

There are indications that the domestic demand for cassava, particularly as a staple food, tends to outweigh the demands of the industrial sector [7]. As farmers are unable to meet their demand, some industries are now engaging in the direct production of their cassava requirements.

The use of cassava wastes as a biogas substrate has been experimented upon, either as a standalone raw material or in combination with livestock manure [10]. Cuzin et al. 1992 [11] have conducted an experiment on the production of biogas using cassava peels. Other researchers have carried out experiments using cassava peels in combination with other feedstocks. Some of the feedstocks that have been used include poultry manure [12], cow dung [13], zebra droppings, pig dung [12], and cowpea [13].

Globally, 60% of the cassava produced is mostly used for consumption in numerous forms by humans, while the animal food industry uses about 33% of the world production. The remaining 7% is used by industries to produce products such as textiles, paper, organic acids, flavor and aroma compounds, and cassava bagasse [14]. Three main types of residues are generated during the industrial processing of cassava: peels, solids, and wastewater. These wastes are poor in protein content, but their residues are very rich in carbohydrate and are generated in large amounts during the production of 'garri' and cassava flour from the tubers.

Cassava peels are an example of plant waste which can be used to produced biogas [15]. Cassava is one of the major root crops produced in sub-Saharan Africa and the world production as at 2002 was estimated to be 1840 million tons [15]. Currently, there is a campaign for expanding the cassava production scale in Nigeria. The implication of this is that there will be increased wastes production from cassava processing. Since cassava peels is a material with high C/N ratio, it will not yield much biogas unless aided with inoculum.

The cost associated with the handling and disposal of these wastes constitutes a huge financial burden to the cassava-processing industries in most rural regions of the country. As a result of this challenge, most rural cassava processors choose to dispose the cassava-processing wastes generated into the environment. These wastes have been identified to be toxic to the environment [16].

The technology of processing cassava roots predominantly includes peeling, grating, dewatering, fermenting, drying, frying, etc. The type and composition of the waste depend on the processing method and type of technology used [17]. In most cassava-processing communities, several tonnes of cassava peels are generated as a waste product from the processing activity and are generally considered to contribute largely to environmental pollution [18].

With an expected increase in cassava production, it is also expected that waste generation will continue to rise. Even though cassava peels can be used as feed for livestock, the quantities generated and the remoteness of many of the communities where processing takes place leaves behind a lot of waste, which is burned or left to rot, with many environmental consequences [19]. Tonukari et al. [20] presented a report of a cassava starch production center which produces 100 tons of tubers per day, with an output of about 47 tons of byproducts. This output may cause environmental problems when abandoned in the surroundings of processing plants or carelessly disposed. The basic form of cassava flour production comprises sorting, weighing, peeling, washing, grating, machine/milling, detoxification, dewatering, granulation, drying milling, sieving, and packaging [21].

## MATERIALS AND METHOD

### Sample Collection

The cassava peels were collected from Agro processing Plant located at Iheakpu – Awka in Igbo Eze, South Local Government Area of Enugu State. The goat dung that was used to blend the cassava in other to have maximum yield were collected from a goat farm at Obukpa in Nsukka Local Government Area of Enugu State. The Inoculum used which was anaerobically digested cassava peels with goat dung where gotten from National Centre for Energy Research and Development, University of Nigeria Nsukka. The cassava peels where reduced to smaller quantity by grinding it in a mill located at Iheakpu – Awka.

## METHODS

The digesters were physically examined to check for leakage. They were also subjected to pressing testing with a pressure of 1 bar. This is to make sure that biogas produced during the anaerobic process is preserved. Digester A contained only cassava peels while Digester B contained cassava peel and goat dung and Digester C contained mixture of cassava peel, goat dung, and Inoculum.

The experiment set up was a batch production set up with 50 liters capacity digester. The ratio of water to cassava peel in the three digesters is 2:1. The pH of the slurry in each digester was taken and the slurry was mixed thoroughly. The digesters were properly tightened to avoid biogas leakage during the anaerobic digestion.

The experimental set-ups were left in an open space to receive appropriate sunrays. The daily temperatures readings were taken at two hours interval from 8 am to 4 pm every day for a period of 20 days. The experimental set-ups were stirred periodically using a stirrer incorporated in the digester. The periodic stirring is done to ensure uniform mixing of the charged slurry in the digester. Pressure valve was used to monitor the pressure of each digester.

### Determination of Total Solid and Volatile Solid

An empty evaporating dish was weighed, and its weight was recorded as W_dish. A sample was collected and weighed with the dish and the weight was recorded as W_sample. The whole system was dried in a drying oven at 103℃ to 105℃ for one hour (22) to drive off water in the sample and the weight was recorded as 〖W〗_(total )[22] Then the residue was cooled in a desiccator and heated again at 550℃ in a muffle furnace for 30 minutes [22] and its weight was recorded as W_fixed . The total, fixed, and volatile solids were determined by comparing the mass of the sample before and after each drying or heating step.

### Testing of Sample

The slurry charged inside the digesters were collected separately every two days through the pressure balance of the digester using a 100ml bottle. The sample, after collection, was immediately taken to the laboratory for analysis to determine the total solid (%), volatile solid (%) within two hours to minimize biological changes that may occur between the time of collection and the actual testing procedure.

## RESULTS AND DISCUSSION

Figure 1 represents cumulative biogas yield for cassava peels which act as a control experiment, cassava peel blended with goat dung, and cassava peel blended with goat dung and Inoculum. The cassava peels in Digester C had 158.9 liters as the maximum cumulative biogas yield for a retention time of 20 days tested.

Digester A which acts as control experiment had smallest cumulative biogas yield of 135.9 liters for the same retention time of 20 days tested.

The results indicate that cassava peel blended with goat dung produces more biogas yield than cassava peel alone. This is similar to the cumulative biogas yield of 3030ml and 1875ml obtained by Nkodi and Taba et al, 2016 [23].

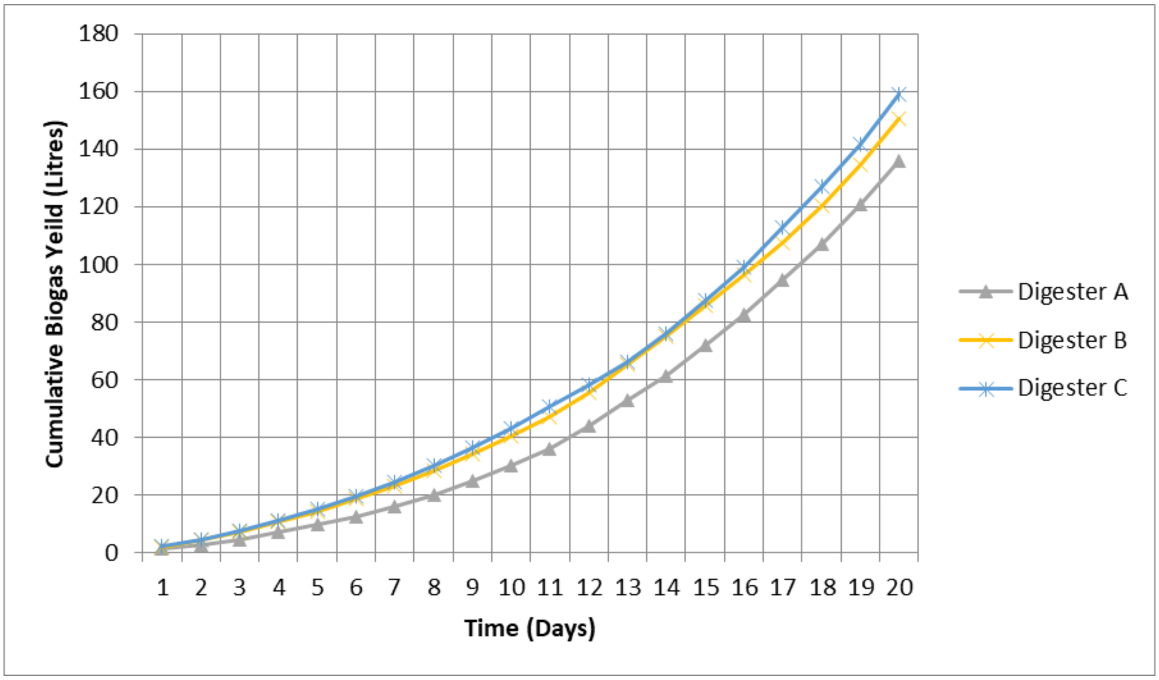


**Figure 1:** Cumulative Biogas Yield versus Time using Cassava Peels and Cassava Peels Blended with Goat Dung.

The pH of the anaerobic reaction varied from 5.6 to 7.8. Nwankwo 2016 reported that the microbes that convert wastes to biogas are sensitive to pH and survive optimally at pH range of 6.5 – 8.0 [24].

**Table 1:** Cumulative Volume of Biogas yield (Liters).

| Days | Digester A | Digester B | Digester C |
|---|---|---|---|
| 1 | 1.3 | 1.9 | 2.2 |
| 2 | 2.9 | 4.3 | 4.7 |
| 3 | 4.7 | 7.1 | 7.6 |
| 4 | 7 | 10.6 | 11.3 |
| 5 | 9.7 | 14.4 | 15.2 |
| 6 | 12.7 | 18.5 | 19.5 |
| 7 | 16.2 | 23.2 | 24.5 |
| 8 | 20.1 | 28.6 | 30.2 |
| 9 | 24.9 | 34.3 | 36.5 |
| 10 | 30.2 | 40.4 | 43.3 |
| 11 | 35.8 | 47.1 | 50.6 |
| 12 | 43.9 | 55.4 | 58.3 |
| 13 | 52.7 | 65.2 | 66.4 |
| 14 | 61.4 | 75.1 | 75.9 |
| 15 | 71.8 | 85.6 | 87.3 |
| 16 | 82.6 | 96.4 | 99.1 |
| 17 | 94.7 | 107.7 | 112.8 |
| 18 | 107.2 | 120.2 | 127 |
| 19 | 120.7 | 134.7 | 141.8 |
| 20 | 135.9 | 150.5 | 158.9 |

Table 2 showed the cumulative biogas produced by Digester A treated with 5% Inoculum and Digester B treated with 10% Inoculum and Digester C treated with 15% Inoculum. It was also observed that Digester A which contained only cassava peels with less Inoculum had lower cumulative biogas yield of 197.6 liters.

Digester B with cassava peels and goat dung as the blend had a cumulative biogas yield of 198.4 liters which is not too far above the Digester A. The cumulative biogas produced by digester C is 204.5 liters which is also higher than the other two digesters showing still that the presence of catalysts (Inoculum) helped in anaerobic digestion of the slurry which lead to more yield in the Digester C.

The maximum atmospheric temperature recorded during the experiment was 30°C. This is similar with the work done by Nwankwo 2014 which has ambient temperature range of 27ºC-32ºC [16].

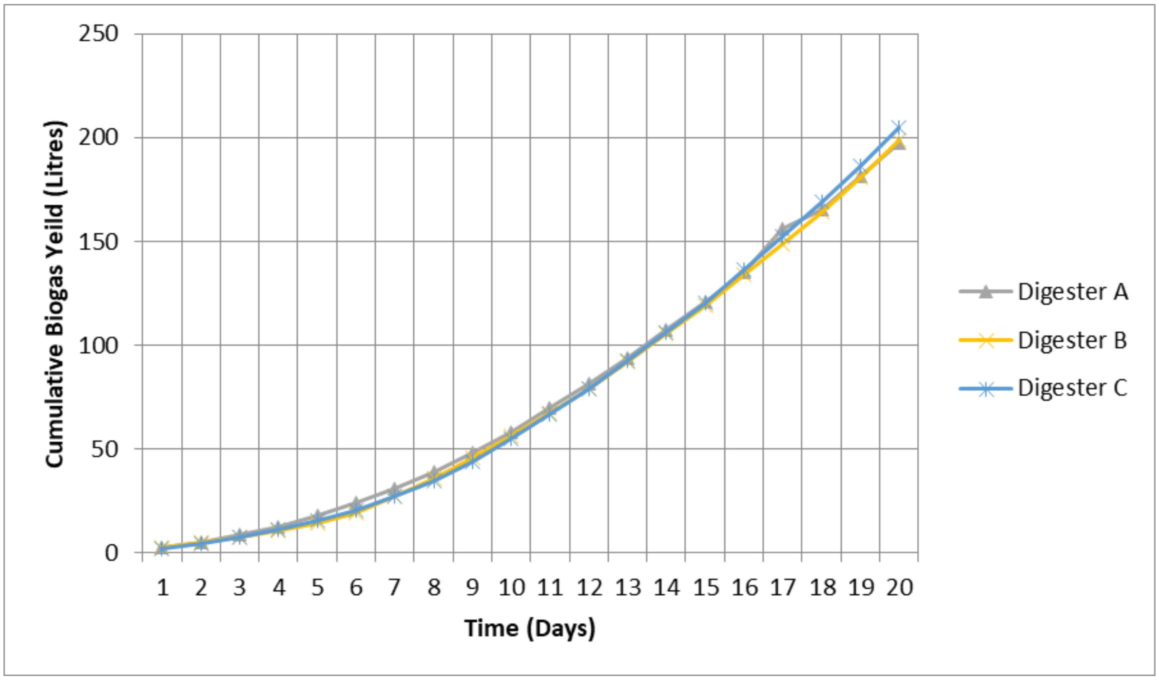


**Figure 2:** Cumulative Biogas Yield versus Time using Cassava Peels and Cassava Peels Blended with Goat Dung.

**Table 2:** Cumulative Volume of Biogas yield (Liters).

| Days | Digester A | Digester B | Digester C |
|---|---|---|---|
| 1 | 2.4 | 2.3 | 2.1 |
| 2 | 5.2 | 4.8 | 4.4 |
| 3 | 8.7 | 7.6 | 7.3 |
| 4 | 12.5 | 10.8 | 11.4 |
| 5 | 17.9 | 14.3 | 15.8 |
| 6 | 24.2 | 18.9 | 20.6 |
| 7 | 31 | 27.1 | 27.5 |
| 8 | 38.7 | 35.8 | 34.8 |
| 9 | 48 | 45.9 | 43.7 |
| 10 | 58.3 | 56.4 | 54.9 |
| 11 | 69.6 | 67.3 | 66.7 |
| 12 | 81.5 | 79.1 | 79.2 |
| 13 | 94 | 91.9 | 92.6 |
| 14 | 107.2 | 105.4 | 106.3 |
| 15 | 121.1 | 118.9 | 120.6 |
| 16 | 135.4 | 133.7 | 136.2 |
| 17 | 156.2 | 148.4 | 152.3 |
| 18 | 165.6 | 164.1 | 169.1 |
| 19 | 181.4 | 180.9 | 186.4 |
| 20 | 197.6 | 198.4 | 204.5 |

Figure 3 indicated Digesters A, B C which contains 20% Inoculum treatment, 25% Inoculum treatment and 30% Inoculum treatment.

The cumulative biogas yield of 198.9 liters was recorded in the digester A while 208.4 liters of cumulative biogas yield was recorded in Digester B. The highest cumulative biogas yield of 216.4 liters was observed in the Digester C with 30% catalytic treatment.

Nwankwo 2014 in his work recorded cumulative biogas yield of 38 liters using cassava peel alone for a lag time of 21 days and 72 liters with plantain peel blended with cow dung for a lag time of 11 days [24]. The total solid concentration recorded in the first day of anaerobic digestion in Digester A was 74.1%. This value decreased to a value of 58.7% at the last days of the test run. Digester C also recorded appreciated value of total solid concentration ranging from 78.3% at day 1 and this dropped to a value of 54.9% at day 20 of the slurry fermentation.

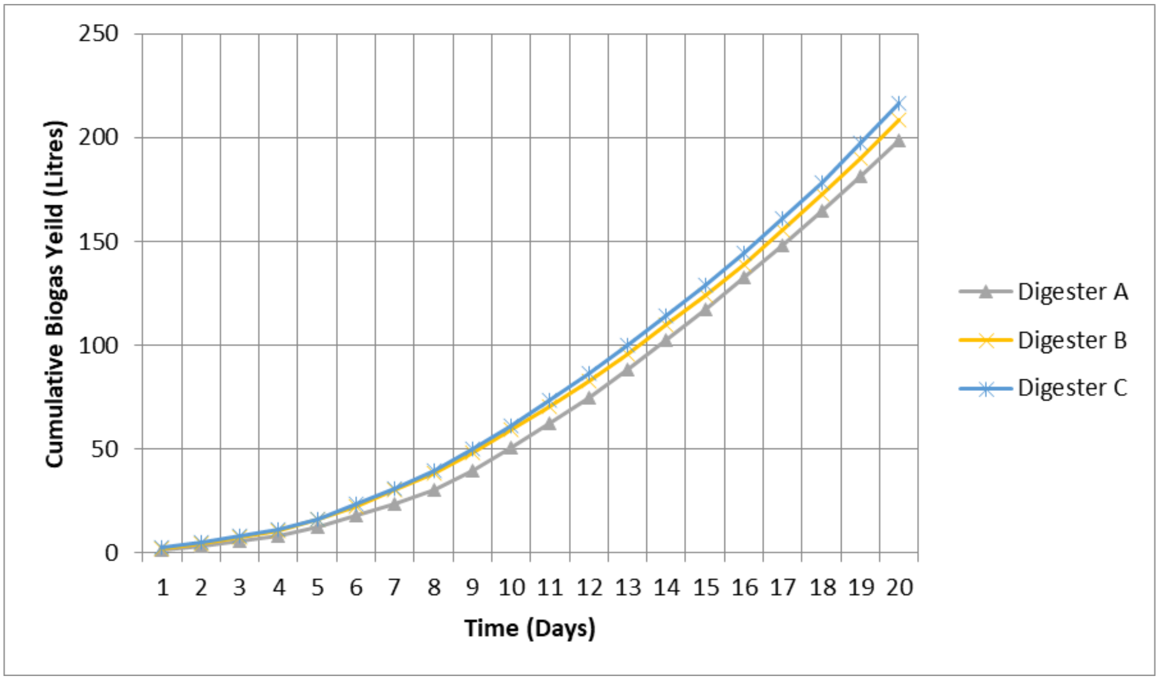


**Figure 3:** Cumulative Biogas Yield versus Time Using Cassava Peels.

**Table 3:** Cumulative Volume of Biogas yield (Liters).

| Days | Digester A | Digester B | Digester C |
|---|---|---|---|
| 1 | 1.6 | 2.1 | 2.3 |
| 2 | 3.1 | 4.4 | 4.9 |
| 3 | 5.5 | 7.3 | 8 |
| 4 | 8.3 | 10.8 | 11.3 |
| 5 | 12.6 | 16.1 | 16.1 |
| 6 | 17.8 | 22.5 | 23.3 |
| 7 | 23.5 | 30.3 | 30.8 |
| 8 | 30.2 | 38.6 | 39.6 |
| 9 | 39.8 | 48.4 | 49.8 |
| 10 | 50.4 | 59.1 | 61.3 |
| 11 | 62.2 | 70.6 | 73.5 |
| 12 | 74.7 | 82.4 | 86.1 |
| 13 | 88.3 | 95.8 | 99.8 |
| 14 | 102.5 | 109.7 | 113.9 |
| 15 | 117.3 | 124 | 128.7 |
| 16 | 132.5 | 138.8 | 144.4 |
| 17 | 148.1 | 155.3 | 161 |
| 18 | 164.6 | 172.6 | 178.5 |
| 19 | 181.4 | 190.1 | 197.3 |
| 20 | 198.9 | 208.4 | 216.4 |

## CONCLUSION

The cassava peels constitute an environmental problem since their degradation in nature produces obnoxious gas, unpleasant odors, and reduces soil fertility. One area of possible use has been to investigate cassava peels for the production of biogas.

Bio-digestion of cassava peels alone gave very poor results since the peels as other lignocellulosic biomasses have a high value of organic carbon and very low value of total nitrogen. This work investigated the production of biogas from cassava peels blended with goat dung. The maximum cumulative biogas produced in the experiment was 216.4 liters while the minimum cumulative biogas produced was 135.5 liters. This maximum cumulative biogas yield was produced from Digester C charged with 30% Inoculum and some blends of goat dung. The total solid concentration recorded in the first day of anaerobic digestion in digester A batch C was 74.1%. This value decreased to a value of 58.7% at the last days of the test run.

## REFERENCES


1. Gopinatthan, C., R. Himanshu, and M.M. Romilly. 2015. "Cost Effective Pretreatment of Cassava Peels for Enhanced Biogas Production". *IOSR Journal of Environmental Science, Toxicology and Food Technology*. (IOSR-JESTFT).

2. Rittmann, B.E. 2008. "Opportunities for Renewable Bioenergy using Microorganisms". *Biotechnol. Bioeng*. 100:203-212.

3. Amon, T,, E. Hackl, D. Jeremic, B. Amon, and J. Boxberger. 2001. "Biogas Production from Animal Wastes, Energy Plants and Organic Wastes". In: A.F.M. Van Velsen and W.H. Verstraete (eds). *Proc. 9th World Congress on Anaerobic Digestion.* 381-386.

4. Asikong, B.E., J. Epoke, B.E. Agbo, E.E. Antai, and M.E. Eja. 2013. "Potentials of Biogas Generation from Mixture of Three Substrates, Water Hyacinth, Cassava Peels and Cow Dung- Wh+Cp+Cd". *Chemical and Process Engineering Research*.

5. Long, C. 1992. "Review and Prospect of Biogas Development". *China Biogas*. 10:104.

6. Lung, M.S., S.S. Anderson, and M. Torry-Smith. 1996. "Building of Flexible Biogas, Biogas Digester in Tanzania, Student Report". Technical University of Denmark, Copenhagen htt://www.fao.org/sp/egdirect/egre0022.htm

7. Olukanni, D.O. and T.O. Olatunji. 2018. "Cassava Waste Management and Biogas Generation Potential in Selected Local Government Areas in Ogun State, Nigeria". *Recycling 2018*, 3:58. doi:10.3390/recycling3040058 www.mdpi.com/journal/recycling.

8. Westby, A. 2008. "Cassava Utilization, Storage and Small-Scale Processing". In" *Cassava Biology, Production and Utilization*. R. Hillock, J. Thresh, and A.C. Bellotti (eds.). CABI Publishing: Wallingford, UK.

9. Olukanni, D.O., J.C. Agunwamba, and R.U. Abalogu. 2013. "Interaction between Suspended and Settled Solid Particles in Cassava Waste Water". *Sci. Res. Essay*. 8:414–424.

10. Kemausuor, F., A. Addo, and L. Darkwah. 2015. *Technical and Socioeconomic Potential of Biogas from Cassava Waste in Ghana*. Hindawi Publishing Corporation Biotechnology Research International.

11. Cuzin N., J. L. Farinet, C. Segretain, and M. Labat, 1992. "Methanogenic Fermentation of Cassava Peel using a Pilot Plug Flow Digester". *Bioresource Technology*. 41(3):259–264.

12. Adelekan, B.A. and A.I. Bamgboye. 2009, "Comparison of Biogas Productivity of Cassava Peels Mixed in Selected Ratios with Major Livestock Waste Types". *African Journal of Agricultural Research*.

13. Ukpai, P.A. and M.N. Nnabuchi. 2012. "Comparative Study of Biogas Production from Cow Dung, Cow Pea, and Cassava Peeling using 45 litres Biogas Digester". A*dvances in Applied Science Research*.

14. Pandey, A, C.R. Soccol, P. Nigam, V.T. Soccol, L.B. Vandenberghe, and R. Mohan. 2000. "Biotechnological Potential of Agro-Industrial Residues. II: Cassava Bagasse". *Bioresour. Technol.*

15. Onibon G.L, I.S. Ajayi, and A.A.G. Olorunnisola. 2019. "Effect of Inoculum on Biogas from Cassava Peels". *Global Scientific Journal*.

16. Omilani, O., A. Abass, and V.O. Okoruwa. 2018. "Willingness to Pay for Value-Added Solid Waste Management System among Cassava Processors in Nigeria". Available online: www.tropentag.de/2015/proceedings/ node515.html (accessed on 22 May 2018).

17. Osunbitan, J.A. 2012. "Short Term Effects of Cassava Processing Waste Water on some Chemical Properties of loamy sand soil in Nigeria". *J. Soil Sci. Environ. Manag*. 3:164–171.

18. Food and Agricultural Organization (FAO): 2004. *United Nations. Annual Statistics*. FAO: Rome, Italy.

19. Eze, J.I. 2010. "Converting Cassava (*Manihot sp.*) Waste from Gari Processing Industry to Energy and Bio-Fertilizer". *Glob. J. Res. Eng*. 10:113–117.

20. Tonukari, N.J., T. Ezedom, C.C. Enuma, S.O. Sakpa, O.J. Avwioroko, L. Eraga, and E. Odiyoma. 2015. "White Gold: Cassava as an Industrial Base". *Am. J. Plant Sci*. 6: 972–979.

21. Aro, S.O., V.A. Aletor, O.O. Tewe, and J.O. Agbede. 2010. "Nutritional Potentials of Cassava Tuber Wastes: A Case Study of a Cassava Starch Processing Factory in South-Western Nigeria". *Livest. Res. Rural Dev*. 22: 1–11.

22. Telliard, W.A. 2001. "Total, Fixed and Volatile Solids in Water Solids, and Bio Solids". U.S Environmental Protection Agency: Washington. D.C. 1-8.

23. Nkodi T.M., K.M. Taba, S. Kayembe, C. Mulaji, and S. Mihigo. 2016. "Biogas Production by Co-Digestion of Cassava Peels with Urea".

*International Journal of Scientific Engineering and Technology*. ISSN:2277-1581. .5(3):139-141.

24. Nwankwo, J.I. 2014. "Production of Biogas from Cassava and Plantain Peels Blended with Cowdung". *International Journal of Life Science Biotechnology and Pharma Research*. Hyderabad, India.

## ABOUT THE AUTHORS

**K.C. Onyeneho,** is a Lecturer at the Department of Mechanical Engineering Technology, Akanu Ibiam Federal Polytechnic Unwana, Afikpo, Ebonyi State. His research interest is in production engineering. kconyeneho@ymail.com, +2348187458600.

**P.E Okoh**, is a Lecturer in the Department of Mechanical Engineering, Institute of Management and Technology, Enugu. emekapromise25@yahoo.com, +2348166761508.

**Audu Ibrahim Ali,** is a Lecturer at Department of Mechanical Engineering, Federal Polytechnic, Idah. +23408033322061.

**I.C. Iloani,** is a Lecturer at the Institute of Management and Technology (IMT), Enugu, Nigeria. Telephone +2348033600163. He has several books and papers to his credit.

**Ajibili Edibo Haruna,** is a Lecturer at Department of Mechanical Engineering, Federal Polytechnic, Idah. ajibilih@gmail.com+23409017019544.

## SUGGESTED CITATION

Onyeneho, K.C., O.P. Emeka, A.I. Ali, I.C. Iloani, and A.E. Haruna. 2019. "Production of Biogas from Cassava Peels Blended with Goat Manure". *Pacific Journal of Science and Technology*. 20(2):35-42.