www.cenresinpub.org
ISSN 2277-0143

EVALUATIONS OF NEEM (AZADIRACHTA INDICA) LITTER FOR PRODUCTION OF BIOGAS IN MAIDUGURI, NORTH-EASTERN NIGERIA

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ABSTRACT

Energy has been an important aspect of man's needs in his daily life. As the demand for energy is excessively increasing, there has been a relentless search for the different forms of energy that will meet up with his needs. Biogas from biomass source is currently being recognized globally as renewable energy source help militate against climate change while providing a renewable cheaper source of domestic energy/lighting source. The study evaluated the availability and viability of Neem litter as a raw material for biogas production within the study area (Maiduguri city).Three study sites were delineated for this study, namely University of Maiduguri campus, Ngaranam and Umarari ward. Neem litter were collected from a quadrats with a dimension of 50 x 100 meters in replicates of three within each of the study sites over a period of three months from January to march, 2012 and was packed in sacks and weighted. The total volume of neem litter collected for University of Maiduguri campus, Ngaranam, and Umarari ward were, 10238kg, 841.9kg, and 845.3kg respectively. The study also determined the proximate composition of the Neem litter to ascertain their organic element status in mg/l and it was found that Neem litter from Unimaid campus has the higher concentration of organic elements. Furthermore, 328.2 kg of Neem litter collected from each of the study sites were fed into the biogas generating set in batches to determine the volume of cumulative biogas that could be generated for each of the study sites. The study showed that neem litter from university of Maiduguri campus produce ($8.08x10^{-6}m^3$) of biogas, Ngaranam ($2.89x10^6$) and Umarari ($1.25x10^{-6}M^3$) respectively. Analysis of variance (ANOVA) was also computed and it was found that there was a significant difference among the volume of biogas produced from the three study sites. The present investigation revealed that Neem litter is not rich enough to produced substantial amount of biogas unless it is blended with a supportive medium like animal dung's due to its high lignin and wax content; coupled with its acidic nature which tends to suppress the viability of anaerobes within the anaerobic digester. Biogas technology can be used as an effective way of wastes treatment/management strategy in recycling organic wastes into energy.

Keywords: *Neemlitter, Cumulative Biogas, energy search and organic elements.*

INTRODUCTION

We live in a world where depletion of resources is beyond control. The need for sustainable development should be said loud and clear. Hence the current and future generations must ensure that all resources are preserved, fully utilized and well managed. (Kathiravale and Muhd 2008). Energy crises with their attendant social, economic and political consequences are not new phenomena on the international scene. There has been tremendous academic

interest in oil politics and the consequences of energy related crises. The impact of the 1973 oil war for instance motivated the more advanced countries of the west to seek out alternative energy sources. Important substitutes for oil systematically researched and developed in these countries, include tar sands, heavy oils, coal, nuclear power, and wind energy conversion amongst others. Hampered by economic limitations, technological and leadership inadequacies and other constraint, the less developed countries have not been as adventurous or progressive (Ayodele 1991). In many African countries, including Nigeria, fuel wood continues to account for over 80% of energy consumption. The use of fuel wood is now found to be detrimental to socio-economic life in these third world nations. One problem of over-dependence on fuel wood is deforestation. Trees are cut indiscriminately to meet the basic needs of the teeming population (Daura. 1998). For instance about 80% of the country's populations that live in the rural areas use firewood as energy sources. The inability to harness cost effective alternative fuel for both industrial and household usage in the various part of the country have resulted in the nationwide domestic energy crisis and a consequent deterioration of the industrial and economic sectors. Situation has therefore created an upsurge in the exploitation and utilization of fuel wood which has resulted in serious ecological problem of deforestation, desertification, erosion, loss of topsoil, infertility, and poor crop yield in most part of the country. The forest in developing countries including Nigeria, are being consumed at an alarming rate of well over 10-15million hectares per annum (Adegoke ,1991).In Nigeria, fuel wood consumption has increased to 10 times and this trend is expected to continue as a result of rising population.

The estimated demand for fuel wood per capita in one cubic meter per person per year and the total national demand for fuel wood was projected to increase from 80 million cubic meters in 1990 to about 120 million cubic meters in the 2000 (Umar, et al,1999). In Nigeria , Neem trees occupy above 3.5 hectares of Land in kebbi, Sokoto, Borno and Zamfara in the Northern parts of the country with a density of about 1200 trees per hectares.The fruit yield is variable ranging from 10-50kg per tree with an average of 20kg (Schmutter, 1995). Neem based products have been under exploited despites abundance of the plant in northrnern Nigeria. Neem trees forms about 90% of the trees in the forestry plantations established in the twelve states within the Savanna Zone under the affrostration programs Taraba state inclusive (Nwokeabia, 1994). Néem litter from the tree of Azadirachta indica or Neem trees represent

Organic wastes that are generated annually in large quantity in Northern Nigeria where it is very abundance (Keay et al, 1964). However, the supply base has confirms to shrink due to deforestation rates of over 260,000 hectares in the rain forest ,103,000 in the savanna and high growth rates of over 3.0 to 3.5 % Umar, (1991). Furthermore, other problems that encourages indiscriminate massive consumption of the biofuels on both the ecosystem and its habitats promoted the emergence of this study by recycling wastes (Néem litter) into a resource (Biogas), which can serve as one of the ways of reducing pressure on indiscriminate cutting of trees for fuel wood. Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas originates from biogenic materials by anaerobic digestion or fermentation of biodegradable materials such as biomass,

manure or sewage, municipal wastes and energy crops (Taylor et al, 2007).In developing countries domestic biogas plants convert livestock manure and night soil into biogas and slurry, the fermented manure is being used as source of organic fertilizer.(Wilson, et al 2011).In developed countries, for instance each year, the U.S.A. produces many hundreds of tons of organic wastes from crops ,forest, and municipalities .This wastes called bioconversion would help dispose of troublesome accumulations of solid wastes. The bioconversion of organic materials into alternative fuels by microorganism is a developing industry at global level.

MATERIALS AND METHODS

Experimental procedures:

Study Area

The following locations were the sample sites where Neem litter were collected as raw materials, considered as wastes, being threat to environmental sanitation, dose, not have any competing demand and being disposed off by incineration.

Location of study sites

Maiduguri lies within Latitudes $11^{o}48'$ - $11^{o}55'$N and longitudes $13^{o}04'$ - $13^{o}14'$E. The geology of the area is that of Chad Basin formation, a lake with the largest area of inland drainage in Africa. It is estimated to have an area of about 1.6 million km^2. Maiduguri is directly underlain by the chad formation of which the exposed section is through the river cut of the Ngada complex. Maiduguri is boarded by Shehuri in the southwest, custom in the east and Abba Ganaram low-cost in the south-east (Beacon services Ltd. 1972).

University of Maiduguri

The University of Maiduguri campus is located between latitudes 11^{o} 45' and 11^{o} 5' North and longitudes 13^{o} 11' and 13^{o} 16' east. It is located at the eastern outskirt of Maiduguri just after Mairi ward settlement. It has a landmass of 4,291.13 hectares.

Ngaranam

Ngaranam ward is located between latitude 11^{o} 52' and 52^{o} 2' North and longitude 13^{o} 08' and 27^{o} 7' east. It is located at the Northern outskirt of Maiduguri adjacent to Maiduguri railway terminus. It has a land mass of 2,525.20 hectares.

Umarari Ward

Umarari ward is located between latitudes 11^{o} 52' and 14^{o} 4' North and longitudes 13^{o} 11' and 13^{o} 16' east. It is located at the Northern outskirt of Maiduguri just adjacent to Maiduguri wire industry. It has a land mass of 1,350.14 hectares.

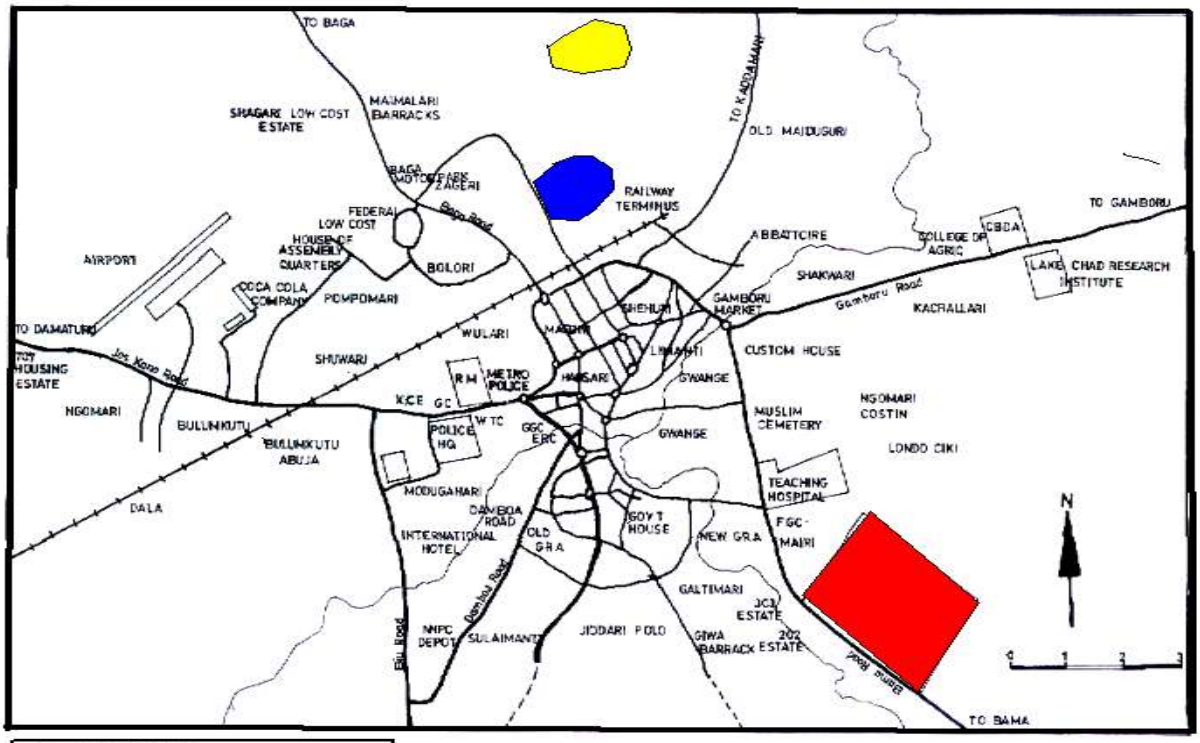

Fig1. Maiduguri showing the study sites
Source: Ministry of Land and Survey (2012).

Source of Neemlitter:

The litter from Neem tree,*Azadirachta indica* represents organic wastes that are generated annually in large quantity in Northern Nigeria, where it is very abundant (keay et al, 1964).

Collection of Raw Materials (Neem litters)

Neem litter was collected within the designated quadrats (50x100meters) in replicates of three located within the three study sites over a period of three months, January, February and March, 2012. This was the period in which leaves fall is highest in Neem tree, where raw material are found to be in abundance. The raw material were collected and stored in nylon sacks.

Preparation of Extracts for Raw-Materials (Neem Litter) to Ash Content

The Neemlitter was converted into ash by air drying process where the Neem litter was put into a porcelain crucible and placed in a muffle furnace and heated up to a temperature of 500^{o}c for 1hr.The ashed sample was removed and cooled at room temperature i.e.37^{o}c .This was done in order to make the organic wastes elements to be released in powdered form (ashed) which was later digested by using 6m hydrochloric acid

Digestion of Ashed Samples

1g of the ashed samples of the organic wastes (Neem litter) was poured into 250ml of beaker and 10ml of 6m hydrochloric acid was added into the content of the beaker which results to the solution of the ashed sample of Neem litter. The solution of the ashed sample was heated on a hot plate for 15mins and was later removed from the source of heat and cooled at room temperature i.e. 37^{o}c.Furthermore, 1ml of concentrated trioxonitrate (V) acid was added to the solution of the ashed samples and heated to complete dryness to enable silica to be hydrated and 1ml of 6m hydrochloric acid and 10ml of distilled water was added to the hydrated samples, and the mixture was heated again to attained absolute dissolution and the solution was filtered and the volume was made up to 100ml by adding distilled water, this make up a solution of suspended organic elements of neem litter.

Analysis of Elements Presence in Neem Litter Extracts

The inductivity coupled plasma (optical emission spectrometer) was used for the analysis in detecting for the elements in the Neem litter extracts. The equipment was calibrated by using standards for the elements in multiple forms. Samples were then introduced to the equipment and emission intensity spectra were obtained, later these emissions were then converted into concentration in mg/l.

Pretreatment of Raw Materials

From the total volume of the Neem litter collected from each of the three study sites, 328.2kg of Neem litter was weighted out (digester capacity,) and was pretreated by soaking in water for 4days to soften the tissue through partial aerobic hydrolysis processes (Ngulde and Yerima 2012).

Sources of Anaerobic Digester

Floating fixed dome-type of anaerobic digester constructed with metal fuel drum with a capacity of 375litres was used for this research.

Making Slurry of Pretreated Raw Materials

The slurries of the pretreated raw materials were made by mixing the raw materials with tap water on a ratio of 1:1 on a unit volume basis (i.e. same volume of water for given volume of raw materials).This means that 328.2kg of Neem litter for each study sites were mixed with 300cm^3 each of tap water and was subsequently fed into the anaerobic digester in batches and the biogas generating set were allowed to attain their digestion periods and at the end of the digestion periods gas were produced.(Ngulde and Yerima 2012).

Statistical Analysis

Two way analysis of variance was used to compute the least significant of variance from which the least significance difference (LSD) was calculated at level of 5% significance.

Result

In this experiment, parameters determined were, volume of Neem litter collected across the three study sites over a period of three months i.e. January, February and March, 2012, moisture content, proximate composition of Neem litters, suspended organic elements, cumulative biogas generated across the three study sites, digestion and retention periods of raw material fed into the anaerobic digester. ANOVA was also computed to find out whether there are any significant differences among the biogas produced from the three study sites. Also the variation between biogas produced per days was noted.

Table1. Determined volume of Neem litter collected across the three study sites (kg).

Study sites	January	February	March	Total
Unimaid campus	352.8	385.7	285.3	10238
Umarari ward	279.1	306.8	256.09	841.9
Ngaranam ward	290.5	365	189.8	845.3

* Total volume of Neem litter (kg) collected over a period of three months in the three study sites =11925.2kg. Experimental Source: lab work (2012).

From table1. 11,925.2kg of Neem litter was collected across the three study sites over a period of three months from January –March, 2012. Shedding of leaves by plants takes place between the month of January to March due to climatic conditions.(Maishanu and Sambo, 1991).

Table2. Moisture content (%) of Neem litter samples collected across the three study sites.

Study Areas	Study sites A	B	C	Average moisture content %	Total moisture content %
Unimaid	6.3	7.2	6.8	6.7	20.3
Ngaranam	4.6	5.3	5.2	5	15.1
Umarari	4.5	4.1	4.6	4.4	13

Experimental Source: Lab work (2012).

From Table 2: The moisture content of samples of Neem litter collected from the replicated study sites were determined, which was also part of the constitutes of the Neem litter.

Table 3. Proximate composition of Neem litter collected across the three study sites

Components	Unimaid	Umarari ward	Ngaranam ward
Total solids (%)	20	13	18
Volatile solids (%)	13	9	11
Moisture content (%)	20.3	13	15.1
Ash content (%)	7	4	9

Experimental Source: Lab work (2012).

Table 4: Concentrations of suspended mineral elements in Neemlitter in mg/l

Sites	Na	K	Ca	Mg	Fe	Cu	Zn	Mn	Ti	Li	Mo	Co	Ni
Unimaid	38.50	11.42	95.32	146.7	13.31	0.07	0.906	1.629	0.567	0.043	0.090	0.022	0.121
Ngaranam	35.20	9.31	90.20	131.6	11.21	0.005	0.0806	1.520	0.431	0.040	0.040	0.090	0.121
Umarari	25.20	6.02	60.10	100.2	8.20	0.002	0.32	0.021	0.021	0.021	0.040	0.012	0.021

Experimental source; lab work (2012)

Table 5: Cumulative Biogas Generated from Neem litter collected across the three study sites.

Study areas	cumulative biogas generated (m^3)	Volume of Neem litter fed into anaerobic digesters (kg)	Digestion period (days)	Retention period (days)
Unimaid	8.08×10^{-6}	328.2	18	15
Umarari ward	2.89×10^{-6}	328.2	10	10
Ngaranam ward	1.2×10^{-6}	328.2	8	8

Experimental Source: Lab work (2012).

Table 4.6 Analysis of variance for cumulative Biogas generated in the three (3) study sites in Cubic meter (m^3)

	Sum of squares	DF	Mean squares	F	SIG
Between groups	0.151	2	0.76	3.683	0.028
Within groups	2.197	107	0.021		
Total	2.348	109			

Experimental Source: Lab work (2012).

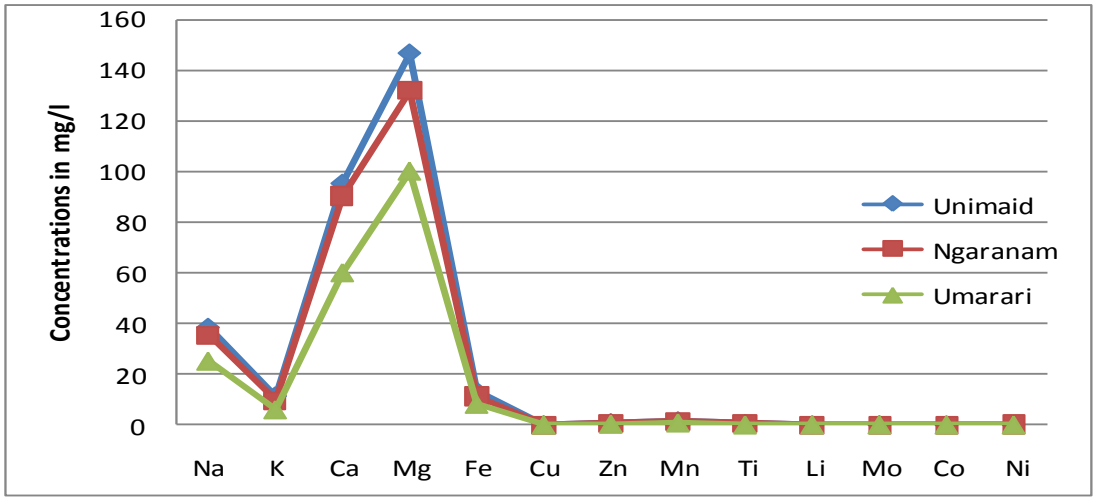

Fig 1. Variations of suspended organic elements in Neem litter extracts

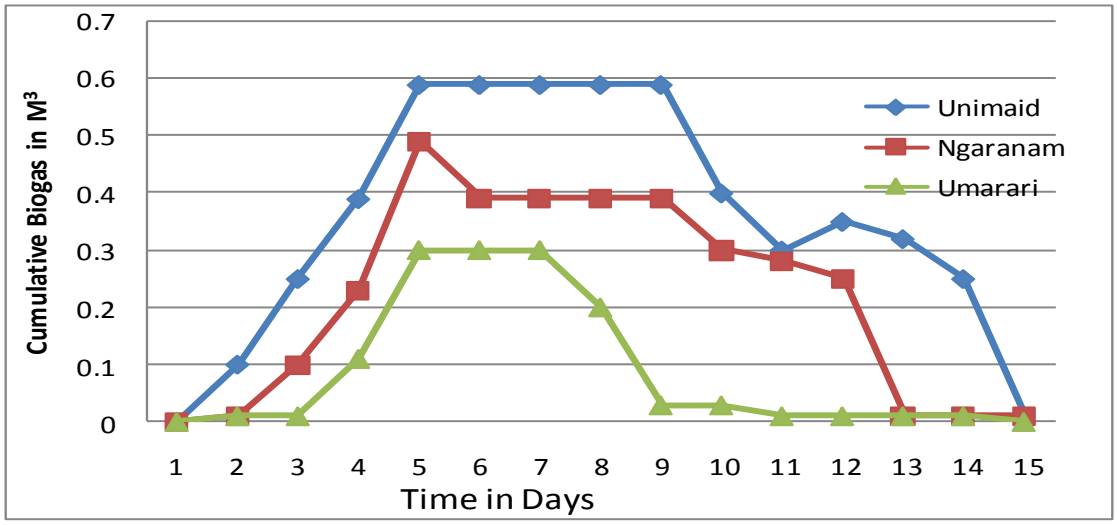

Fig 2. Cumulative Biogas Generated (M^3) from Neem litters from the 3 study sites

RESULTS AND DISCUSSION

The Present investigation revealed that the Neem litter as a raw material for biogas production within the study area is available in abundance in the months of January, February and March only. The result in table 1, indicates that higher volumes of Neem litter was obtained in the month of February, where the results show that volume of Neem litter collected across the three study sites over a period of three months was 11,925 kg. This period of Neem litter collection has tallied with the research findings of Maishanu and Sambo, 1991, who disclosed that shedding of leaves by plants takes place between the months of January to March due to climatic conditions. The moisture content of the Neem litter collected across the three study sites was also determined and the result shows that the samples of Neem litter collected from the university of Maiduguri campus has the highest

moisture content of 20.3%. This might be unconnected with the ways in which Neem trees located within University of Maiduguri campus were well taken care of, the plants did not show any signs of environmental stress. Leaf surface area/sizes, leaf length as parameters are all higher in samples of Neem litter from University of Maiduguri campus. While these parameters mentioned above were less in the samples of Neem litter from the other two study sites. The physical appearance of the plants located in the other two study sites shows some impact of environmental stress on these plant. This might be unconnected with the reason why their moisture and organic content became less compared with Neem plants located in the University of Maidugur and probably the species of the Neem trees might have some variations. Furthermore, the organic content of the samples of Neem litter collected from the three study sites were also determined with the view of finding which of the samples has the highest nutritional requirements of the anaerobes, which was expressed in terms of total solids (TS),Volatile solid (VS) and ash content(see table 3).The total solids comprises of all the degradable and partially degradable materials, while volatile solids constitutes the organic constitutes which tend to have high vapor pressure on partial or complete degradation they are change to vapor/gasses. The Samples of Neem litter collected from University of Maiduguri campus have the highest organic content of 63%. This has correlation with the research findings of Anunputtin and Rodlong (2004), said potentially all organic wastes materials contains adequate quantities of the nutrients essential for the growth and metabolism of the anaerobes bacteria in biogas production.

However, the chemical composition and availability of the biological nutrients contained in these materials vary with species, factors affecting growth and age of the plant or animal materials/wastes. The study also determined the concentrations of the suspended organic elements in mg/l in the Neem litter samples collected from the three study sites(see table 4). The findings show that the Neem litter from the University of Maiduguri has the highest concentrations of organic elements in mg/l. Due to limitation of standardization reagent for calibrating the analytical equipment, thirteen organic elements only were determined and all these elements were found to be higher in concentrations in mg/l in Neem litter from University of Maiduguri. Referring to fig 1, it can be deduced that there are variations in the concentrations of organic elements found in the Neem litter collected from the three study sites, samples of Neem litter from the University of Maiduguri has the highest concentrations of organic elements and samples from Umarari has the least concentrations of organic elements in mg/l(see table4).

Fig 2, disclosed the production of the cumulative biogas generated in (M^3) from Neem litter collected from the 3 study sites. Biogas production is a concerted three stages of biochemical process comprising of hydrolysis, acetogenesis and methanogenesis as shown by the below equations:

i. $(C_6H_{10}O_5)n + \longrightarrow$ $nH_2o\ n(C_6H_{12}O_6)$.....hydrolysis.

ii. $n(C_6H_{12}O_6) \longrightarrow$ nCH_3COOH---Acetogenesis.

iii. $3CH3OOH \longrightarrow$ $nCH_4 + CO_2$.....Methanogenesis.

Thus for an effective anaerobic digestion operation for biogas production, a balance among the acetogenesis and methanogenesis is crucial (Centrell et al,2008) also karki, 1984, disclosed that wastes material of plants and animal origins consists of mainly of carbohydrates, lipids, protein and organic materials which are in larger molecular complex substances that cannot pass through the membrane of anaerobes such larger molecular complex substances need to be solubilized into simpler ones with the help of extra cellular enzymes release by the anaerobes. Hence, the above equation entails the breaking down processes of the Neem litter to release the biogas. The study shows that the Neem litter from the University of Maiduguri gave the highest gas(see fig 1).This might be unconnected with its richness in terms of its organic content because, all the three biogas sets were operated under the same environmental parameters i.e. same temperature range within which anaerobic digesters were operated, PH range, volume of inoculums used, and volume of raw material slurry fed into the anaerobic digester. The study also showed that the lag phase of anaerobes in the University of Maiduguri campus anaerobic digester was from the 4^{th} to 10^{th} day. That was the stationery phase and period within which higher volume of gas was generated and on the 11^{th} day gas production declines and this might be unconnected with the exhaustion of nutrients followed by decline in the population of anaerobes within the anaerobic digester. Similarly the raw material from Ngaranam, being second richer in terms of organic content became next to University of Maiduguri campus in the biogas production, with its lag phase as from 5^{th} to 9^{th} days, while Neem litter from Umarari with the low organic content produced the least biogas having its lag phase as from 4^{th} to 7^{th} day.

However, based on the observations of the trends of the biogas production (see fig 2) the study noted that the Neem litter seems not to be a good raw material when used alone; unless it is blended with animal dung to enrich its organic content. This has been attributed to the presence of lignin and wax in plants tissue giving rise to slower rates of hydrolysis (Lucas and Bamgboye, 1998). The acidic nature of the Neem litter has also lead to creating a hostile environment for the anaerobes which also serve a factor for the low gas yield; this might be unconnected with the reason why low volume of biogas, low retention periods and high digestion period were noted in table 5. The study computed for the analysis of variance (ANOVA), to find out whether there were any significance differences or not despite the fact that raw material used were from identical source (Neem trees). The results showed that F value is 3.685 while the significance value is 0.028, which is less than table value of significance of 0.05 confidence limit; this means that there was a significance differences among the volumes of cumulative biogas generated across the three study sites. This might be unconnected with the variations noted in terms of the organic content which might be unconnected with the impact of environmental influences noted in the three study sites. This entails that the impact of environmental factors can influence variations of richness of organic elements in biomass which can equally influence the rate of biogas production in biomass.

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