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Comparative Analysis of Biogas Yields from Plantain and Banana Peels

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Abstract: Biogas technology offers an attractive platform to utilize certain categories of biomass for meeting our energy needs if it is properly harnessed. Biogas is produced in many different environments, including landfills, sewage sludge and during anaerobic degradation of organic material. In Nigeria, various biomass such banana and plantain peels are readily available and can be utilized in the production of biogas. In this research work, comparative analysis of biogas yields from plantain and banana peels was investigated. Collected plantain and banana peels served as the biodegradable solid wastes. The collected sample was measured with a universal weighing balance and recorded as sample A (Banana Peels, 20 kg) and sample B (Plantain Peels, 20 kg) respectively. The collected substrates were ground into pieces to increase its surface area, and then mixed with water in ratio of 1:2. The mixture was charged into the 0.2 m^3 plastic bio-digester and made air tight. Process parameters of anaerobic digestion such as temperature and pressure were monitored and recorded. The results obtained revealed that both plantain and banana peels are potential feedstocks for biogas production. Besides, it was observed that plantain peels have a better biogas yield as compare to banana peels. Thus, with the installation of household biogas plants across sub-Sahara Africa countries communities can go a long way in solving parts of their energy needs.

Keywords: Biogas, Plantain Peels, Banana Peels, Temperature, Pressure

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INTRODUCTION

The basic of life is energy. The most fascinating feature of any civilized society is the availability of energy for domestic, agricultural and industrial purposes [1-2]. However, sub-Sahara Africa countries like Nigeria, Mali, Niger, etc., are faced with the problem of access to sustainable energy [3]. Moe so, the energy problem facing average Nigerians is affecting the entirely country and thus, many of the energy decisions have to be coordinated between all levels of government [4]. A more serious problem is our increasing population culminating in high energy demand and a limited rapidly depleting energy resource which has resulted in severe energy crisis [5]. Due to the aforementioned constraints, countries in sub-Saharan Africa rely on wood fuel and fossil fuel for heating and lighting, which has resulted in the deaths of several people due to health hazards such as inhaling carbon monoxide (CO) during indoor cooking [6,7].

Furthermore, the cost of energy for domestic, commercial and industrial uses in Nigeria has risen astronomically in the past few years following the liberalization and reform of the oil industry and the energy sector as a whole. This calls for serious measures and adequate policies in perfecting utilization, exploration and exploitation of our energy sources and pursuit of new alternative energy sources and its conservation. The biogas technology is one of such systems and has been found to be cost effective and environmentally sound [8]. It is defined as ecology-oriented form of appropriate technology based on degradation of organic materials under suitable and stable temperature to produce a combustible mixture of methane gas known as biogas leaving behind slurry known as bio fertilizer [9-11]. Moreover, using of waste biomass such plantain and banana peels to produce biogas energy can reduce the use of fossil fuels, reduce greenhouse gas emissions and reduce pollution and waste management problems. Biomass represents a continuously renewable potential source of methane and thus offers a partial solution to the eventual prospects of fossil fuel.

Besides, biogas from biomass is renewable and saves fossil fuel, fuel wood and forest. Apart from the financial benefit in terms of the sale and/or utilization of biogas, biogas production provides social benefits to environment (improvement in air quality, reduction in greenhouse gas emission); health (improvement in hygiene, reduce water contamination, reduced zoonotic and other pathogenic infections). After an initial investment in the system; cooking with biogas is quicker and easier than cooking with firewood. Biogas systems provide a residual organic waste after anaerobic digestion that has superior nutrients quantities over the usual organic fertilizer. Effluent (called slurry or sludge) is the residue of inputs that comes out from the compensation chamber after the substrate is acted upon by the methanogenic bacteria in an anaerobic condition inside the digester. The effluent is the second by – product that comes out of the digester after extracting biogas. It is a stabilized manure almost pathogen free and has proved to contain high quality organic materials for plant nutrition and fish production [12-15]. Because of the availability, sustainability, accessibility and renewability of biogas, it is more desirable as an alternative source of energy in the sense that it is local in origin and production. It is also an energy source that can be useful for all-purpose, heating, lighting, small-scale electric power generation etc. [16]. Therefore, this research work that focused on comparative analysis of biogas yields from plantain and banana peels can be a gateway in solving part of energy problems in sub-Sahara Africa countries.

MATERIALS AND METHODS

The bio-digester was a 0.2 m^3 made from plastic materials. Other accessories of the bio-digesters include steel; compressor, gas bottle, scrubber, thermometer, a plastic bucket, manometer, connecting hoses and weighing scale. The biodegradable solid wastes that served as substrates (banana and plantain peels, Fig. 1) was measured with a universal weighing balance and recorded as sample A (Banana Peels, 20 kg) and sample B (Plantain Peels, 20 kg) respectively.

i. Plantain Peels ii. Banana Peels

Figure 1 Substrates

The collected substrates were ground into pieces to increase its surface area, and then mixed with water in ratio of 1:2. The mixture was charged into the 0.2 m^3 plastic bio-digester and made air tight. The digester content was stirred several times per day with the aim of mixing the substrates inside the digester for efficient biogas generation. Stirring prevents formation of swimming layers and of sediments; it also brings the micro-organisms (MOs) in contact with the feedstock particles, facilitates the up-flow of gas bubbles and homogenizes distribution of heat and nutrients through the whole mass of substrates. The pressure and temperature readings are taken daily. Before evacuation of biogas, the initial mass of the gas bottle and the final mass after the gas is transferred are noted. The gas generated is calculated by subtracting the initial mass of the gas bottle from the final mass of the gas bottle as shown in Equation 1.

$$M_g = M_{g2} - M_{g1} \quad (1)$$

Where;

M_g = Mass of gas produced

M_{g2} = Final mass of the gas bottle

M_{g1} = Initial mass of the gas bottle

RESULTS AND DISCUSSION

Table 1 shows the results of comparative analysis of biogas yields from plantain and banana peels. The performance analysis of pressure in both cases revealed that approximately pressure readings (bar) were generated with experimentation with plantain peels and banana peels digesters. This was an indication that the microbial activities in both cases are in the same pattern since pressure build up is as results of biogas yields resulting from anaerobic digestion process via hydrolysis, acetogenesis, acidogenesis, and methanogenesis.

Table 1: Results of comparative analysis of biogas yields from plantain and banana peels

Days	**Bio-digester charge with plantain peels**				**Bio-digester charge with plantain peels**			
	Press. (Bar)	**Temp. (ºC)**	**Remark**	**M_g (kg)**	**Press. (Bar)**	**Temp. (ºC)**	**Remark**	**M_g (kg)**
1	0.00	26	No gas	-	0.00	22	No gas	-
2	0.00	27	No gas	-	0.00	23	No gas	-
3	0.00	30	No gas	-	0.00	25	No gas	-
4	0.00	28	No gas	-	0.00	23	No gas	-
5	0.00	31	No gas	-	0.00	29	No gas	-
6	0.00	32	No gas	-	0.00	29	No gas	-
7	0.00	33	No gas	-	0.00	32	No gas	-
8	0.00	32	No gas	-	0.00	31	No gas	-
9	0.00	37	No flame	-	0.00	35	No gas	-
10	0.00	31	No flame	-	0.00	29	No gas	-
11	0.00	32	No flame	-	0.00	28	No gas	-
12	0.00	34	No flame	-	0.00	33	No gas	-
13	0.00	30	No flame	-	0.00	25	No gas	-
14	0.45	26	Yellow flame	-	0.02	21	No flame	-
15	0.55	32	Yellow flame	-	0.03	30	No flame	-
16	0.58	29	Yellow flame	-	0.30	25	No flame	-
17	0.69	31	Blue flame	-	0.38	26	No flame	-
18	0.78	35	Blue flame	-	0.41	34	Yellow flame	-
19	0.92	33	Blue flame	-	0.55	32	Blue flame	-
20	0.85	30	Blue flame	0.15	0.67	26	Blue flame	0.17
21	0.00	33	Blue flame	-	0.71	27	Blue flame	-
22	0.63	34	Blue flame	-	0.75	31	Blue flame	-
23	0.75	28	Blue flame	-	0.77	23	Blue flame	-
24	0.94	30	Blue flame	-	0.82	26	Blue flame	-
25	0.88	34	Blue flame	-	0.83	31	Blue flame	-
26	0.68	35	Blue flame	-	0.84	32	Blue flame	-
27	0.76	33	Blue flame	-	0.00	29	Blue flame	-
28	0.88	33	Blue flame	0.20	0.35	30	Blue flame	0.21
28	0.59	34	Blue flame	-	0.55	29	Blue flame	-
29	0.68	33	Blue flame	-	0.68	28	Blue flame	-
30	0.70	35	Blue flame	-	0.77	29	Blue flame	-
31	1.00	31	Blue flame	-	0.21	30	Blue flame	-
32	0.55	29	Blue flame	-	0.34	26	Blue flame	-
33	0.69	35	Blue flame	-	0.45	31	Blue flame	-
34	0.77	33	Blue flame	-	0.58	30	Blue flame	-
35	0.88	35	Blue flame	0.15	0.68	33	Blue flame	0.16
36	0.58	34	Blue flame	-	0.74	34	Blue flame	-
37	0.66	32	Blue flame	-	0.75	29	Blue flame	-
38	0.79	35	Blue flame	-	0.81	30	Blue flame	-
39	0.92	35	Blue flame	-	0.20	31	Blue flame	-
40	0.51	36	Blue flame	-	0.45	34	Blue flame	-
41	0.72	37	Blue flame	-	0.51	36	Blue flame	-

42	0.76	32	Blue flame		0.53	30	Blue flame	-
43	0.87	35	Blue flame	0.17	0.65	33	Blue flame	0.19
44	0.53	33	Blue flame	-	0.66	34	Blue flame	-
45	0.67	30	Blue flame	-	0.76	29	Blue flame	-
46	0.72	27	Blue flame	-	0.77	24	Blue flame	-
47	0.75	33	Blue flame	-	0.82	33	Blue flame	-
48	0.80	32	Blue flame	-	0.31	31	Blue flame	-
49	0.82	34	Blue flame	-	0.45	33	Blue flame	-
50	0.71	23	Blue flame	-	0.48	20	Blue flame	-
51	0.85	25	Blue flame	0.16	0.56	24	Blue flame	0.17
52	0.50	27	Blue flame	-	0.61	26	Blue flame	-
53	0.57	25	Blue flame	-	0.62	23	Blue flame	-
54	0.55	34	Blue flame	-	0.66	34	Blue flame	-
55	0.55	27	Blue flame	-	0.69	27	Blue flame	-
56	0.52	35	Blue flame	-	0.70	35	Blue flame	-
57	0.51	33	Blue flame	-	0.76	30	Blue flame	-
58	0.45	36	Blue flame	0.09	0.84	34	Blue flame	0.10
59	0.00	26	No flame	-	0.23	23	Blue flame	-
60	0.00	30	No flame	-	0.29	29	Blue flame	-
61	0.00	33	No flame	-	0.45	33	Blue flame	-
62	0.00	34	No flame	-	0.55	33	Blue flame	-
63	0.50	31	Yellow flame	-	0.56	30	Blue flame	-
64	0.56	29	Yellow flame	-	0.59	29	Blue flame	-
65	0.58	32	Blue flame	-	0.63	31	Blue flame	-
66	0.68	34	Blue flame	-	0.69	32	Blue flame	-
67	0.83	30	Blue flame	-	0.73	29	Blue flame	-
68	0.85	35	Blue flame	0.18	0.86	33	Blue flame	0.19
69	0.54	32	Blue flame	-	0.29	30	Blue flame	-
70	0.59	33	Blue flame	-	0.35	31	Blue flame	-
71	0.68	35	Blue flame	-	0.41	33	Blue flame	-
72	0.77	34	Blue flame	-	0.48	33	Blue flame	-
73	0.86	33	Blue flame	-	0.58	32	Blue flame	-
74	0.95	33	Blue flame	-	0.62	32	Blue flame	-
75	0.56	29	Blue flame	-	0.76	28	Blue flame	-
76	0.62	31	Blue flame	-	0.79	31	Blue flame	-
77	0.68	27	Blue flame	-	0.86	26	Blue flame	-
78	0.73	33	Blue flame	-	0.33	32	Blue flame	-
79	0.86	34	Blue flame	0.15	0.44	34	Blue flame	0.17
80	0.63	24	Blue flame	-	0.49	22	Blue flame	-
81	0.68	33	Blue flame	-	0.53	32	Blue flame	-
82	0.71	32	Blue flame	-	0.59	31	Blue flame	-
83	0.79	34	Blue flame	-	0.63	32	Blue flame	-
84	0.81	29	Blue flame	-	0.69	26	Blue flame	-
85	0.58	31	Blue flame	-	0.78	31	Blue flame	-
86	0.67	33	Blue flame	-	0.80	32	Blue flame	-
87	0.79	34	Blue flame	-	0.45	34	Blue flame	-
88	0.88	30	Blue flame	0.18	0.47	29	Blue flame	0.19
89	0.64	29	Blue flame	-	0.40	28	Blue flame	-
90	0.45	33	Blue flame	0.05	0.39	32	Blue flame	0.09

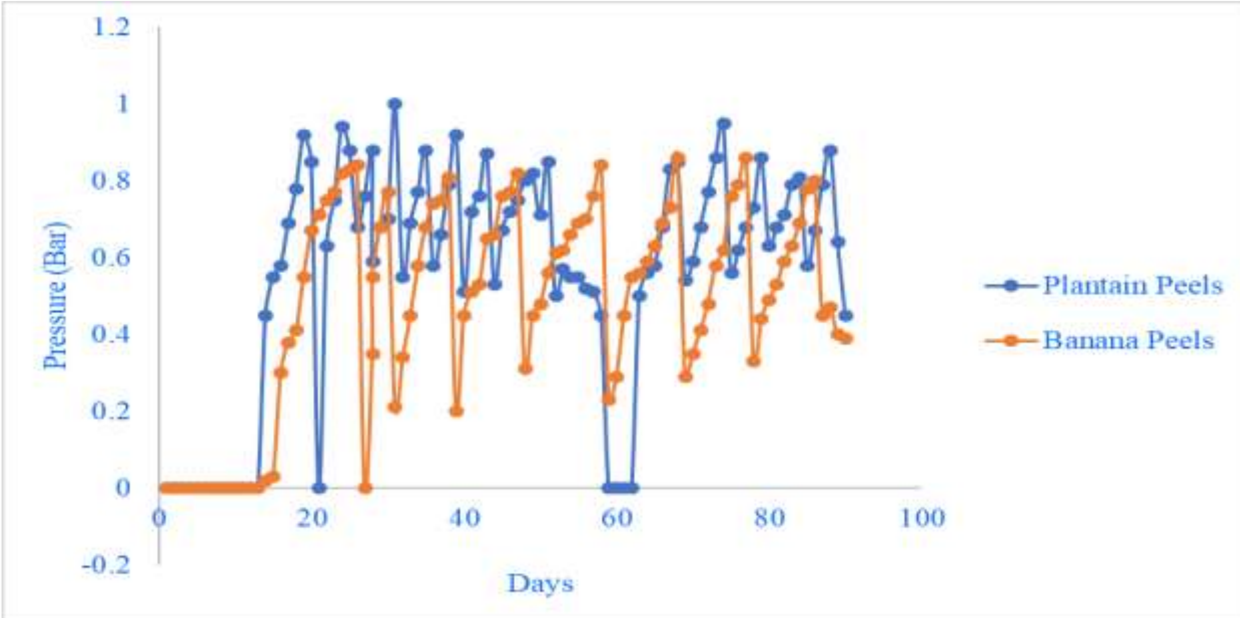

Figure 2: Results of comparative analysis of pressure buildup

Furthermore, a better mesophilic temperature was recorded as depicted in Table 1. In general, the higher the temperature inside the digester, the less time required for complete digestion of organic materials, thus, more production of biogas since more methanogenic bacteria are working upon substrate and also more destruction for diseases causing microbes as reported by [8]. According to [8], the temperature inside the digester should be stable, since the methanogenic bacteria are highly sensitive toward changes and variations of temperature inside the digester especially at high temperature ranges where the productivity of the biogas dropped significantly, while it drops gradually at low temperature range. Similarly, a sudden or fast temperature changes reduces the production of biogas or might stop its production, so temperature monitoring is essential especially for biogas plants work at high and low temperature range [8]. The results of comparative biogas yields showed that frequency of biogas evacuation for both sample A and sample B are the same. However, a better biogas yield was achieved with sample B (i.e., plantain peels) as shown in Table 1 and Fig. 3.

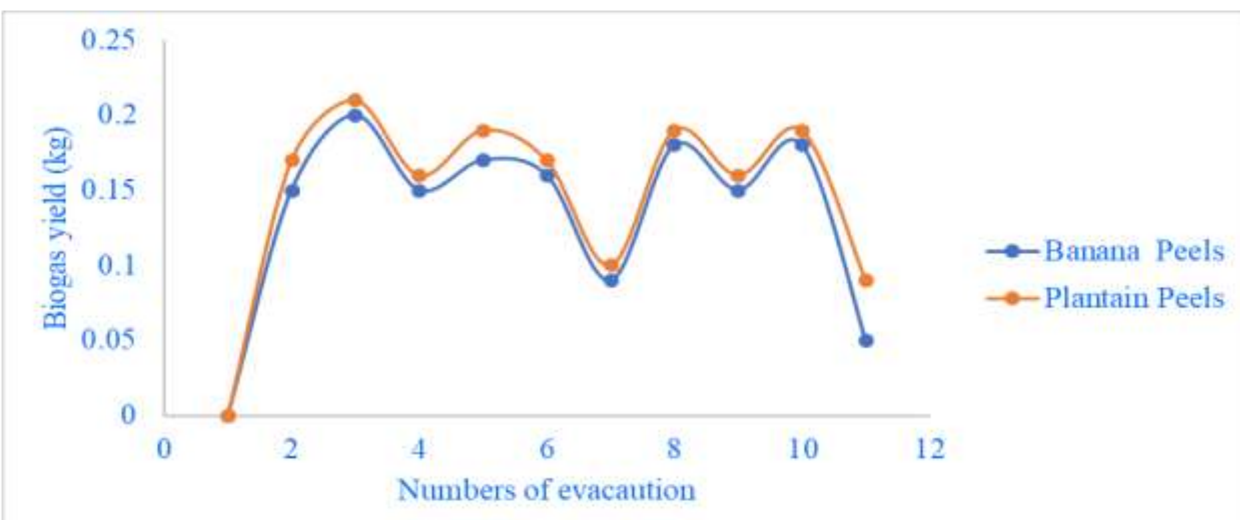

Figure 3: Comparative analysis of biogas yields

CONCLUSION

The demand for energy in Nigeria is growing by the day. According to Africa Progressive Report, Nigeria has a human population estimated above 200 million and 95 million of the population relies on wood, charcoal and straw for energy [5]. The need for exploring and exploiting new sources of energy which are renewable as well as environmentally friendly cannot be overemphasized. In this research work, an investigation was carried out on plantain and banana peels as a substrate for production of biogas that is environmentally friendly. The outcome of the results revealed that both plantain and banana peels are potential feedstocks for biogas production. Also, the parameter analysis confirmed that throughout the period of investigation, good mesophilic temperature readings were recorded and this makes the study area (Nigeria) good for biogas plants installation and production. Moreso, it was observed that plantain peels have a better biogas yield as compare to banana peels. Thus, with the installation of household biogas plants across sub-Sahara Africa countries communities can go a long way in solving parts of their energy needs.

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