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Comparative Study of The Effects Of Sawdust From Two Species Of Hard Wood And Soft Wood As Seeding Materials On Biogas Production

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Abstract: The effects of two varieties of sawdust from hard and soft woods as seeding materials on biogas yield were investigated. The substrates for the experiment in an anaerobic laboratory digester are cow dung and cassava peels. The hard woods are Mahogany and Iroko, while the soft woods are Obeche and Araba. The experimental set-ups were sub-divided into four groups of digesters. Each group was made up of four digesters seeded with sawdust from the wood types in the following percentages: 33%, 27%, 20%, and 11%. 200g of cow dung and cassava peels were mixed with 120cm^3 of distilled water in each digester. The seeding materials in different percentages were added and mixed thoroughly and the biogas produced was recorded at a regular interval of 4 days for an hydraulic retention time of 40 days. The volume of biogas produced ranged from 60cm^3 to 2800cm^3. In all the experiments, the biogas yield decreases with decrease in percentage of sawdust seeding materials. Digester A in group I with 33% of mahogany has the largest biogas yield of 329.63 cm^3/ day while digester H in Group II with 11% Iroko sawdust has the least yield of 61.63 cm^3/day.

Keywords: *Biogas, Hard wood, Soft wood, Anaerobic digester, Media content.*

I. INTRODUCTION

Society is today confronted with dwindling and depletion sources of fossil fuels and chemical feedstock, and battling with the proliferation of wastes generated by municipalities, agriculture and industries. The conversion techniques of renewable resources or wastes to useful chemicals and fuels by microbial fermentation through a reactor signifies a tremendous challenge for engineers in global technological stance, and the future ahead with respect to energy demand.

Anaerobic biodegradation of cellulosic materials is a biological engineering process [1] in which a methane –rich gas (biogas) is produced and slurry that is of proven value as fertilizer and animal feed is left as a residue. Several works have been undertaken in improving biogas yield such as the pretreatment of waste feedstock [2]. These pretreatments include: preheating, milling, chemical treatment with sodium hydroxide (NaOH) and other components. One of the major and relevant components of the process is the micro –organisms that are responsible for the enzymatic or catalytic breakdown of the feedstock and the subsequent conversion to methane (CH_4), carbon dioxide (CO_2) and traces of hydrogen (H_2), nitrogen (N_2) and hydrogen sulphide (H_2S).

Sawdusts are produced as a small discontinuous chips or small fragments of wood during sawing of logs of timber into marketable sizes. The chips flow from the cutting edges of the saw blade to the floor during sawing operation, hence its name Sawdust has hitherto been classified as a waste and a nuisance to man and its environment, but in recent years, researches have shown that sawdusts can be used in the production of biogas, packaging fillers, as lagging materials etc [3,4]. The use of media materials (sawdust as seeding materials) to ensure a higher concentration of these micro- organisms would accelerate the rate of biogas yield by ensuring the passage of the three phases of gas production throughout the digester concurrently. This affects the start-up characteristics of the process positively by acting as the seeding micro-organism in different locations during feed stocks reloading [5]. The quantity and quality of media materials [6] such as synthetic materials, wood species, limestones etc to be expressed in percentage of total volume appropriateness especially since a higher percentage symbolizes a lower input of cellulosic material as feedstock, which in turn affects biogas yield.

Generally, the organic matter must be highly degradable to achieve a large yielding gas. Conversely, lower gas production rates would result from less biodegradable wastes [7]. Hence, it is paramount to determine an optimal percentage of media material. The effects of media material in biogas production have been well investigated by researchers in Nigeria and other parts of the world and are well recorded in literature [8]. Wastes like manure, agricultural crops, food wastes, urban refuse, industrial wastes, logging and manufacturing residues have been found to be have biogas generation potentials [9].

This work investigates the effects of seeding varying quantities of two hardwoods and soft woods species on biogas yield using cowdung and cassava peels as feedstocks. The two hard wood species are Khaya species [Meliaceae family] known as Mahogany and Milicia excelsa [moraceae family] known as Iroko in local dialect. The two soft wood species are Triplochiton scleroxlyon (Obeche) and Cieba pentandra [bombacaceae family] (Araba in local dialect).

II. MATERIALS AND METHOD

Freshly voided cow dung was collected from the main abattoir in Ado-Ekiti while fresh cassava peels were collected from a gaari processing factory at the Onigari area of Ado Ekiti. The cassava peels were sundried and ground with the aid of a clean mortar and pestle. Sawdust from two hardwood species: Mahogany and Iroko and soft wood species: obeche and araba were collected from the Ewenla sawmill in Ado Ekiti and were used as seeding material to determine their effects on biogas generation. These four species were chosen because of their cellulose concentration and availability in the local environment. The Cow dung, Cassava peels, and sawdust samples were screened for unwanted foreign material like wood, stone, metal, bone, etc.

Sixteen digesters divided into four groups of four digesters were set up in the laboratory. The digesters were labelled A to P and each of them contains 200g of both cow dung (CD) and cassava peels (CP) in equal proportion. They were mixed with 120 cm^3 of sterile distilled water. Each group were seeded with varying quantity of Mahogany, Iroko, Obeche, Araba sawdust respectively.

Group I digesters, labelled A to D were seeded with 200g, 150g, 100g, and 50g of Mahogany wood (MW) sawdust respectively while group II digesters, labelled E to H were seeded with 200g, 150g, 100g, and 50g of Iroko wood sawdust respectively. Groups III and IV consisted of digesters labelled (I-L) and (M-P) respectively and were seeded with the same quantity of Obeche and Araba sawdust.

The resulting slurry was thereafter fed into the airtight digester bottles with the aid of a funnel. Each digester bottle was connected to a measuring cylinder inverted over acidified water in a plastic bowl as shown in Fig. 1. The cylinder was used as a measuring scale as well as gas collector. The acidified water was prepared by adding 0.05ml sulphuric acid (H_2SO_4) to 18.4w of water. This acidified water solution was used to prevent the dissolution of the biogas generated into the water. The digesters were corked to generate an anaerobic condition. The volumes of biogas produced were recorded at a specified interval of 4days for an Hydraulic Retention Time (HRT) of 40days.

In the course of the experiment, the average ambient temperature was 35°C while the pH varied between 6 and 8. The digester bottles were shaken daily to prevent the settling of the bacteria at the digester base and maintaining firm contact between bacteria and manure properly, prevent surface scum formation of the slurry in the digester, and facilitate the generation of biogas.

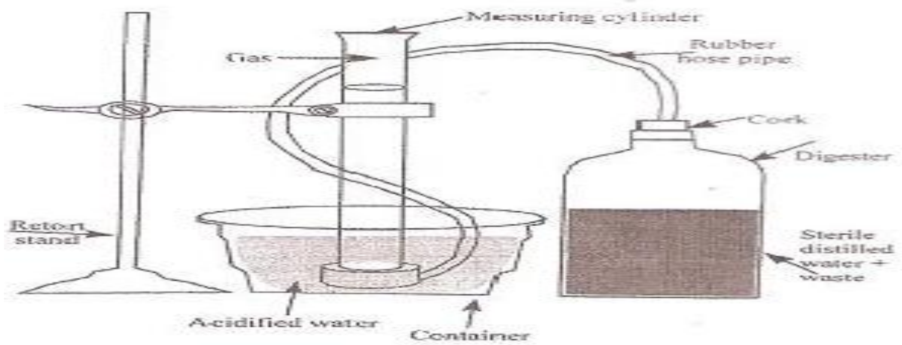

Figure 1: Experimental set up for biogas production.

III. RESULTS AND DISCUSSIONS

The quantities of biogas generated from all the digesters (A-P) were recorded every four days for an HRT of 40days and tabulated as shown in Tables 1 and 2. Table 1 shows the biogas production every four days for a total of 40 days for digesters group I and II while Table 2 depicts the biogas production from digesters in group III and IV.

Table 1: The Table of biogas generations in cm^3 for digesters in groups I and II

Period (Days)	Group I digesters (Mahogany sawdust)				Group II digesters (Iroko sawdust)			
	A (cm^3)	B (cm^3)	C (cm^3)	D (cm^3)	E(cm^3)	F(cm^3)	G(cm^3)	H(cm^3)
1-4	615	490	460	400	260	200	240	85
5-8	1750	1190	995	799	600	320	360	125
9-12	2215	1885	1220	920	1000	530	700	290
13-16	2800	2480	1820	1145	1130	875	740	710
17-20	1480	1260	1710	950	800	510	345	520
21-24	1100	950	880	845	790	425	280	295
25-28	1025	920	850	715	760	415	215	200
29-32	980	745	850	610	675	350	170	100
33-36	690	420	760	300	260	320	140	80
37-40	530	395	300	280	170	120	100	60
Total	13185	10735	9845	6964	6445	4065	3290	2465
Mean (cm^3/day)	329.62	268.38	246.13	174.1	161.13	101.63	82.25	61.63

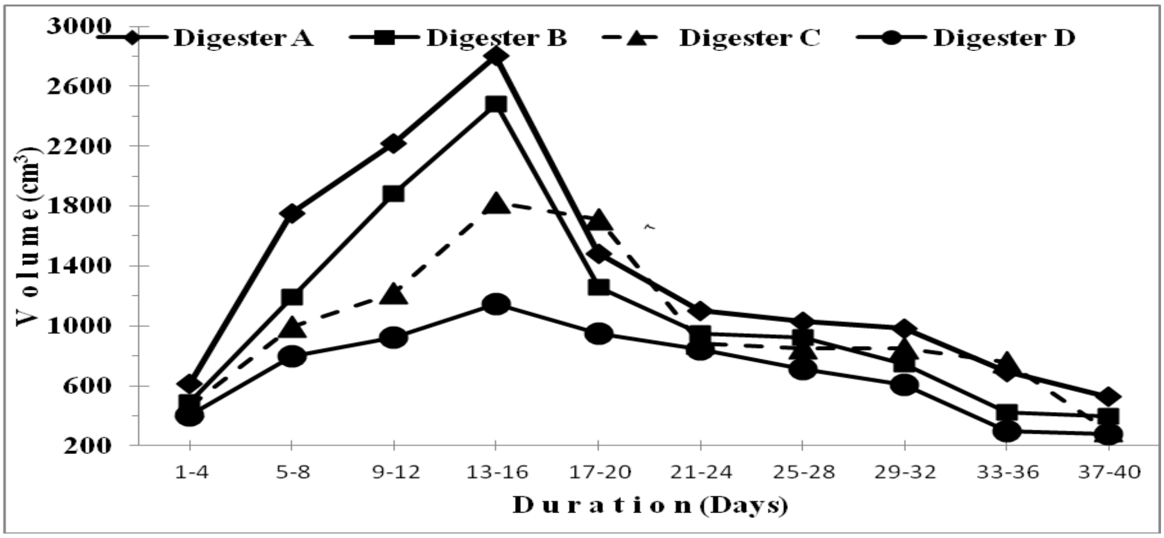

Figure 2: Daily production of biogas in Digesters (A-D) seeded with hardwood (Mahogany) sawdust

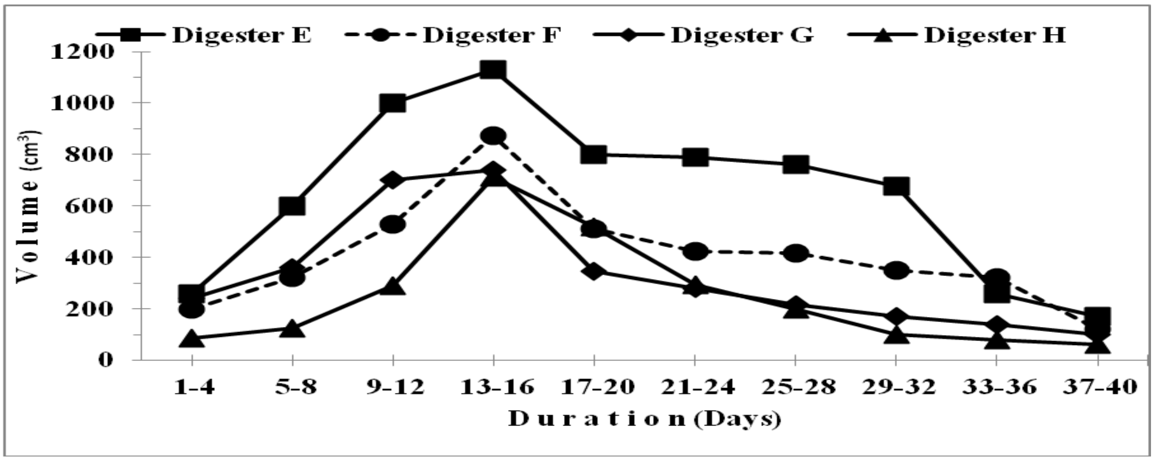

Figure 3: Daily production of biogas in Digesters (E-H) seeded with hardwood (Iroko) sawdust

The result shown above revealed that, the rate of biogas produced was solely dependent on the quantity of seeding media material in line with Adeyemo S.B. and Adeyanju A.A. [10]. Of the four digesters in group I, digester A (with 200g of mahogany sawdust) produced the highest quantity of biogas compared with digesters B, C, D which are seeded with 150g, 100g, and 50g of mahogany respectively as shown in Table 1. The lowest production of gas was recorded between day 37-40 for all the digesters while the peak period of gas production was between day 13-16, where digesters A,B,C, and D recorded 2,800cm^3, 2,480cm^3, 1,820cm^3 and 1,1450cm^3 respectively as shown in Fig. 2. With the presence of the media material having higher moisture content could be explained by the fact that, the biodegradation process commenced within 48hours which is in line with that of Itodo I.N, Lucas E.B. and Kucha E.I [11]. The total volume of gas produced within 40days of digestion by digesters A, B, C, and D was 13,185cm^3, 10,735cm^3, 9,845cm^3 and 6,964cm^3 respectively.

The rate of biogas produced appeared highest in digester A followed respectively by digesters B, C, and D and this is due to the variation in the media content of the mahogany wood. It was noticed that, production of gas in all the digesters lasted for 40days and there was no deterioration noticed in the wood samples used. This may be due primarily to the abundant presence of lignin (which is not readily biodegradable by anaerobic organisms) in the wood samples.

For group II digesters seeded with varying quantity of Iroko sawdust, digester E with highest quantity of iroko sawdust (200g) was the most productive followed by digesters F, G, and H seeded with 150g, 100g, and 50g respectively in that order. Group II digesters also followed the same pattern of yield as group I digesters with the highest yield occurring between 13-16days as shown in Fig. 3. The mean daily yield was 161.13cm^3, 101.63cm^3, 82.25cm^3, and 61.63cm^3 for digesters E, F, G and H respectively as shown in Table 1 and Fig. 4.

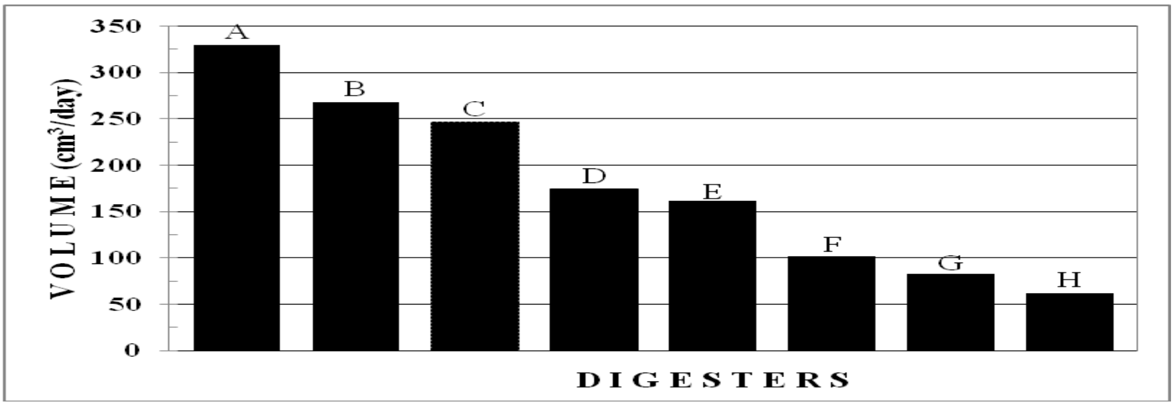

Figure 4: Comparative mean volumetric production of biogas/day in Digesters (A-H) seeded with hardwood sawdust

From Fig. 4, it is clear that the mean daily yield of each digester is directly proportional to the quantity of seeding material used. Also, digesters seeded with mahogany sawdust were more productive that those seeded with iroko sawdust even though mahogany and iroko woods are both hard wood species. Mahogany sawdust exhibit great biogas yield so much that the digester D seeded with 50g of mahogany sawdust yields more that digester E which was seeded with 200g of iroko sawdust. This shows that wood species affects biogas yield more that the quantity of seeding material.

Table 2: The Table of biogas generations in cm^3 for digesters in groups III and IV

Period (Days)	Group III digesters (Obeche sawdust)				Group IV digesters (Araba sawdust)			
	I (cm^3)	J(cm^3)	K(cm^3)	L(cm^3)	M(cm^3)	N(cm^3)	O(cm^3)	P(cm^3)
1-4	400	340	320	290	280	200	150	100
5-8	1200	1090	900	680	800	700	440	300
9-12	2050	1400	1200	890	1140	970	800	780
13-16	2400	2010	1750	1000	1200	1040	900	790
17-20	1300	1100	1000	790	930	840	650	450
21-24	940	900	800	510	790	610	450	290
25-28	600	550	500	400	690	400	320	230
29-32	550	450	400	350	640	380	300	230
33-36	480	400	350	230	320	295	250	180
37-40	330	310	240	200	200	170	120	80
Total	10250	8550	7460	5340	6990	5605	4380	3430
Mean (cm^3/day)	256.25	213.75	186.5	133.5	174.75	140.13	109.5	85.75

Groups III and IV digesters are both seeded with soft woods, while group III digesters were seeded with Obeche, group IV digesters were seeded with araba sawdust. The production patterns were also similar to those exhibited by groups I and II digesters which are seeded with hard wood species.

For group III digesters, digester I which was seeded with 200g obeche sawdust was the most productive followed by digesters J, K, and L which were seeded with 150g, 100g, and 50g respectively. The highest yield occurred during the 13-16 days while the least yields were recorded in 37-40 days as shown in Table 2 and Fig. 5. Similar trends were also witnessed in group IV digesters seeded with varying quantity of araba sawdust where digester M seeded with 200g of araba sawdust was the most productive when compared with digesters N, O and P which are seeded with 150g, 100g and 50g of araba sawdust respectively. Fig. 6 reveals that the peak biogas yields were recorded between 13-16 days while the least were recorded between 37-40 days.

The mean daily production was highest in digester I (256.25cm^3) and was followed by digester J (213.75cm^3), digester K (186.5cm^3), and digester L (133.5cm^3) in that order for group III digesters. The average daily production for group IV digesters was highest in digester M (174.75cm^3) followed by digester N (140.13cm^3), digester O (109.5cm^3) and digester P (85.75cm^3) in that order as shown in Fig. 7.

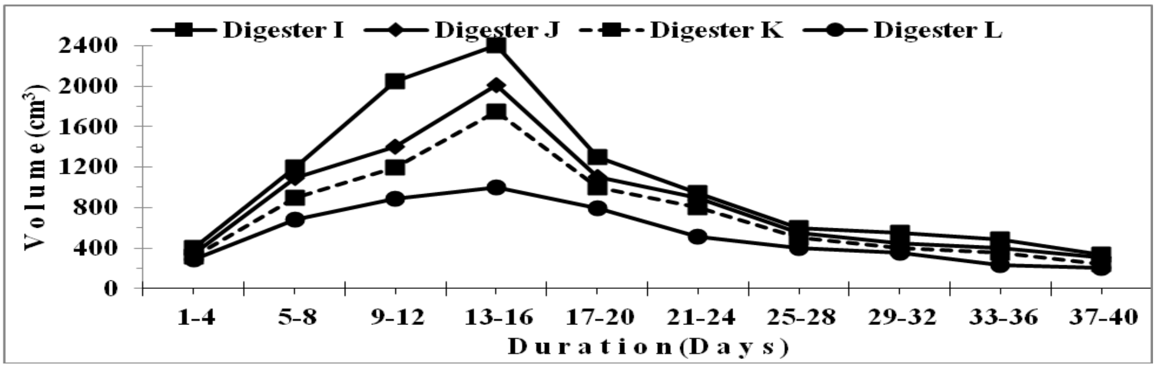

Figure 5: Daily production of biogas in Digesters (I-L) seeded with softwood (Obeche) sawdust

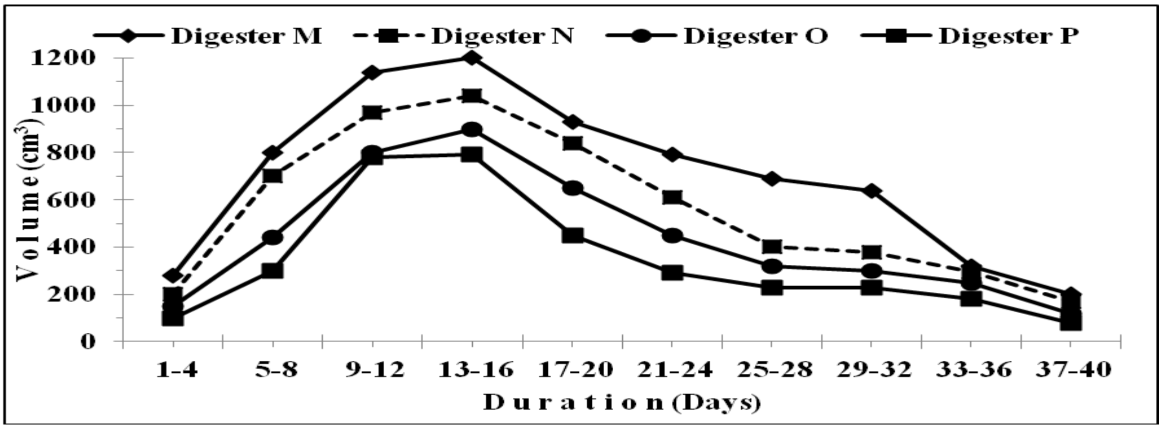

Figure 6: Daily production of biogas in Digesters (M-P) seeded with softwood (Araba) sawdust

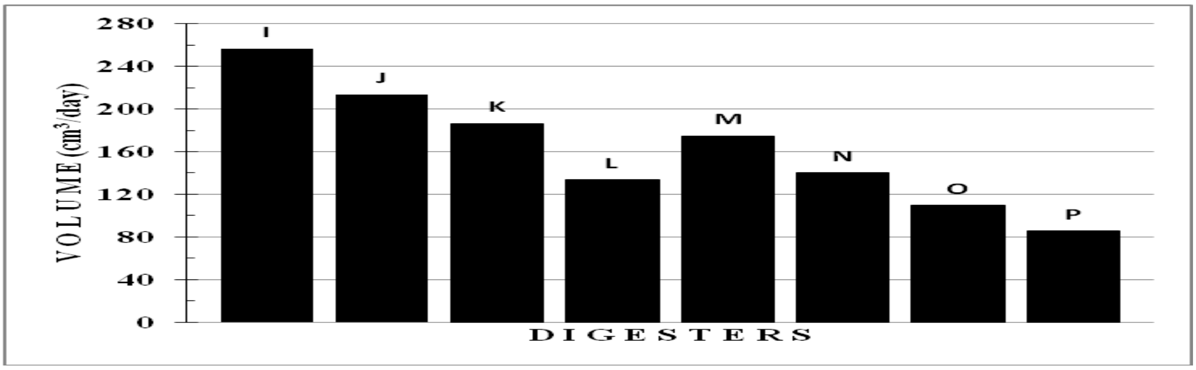

Figure 7: Comparative mean volumetric production of biogas/day in Digesters (I-P) seeded with softwoods sawdust

Unlike what happened in the case of hardwood where digester D that was seeded with 50g of mahogany sawdust yielded more biogas/day than digester E seeded with 200g of iroko sawdust (Fig. 4), digester L seeded with 50g of Obeche sawdust produced less biogas/day than digester M seeded with 200g araba sawdust (Fig. 7).

Comparatively, of the four digesters seeded with 200g of sawdust, digester A (seeded with 200g mahogany hardwood sawdust) is the most productive followed by digester I (seeded with 200g obeche softwood sawdust), digester M (seeded with 200g araba softwood sawdust), and digester E (seeded with 200g iroko hardwood sawdust) in that order. Also of all the sixteen digesters digester A was the most productive generating 329.62cm^3 in 40 days while digester P generated the least volume of biogas of 3430cm^3 during the same period.

IV. CONCLUSION

The tremendous increasing costs of conventional fuels in the urban areas necessitate the exploration of other energy sources. Biogas could be produced from animal wastes, wood wastes and other bio-wastes to substitute for fossils fuels. The search for alternative energy sources such as biogas should be intensified so that, ecological disasters like deforestation could be solved.

This research work has shown an increase production of biogas through the use of varying quantities of seeding materials (varieties of wood species). The various concentration of the two hard woods (mahogany and Iroko) exhibits good and better characteristics in accelerating biogas yield than the two other soft woods (Obeche and Araba). However, mahogany wood had distinguished its media potential unique content in generating the highest rate of biogas production among other tested wood species. More researches should be carried out to determine the exact quantity of mahogany sawdust that will guarantee optimum biogas yield.

Hence, while the quantity of seeding material can increase biogas yield, the type and quality of seeding material can also contribute significantly to the production capacity.

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