ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 6 , June 2020

An Investigative Study of the Impacts of Charcoal Production on the Soils of Adjoining Environments of Ibarapa Axis in Oyo State, Nigeria

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ABSTRACT: Investigations on the impact of charcoal production on the ecology, health, social and economic lives of the people and environment of Ibarapa axis of Oyo State, southwest, Nigeria was carried out between January and July, 2019. Six plots of charcoal loading soil sample (LSS), Burnt soil samples (BSS) and the Control Soil Sample (CSS) which serve as the control plots were selected for the study with considerable distance apart. Soil samples were collected randomly from fifteen (15) sampling points in each of the area of the LSS, BSS and CSS. The soil samples were collected from 0-15 cm and 15-30cm depth which is referred to as topsoil and subsoil. The depth was taken because the activity investigated on this study takes place within this soil profiles aforementioned. The soil samples were collected with bucket auger and mixed thoroughly in a tray and packed well into well labelled polythene bags. They were then air-dried, crushed and passed through a 2mm sieve for various laboratory analysis using standard methods. The analysis of soil particle size however revealed that there's a significant difference between active sites and non-active sites of charcoal production in the top 0-15 cm in clay and silt but showed no similar difference in the 15-30 cm. This however, was different in the case of sand which showed no significant difference in both active and non active (control) or at the two different levels of soil samples. The results also showed significant difference in the mean values of soil properties like organic carbon, total nitrogen, calcium, potassium, copper and zinc of both between the active and non-active sites at the top 0-15 cm under consideration at 5% confidence level. Except in the case of total nitrogen which has shown significant difference at both two sample levels, the significant difference seems to be limited to the top soils in all the other cases. The results of the analyses of variance of soil parameters shows significant difference in pH, Organic Carbon, Ave.P, Ex-Acidity, Ca, Mg, K, Na, Zn in the top 0-15cm, Mg, Na, Fe, and Cu in the 15-30cm layer at ($P < 0.05$). Owing to the anthropocentric nature of the study, questionnaire administration was also employed to gather information. The study concluded that charcoal production has significant impact on socio-economic lives of the people and on the physical and chemical soil properties and recommends relevant government authorities to up their game to protect the already degraded forest ecosystems from further deterioration.

KEY WORDS: Charcoal, Loading Stations, Burnt Soil, Adjoining Environments, Ibarapa Axis

I.INTRODUCTION

Charcoal production and other related activities are expanding in scope and magnitude in many tropical catchments especially in Sub-Saharan African countries like Nigeria (Oguntunde et al, 2004, Glaser et al, 2002, Eniola and Odebode, 2018). The rapid rate of forest resources depletion and its attendant consequences on the social, economic and ecological components of human existence especially across the humid tropics has been the focus of much environmental concern in recent years (Teye, 2008). Vegetation plays a vital role on the physical environment and helps to define the resources and the character of a place (Eniola, et.al., 2012). It provides necessities to humanity such as food, shelter, clothing and medicine (Lattimore, et.al., 2009). Aside this vegetation also provides fuel for the survival of man (Izekor & Amiandamhen 2017). There are various forms of fuel that man derives from vegetation. Charcoal however is the most used fuel especially in the emerging and developing countries. In most parts of the continent of Africa, Biomass is the main and, indeed traditional source of energy for the populace (Namaalwa, et.al., 2009). Charcoal is the principal energy producing fuel commonly used in urban households and institutions for cooking and heating whereas firewood is commonly used in rural settlements (Maes & Verbist, 2012). According to Byer (1987), Africa has firewood and charcoal as the commonest forms of biomass being used. The advantages accrued from charcoal production are numerous and includes source of revenue in rural households, employment generation, source of fuel and so on (Kammen and Lew, 2005). This implies that the production, packaging, transportation and exportation form important components of the economic value chain in areas like Ibarapa Axis of Oyo State that sustain the livelihood of many households. In addition, with the unavailability and high cost of liquefied natural gas and epileptic nature of power supply from the national grid of most developing countries, charcoal has become the prime fuel for cooking (Olarinde and Olusola 2018). Again, unlike other forms of biomass such as fuel, residue and dung, charcoal can be stored without the fear for insects (Kammen and Lew, 2005). In the past fifteen years, there has been a rising demand of charcoal consumption both locally and globally. This increasingly high demand for charcoal has steadily pushed up production and supply in Ibarapa areas of Oyo State, the charcoal production and export has increased steadily, so woodland resources are being consumed faster than they are regenerated. The unsustainable utilization of tree resources for charcoal production has led to a significant depletion of trees and forest resources. Soil erosion has developed in many deforested areas, and roads made by the trucks carrying or fetching charcoal in the remote areas had caused formation of gullies that can be seen in most of the study areas. Finding ways to effectively monitor manage and support sustainable production and trade in wood fuel, especially charcoal, is critical for the area today.

As there has been no comprehensive report on the charcoal production of these areas and its negative impact on both the eco-system and socio-economy of the population in the area, this case study was undertaken to ascertain the magnitude of charcoal production in the area. It was also intended to determine appropriate measures to reduce the effects of charcoal production on the environment and livelihood of the rural society.

II. MATERIAL AND METHODS

A. STUDY AREA

This study was conducted in Ibarapa East Local Government Area of Oyo State which lies between latitude 7° 25’ and 7° 45’ North and longitude 3° 15’ and 3° 35’ East (Oladapo et al., 2008). The total land area is about 838 km2 with a population of 118,226 according to 2006 population census (National Bureau of Statistics, 2006). The local government area has Eruwa as the local government headquarters and Lanlate as one of the major towns in the area. The local government area experiences the tropical hinterland climate with annual rainfall of between 1500 and 2000 mm. The relative humidity is over 70% in the morning and falls to between 50 and 70% in the afternoon. The mean annual temperature is 27°C and the annual temperature range is 8°C. Its vegetation is of savanna types most especially guinea and derived savanna, vegetal species include *Panicum maximum, Imperata cylindrical, Andropogon gayanus, Chromolaena odorata, Eupatorium odoratum, Tithonia diversifofolia, Parkia biglobosa, Vitellaria paradoxa,* and *Piliostigma reticulata* which are raw materials in production of charcoal. The soils in the study area are ferruginous tropical soils (Gbadegesin and Olabode, 1999). The soil base saturation is high, usually exceeding 80% and the soils generally tend to be neutral or slightly alkaline in reaction.

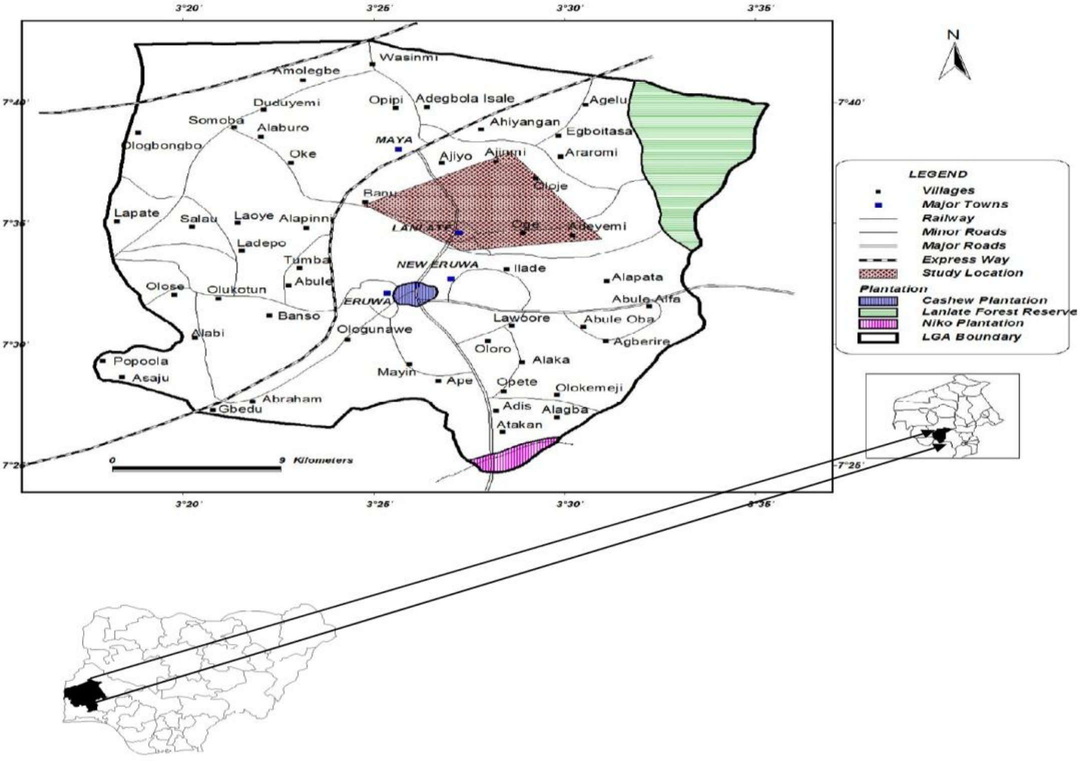

FIGURE 1: Map of Ibarapo Region of Oyo State

B. SOIL SAMPLE COLLECTION AND ANALYSIS

Six plots of charcoal loading soil sample (LSS), Burnt soil samples (BSS) and the Control Soil Sample (CSS) (plots of land that have not been subjected to charcoal production and loading) were selected for the study with considerable distance apart. Soil samples were collected randomly from fifteen (15) sampling points in each of the area of the LSS, BSS and CSS. Both plots are within the same climatic region, relief, parent material and soil types. This makes comparison of soil properties between the three locations possible. Thus any difference observed between the soils under charcoal production, charcoal loading stations and control plots will be accounted for by differences in land use pattern. Moreover, both plots are located in the derived savanna zone of the study area with comparable topographical locations on flat or plain upper segments of the catena to ensure that catenaries effects on soil characteristics were minimal. The soil samples were collected from 0 to15 cm depth which is referred to as topsoil and was taken because most of the activities on the top soil take place within this region. The soil samples were collected with bucket auger and mixed thoroughly in a tray for homogenization after which they were then adequately packed into well labelled polythene bags. The samples were then air-dried, crushed and passed through a 2 mm sieve for various laboratory analyses. The laboratory analyses carried out on the soil samples include particle size composition determined by the hydrometer method (Dietrich, 2005), organic carbon by dichromate oxidation method (Walkey and Black, 1934; Aweto and Dikinya, 2003), total nitrogen using Micro-Kjeldalhl method (Nakano and Miyauchi, 1996), available phosphorus by the method of Bray and Kurtz, exchangeable calcium, sodium and potassium were determined by flame photometry, exchangeable magnesium was determined by atomic absorption spectrophotometry (Nakano and Miyauchi, 1996), soil pH was determined potentiometrically in distilled water using a soil to water ratio of 1.1 base saturation (Gbadegesin and Olabode,1999), soil extracts obtained by leaching soil samples with 1 M ammonium acetate were used for determining exchangeable cations and soil cation exchange capacity (Aweto and Dikinya, 2003). Results from the laboratory analyses were thereafter subjected to statistical analysis using Statistical Package for Social Science (SPSS) whereby the mean and standard deviation of each soil property under LSS, BSS and CSS were determined. The analysis of variance (ANOVA) technique was used to infer whether there are significant differences in the properties of soil between the LSS, BSS and CSS.

Plate 1 Questionnaire administration at loading station

Plate 2 Questionnaire administration at production site

Plate 3 Burning of wood for charcoal

Plate 4 Trailer load of charcoal ready for the market

III. RESULTS AND DISCUSSION

A. Characteristics of Respondents

The study's respondents during the field data findings were charcoal loading stations, and identified persons involved in various aspects of charcoal production in Ibarapa communities. This sampling method separates the population into different subgroups and regular intervals were chosen after a random start, selections were based on various roles in the charcoal production process. 50 questionnaires were successfully administered and recovered from respondents. Questionnaire administration was assisted by educated indigenes that were recruited and given necessary explanations on sampling techniques. This analysis has been done specifically to show the representation of the respondents with regards to their sex, ages, number of years in charcoal production as well as level of education.

B. Sex Distribution of Respondents

During the research, 50 respondents involved in charcoal production were interviewed, of which 30 constituting 60.0% were males and the remaining 20 representing 40% were females. The dominance of men in both the production of charcoal and wood fuel is a signal that males are known for jobs that are energy demanding unlike females.

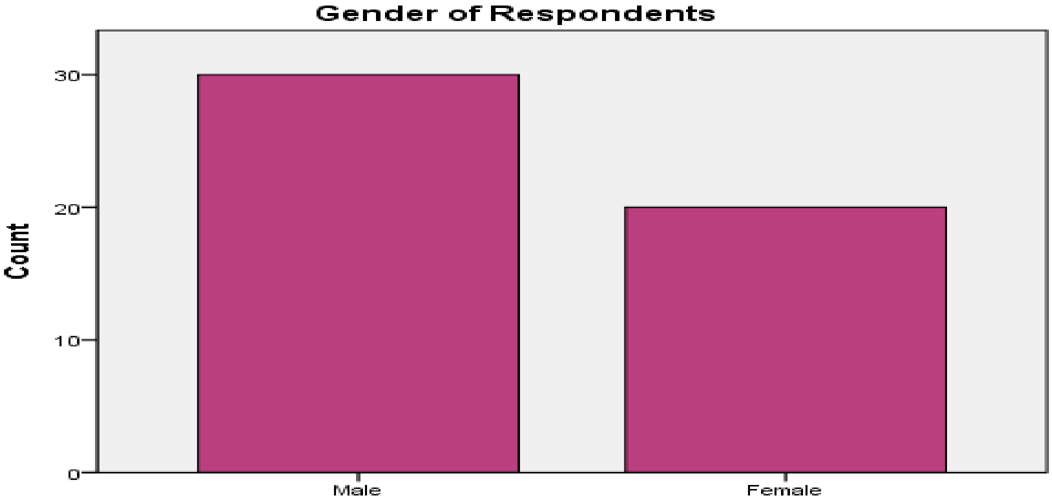

Figure 2: Gender characteristics of respondents

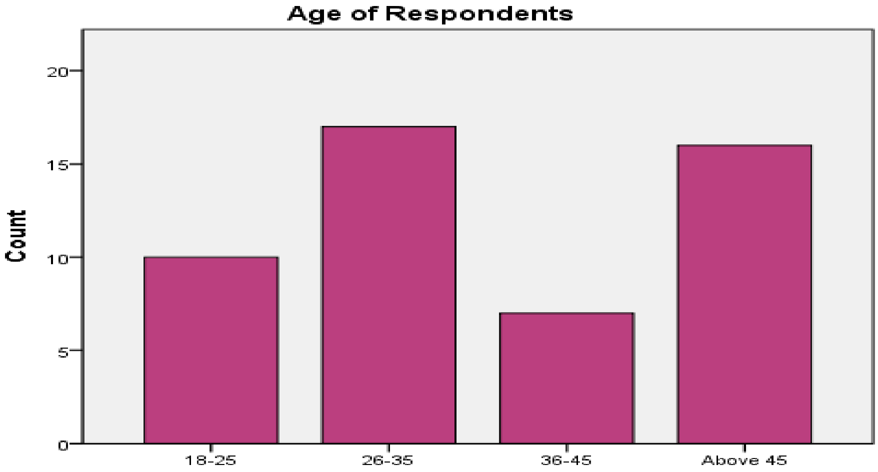

Figure 3: Age characteristics of respondents

The result of the study showed that different age brackets are involved in the production of charcoal, 10 respondents (20%) were between the age range of 18-25, 17 (34%) were between the range of 26-35, 7 respondents that made up 14% were in the range 36-45 and 16 (332%) were above 45 years.

Table 1 Educational characteristic of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary	20	40.0	40.0	40.0
	Secondary	18	36.0	36.0	76.0
	Tertiary	12	24.0	24.0	100.0
	Total	50	100.0	100.0	

The educational status of the people having the charcoal production was also taken into consideration in this study, where it was observed that the highest percentage of the people has a primary school education; about 40% of them, followed by those with secondary school education, having a percentage 36% and 24% was found among those that have higher education. This was similar to the report of (Ogara 2011) who reported that the trade is mostly involving people with low education, from his report he affirmed that junior class dropouts had the highest number of frequency in his research.

To proceed in this study for more information on the production of charcoal, the marital status of the people involved was also noted. It was therefore observed that the percentage of the married people involved is very much higher than the other group of people involving in the production as it carries about 83.0%, the percentage of another group of people involved are very minimal; the singles involved are about 7%, the widowers are about 5% while the widows and divorce are about 4% and 1% respectively.

The income levels of the respondent was also considered, 28% make less than 20,000 on average monthly, 12% earn between 20.000-49.000, 24% of respondents earns 50.000-99.000 and more of the respondents make more than 100,000 averagely on monthly basis.

Table 2 Income levels of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 20.000	14	28.0	28.0	28.0
	20.000-49.000	6	12.0	12.0	40.0
	50.000-99.000	12	24.0	24.0	64.0
	More than 100.000	18	36.0	36.0	100.0
	Total	50	100.0	100.0	

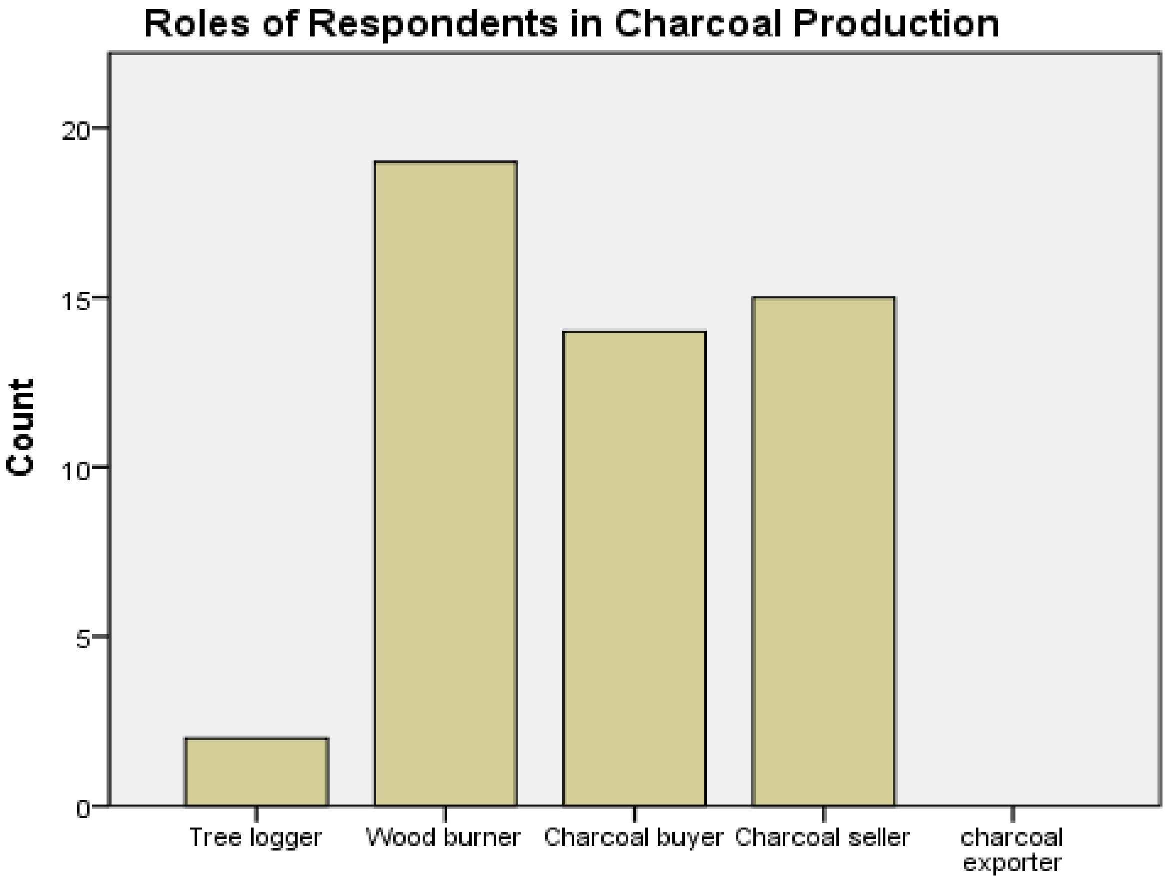

Figure 3 Roles of respondents in Charcoal production

	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 5yrs	10	20.0	20.0	20.0
6-10yrs	3	6.0	6.0	26.0
10-20yrs	4	8.0	8.0	34.0
20yrs and above	33	66.0	66.0	100.0
Total	50	100.0	100.0	

Table 3 Years of Experience in Charcoal Production

The years of experience in the production of charcoal differs. About 20% of the respondents have been into the production of charcoal for less than 5 years, 6% of them have an experience of about 6-10 years. Some of the respondents also, have an experience of fewer than 20 years but more than 10 years and they are about 8% while about 66% of them have an experience of 20 years and above.

Table 4 Primary Occupation

	Frequency	Percent	Valid Percent	Cumulative Percent
Farming	13	26.0	26.0	26.0
Trading	11	22.0	22.0	48.0
Transporter	14	28.0	28.0	76.0
Arts and Crafts	12	24.0	24.0	100.0
Total	50	100.0	100.0	

It is expedient to know if these groups of people have another source of income or primary occupation aside the production of charcoal. It was discovered that about 26% of these people are into farming while about 12% are artisans,11% were involved in different forms of trades and 14% were motorbikes and vehicle transporters, which agrees with the to finding of (Izekor & Amiandamhen 2017) who reported that most of the respondents in their study area were business men and women .

Table 5 Tree Species

	Frequency	Percent	Valid Percent	Cumulative Percent
Terminalia glaucencens (Idi)	10	20.0	20.0	20.0
Disternonanthus benthamianus (Ayan)	20	40.0	40.0	60.0
Azadirachta indica (Dongoyaro)	6	12.0	12.0	72.0
Butyrospermum paradoxium (Emi)	4	8.0	8.0	80.0
Dialium guineense (Ayin)	10	20.0	20.0	100.0
Total	50	100.0	100.0	

Various trees species were revealed by the results of the study to be used in the production of charcoal. Common among the species were Disternonanthus benthamianus (Ayan) 40%, Dialium guineense (Emi) 20%, Terminalia glaucencens (Idi) 20%, Azadirachta indica (Dongoyaro) 12% and Butyrospermum paradoxium (Emi) 12%. It was also noted during the course of the study that various fruit trees and other species of medicinal and economic importance are being cut down and burnt to meet the demand of charcoal export.

SUMMARY OF FINDINGS

Proportions of clay, sand and silt and properties in soil from Loading sites LSS, Burnt sites BSS and Control Sites CSS with no evidence of charcoal production (unburnt sites)

A. SAND

The percentage of sand at the Loading site sample LSS within 0-15 cm depth of soil range from 40.9 to 83.80%, (mean 58.50 and standard deviation 22.46), at the Burnt site sample BSS it ranged from 56.10-84.00 (mean 74.33 and standard deviation 15.80) and at the control site sample CSS ranged from 60.80-83.80% (mean 75.53% and standard deviation 13.00). The analysis of variance (ANOVA) showed that sand content at LSS, BSS and CSS site are not significantly different ($P < 0.05$). The percentage of sand at the Loading site sample LSS within 15-30 cm depth of soil range from 40.00 to 81.90%, (mean 56.93 and standard deviation 22.07), at the Burnt site sample BSS it ranged from 54.90-81.87 (mean 72.06% and standard deviation 14.87) and at the control site sample CSS ranged from 58.40-79.00% (mean 70.96% and standard deviation 11.02). The analysis of variance (ANOVA) showed that sand content at LSS, BSS and CSS site are not significantly different ($p \leq 0.05$).

B. SILT

The percentage of silt at the Loading site sample LSS within 0-15 cm depth of soil range from 7.40 to 32.10%, (mean 21.87 and standard deviation 12.72), at the Burnt site sample BSS it ranged from 8.02 to 28.10 (mean 16.50 and standard deviation 13.57) and at the control site sample CSS ranged from 8.02-28.10% (mean 14.88% and standard deviation 11.45). The analysis of variance (ANOVA) showed that sand content at LSS, BSS and CSS site are significantly different ($P < 0.05$). The percentage of silt at the Loading site sample LSS within 15-30 cm depth of soil range from 10.40 to 30.10%, (mean 22.90 and standard deviation 10.86), at the Burnt site sample BSS it ranged from 10.00 to 33.10 (mean 17.90 and standard deviation 13.16) and at the control site sample CSS ranged from 10.02-30.00% (mean 18.46% and standard deviation 10.29). The analysis of variance (ANOVA) showed that sand content at LSS, BSS and CSS site are significantly different ($p \leq 0.05$).

C. CLAY

The percentage of clay at the Loading site sample LSS within 0-15 cm depth of soil range from 8.57 to 27.00%, (mean 19.62 and standard deviation 9.70), at the Burnt site sample BSS it ranged from 6.50 to 11.80 (mean 8.96 and standard deviation 2.66) and at the control site sample CSS ranged from 8.18-11.10% (mean 9.32% and standard deviation 1.56). The analysis of variance (ANOVA) showed that sand content at LSS, BSS and CSS site are not significantly different ($P < 0.05$). The percentage of clay at the Loading site sample LSS within 15-30 cm depth of soil range from 7.70 to 29.90%, (mean 20.16 and standard deviation 11.34), at the Burnt site sample BSS it ranged from 8.90 to 12.00 (mean 10.03 and standard deviation 1.70) and at the control site sample CSS ranged from 9.30-11.60% (mean 10.03% and standard deviation 1.16). The analysis of variance (ANOVA) showed that sand content at LSS, BSS and CSS site are not significantly different ($p \leq 0.05$).

D. SOIL pH

The pH within the 0-15 cm depth of soil at LSS, BSS and CSS, pH has a variation of 6.00 to 6.90 at LSS (Mean ± S.D, 6.36±0.47), BSS 5.90-6.30 (6.10±0.20) and CSS ranged from 6.90-7.10 (6.96±0.11). The pH within the 15-30 cm depth of soil at LSS, BSS and CSS, pH has a variation of 6.20 to 6.90 at LSS (Mean ± S.D, 6.46±0.37), BSS 6.00-6.50 (6.16±0.28) and CSS ranged from 6.60-6.80 (6.73±0.11). The value of the pH from the sampled locations indicates the soils were slightly acidic, while the control site however had a near neutral pH. Soil acidity and alkalinity play the greatest influence on availability of nutrients to plants and the type of organism found in the soil. The pH also affects the solubility of metal and therefore its availability to plants is made more accessible to plants at acidic pH. The slightly acidic results of the soils from the two sample locations may be attributed to the presence of some weak carbonate radicals (CO3 and HCO3 ions) from the carbon containing charcoal.

E. ORGANIC CARBON

The value of organic carbon within the 0-15 cm depth of soil at LSS, BSS and CSS, organic carbon has a variation of 6.88 to 9.80 at LSS (Mean ± S.D , 7.89±1.65), at BSS 4.52-6.00 (5.17±0.75) and CSS ranged from 1.53-5.00 (2.70±1.98). The value of organic carbon within the 15-30 cm depth of soil at LSS, BSS and CSS, organic carbon has a variation of 2.67 to 9.10 at LSS (Mean ± S.D , 6.55±3.41), at BSS 4.80-6.30 (5.7±0.83) and CSS ranged from 2.75-5.90 (4.05±1.64).

The recorded rises in the organic carbon at both the loading and the burnt sites is an indicator that the practice of charcoal production is one that exacerbates the carbon content of the soil. While carbon content is a vital determiner of the organic richness and fertility of a soil, very extreme levels may also indicate that the soil may be slightly polluted or even slightly acidic as seen in this case.

F. TOTAL NITROGEN

The value of total nitrogen within the 0-15 cm depth of soil at LSS, BSS and CSS, total nitrogen has a variation of 0.47-0.75 at LSS (Mean ± S.D, 0.61±0.14), at BSS 0.34-0.40 (0.36±0.34) and CSS ranged from 0.11-0.90 (0.45±0.40).

The value of total nitrogen within the 15-30 cm depth of soil at LSS, BSS and CSS, total nitrogen has a variation of 0.23-0.76 at LSS (Mean ± S.D , 0.50±0.26), at BSS 0.38-0.42 (0.39±0.02) and CSS ranged from 0.24-0.91 (0.55±0.33).

Nitrogen and phosphorus are two vital nutrients that contribute to soil quality and plant growth. Nitrogen is essential for all forms of life and also an important nutrient for plant growth. The results revealed that nitrogen levels were low.

G. AVAILABLE PHOSPHORUS

The value of Available Phosphorus within the 0-15 cm depth of soil at LSS, BSS and CSS, Available Phosphorus has a variation of 51.95-54.90 at LSS (Mean ± S.D , 53.25±1.50), at BSS 41.03-42.60 (41.91±0.80) and CSS ranged from 39.20-44.90 (41.43±0.04).

The value of Available Phosphorus within the 15-30 cm depth of soil at LSS, BSS and CSS, Available Phosphorus has a variation of 42.17-50.00 at LSS (Mean ± S.D , 47.19±4.35), at BSS 40.661-41.90 (41.17±0.66) and CSS ranged from 39.00-50.00 (41.40±3.10).

Phosphorous is necessary for seed germination and essential for flowering and fruits formation; deficiency symptoms are purple stems and leaves, coupled with poor yields of fruits(Shah et al., 2017). The value obtained showed that the all soils under study had enough available phosphorus.

H. EXCHANGEABLE ACIDITY

The value of Exchangeable Acidity within the 0-15 cm depth of soil at LSS, BSS and CSS, Exchangeable Acidity has a variation of 0.20-0.30 at LSS (Mean ± S.D , 0.24±0.05), at BSS 0.15-0.20 (0.18±0.28) and CSS ranged from 0.10-0.15 (0.12±0.26).

The value of Exchangeable Acidity within the 15-30 cm depth of soil at LSS, BSS and CSS, Exchangeable Acidity has a variation of 0.10-0.27 at LSS (Mean ± S.D , 0.19±0.08), at BSS 0.20-0.25 (0.21±0.02) and CSS ranged from 0.22-0.30 (0.25±0.04).

I. CALCIUM Ca

The value of Ca within the 0-15 cm depth of soil at LSS, BSS and CSS, Ca has a variation of 2.90-4.20 at LSS (Mean ± S.D , 3.41±0.69), at BSS 0.15-0.49 (0.31±0.17) and CSS ranged from 0.06-0.97 (1.24±0.10).

The value of Ca within the 15-30 cm depth of soil at LSS, BSS and CSS, Ca has a variation of 1.86-3.00 at LSS (Mean ± S.D , 2.32±0.60), at BSS 0.20-1.90 (0.81±0.94) and CSS ranged from 0.91-1.90 (1.26±0.55).

J. MAGNESIUM Mg

The value of Mg within the 0-15 cm depth of soil at LSS, BSS and CSS, Ca has a variation of 0.45-0.56 at LSS (Mean ± S.D, 0.50±0.05), at BSS 0.45-0.50 (0.48±0.02) and CSS ranged from 0.60-0.80 (0.67±0.11).

The value of Mg within the 15-30 cm depth of soil at LSS, BSS and CSS, Ca has a variation of 0.51-0.89 at LSS (Mean ± S.D , 0.70±0.70), at BSS 0.46-0.52 (0.50±0.50) and CSS ranged from 0.76-0.87 (0.81±0.05).

K. POTASSIUM K

The value of K within the 0-15 cm depth of soil at LSS, BSS and CSS, K has a variation of 0.74-0.88 at LSS (Mean ± S.D, 0.87±0.07), at BSS 0.12-0.25 (0.16±0.07) and CSS ranged from 0.89-0.98 (0.94±0.04).

The value of K within the 15-30 cm depth of soil at LSS, BSS and CSS, K has a variation of 0.23-0.92 at LSS (Mean ± S.D , 0.63±0.36), at BSS 0.24-0.38 (0.29±0.07) and CSS ranged from 0.24-0.61 (0.36±0.21).

L. SODIUM Na

The value of **Na** within the 0-15 cm depth of soil at LSS, BSS and CSS, **Na** has a variation of 0.40-0.59 at LSS (Mean ± S.D, 0.47±0.10), at BSS 0.34-0.40 (0.36±0.03) and CSS ranged from 0.30-0.45 (0.30±0.05).

The value of **Na** within the 15-30 cm depth of soil at LSS, BSS and CSS, **Na** has a variation of 0.40-0.52 at LSS (Mean ± S.D, 0.47±0.06), at BSS 0.37-0.44 (0.39±0.03) and CSS ranged from 0.33-0.43 (0.38±0.05).

M. MANGANESE Mn

The value of **Mn** within the 0-15 cm depth of soil at LSS, BSS and CSS, **Mn** has a variation of 64.90-66.90 at LSS (Mean ± S.D, 66.00±1.01), at BSS 3.10-5.40 (4.10±1.17) and CSS ranged from 39.30-40.00 (39.76±0.40).

The value of **Mn** within the 15-30 cm depth of soil at LSS, BSS and CSS, **Mn** has a variation of 62.90-64.40 at LSS (Mean ± S.D, 63.50±0.79), at BSS 0.30-5.10 (2.86±2.41) and CSS ranged from 23.20-35.60 (27.60±6.93).

N. IRON Fe

The value of **Fe** within the 0-15 cm depth of soil at LSS, BSS and CSS, **Fe** has a variation of 50.80-88.90 at LSS (Mean ± S.D, 66.80±19.76), at BSS 80.40-99.00 (89.80±9.30) and CSS ranged from 59.50-66.00 (62.20±3.30).

The value of **Fe** within the 15-30 cm depth of soil at LSS, BSS and CSS, **Fe** has a variation of 76.20-82.80 at LSS (Mean ± S.D, 79.73±3.32), at BSS 78.20-85.90 (81.36±4.02) and CSS ranged from 68.10-70.70 (69.53±1.32).

O. COPPER Cu

The value of **Cu** within the 0-15 cm depth of soil at LSS, BSS and CSS, **Cu** has a variation of 0.84-0.90 at LSS (Mean ± S.D, 0.87±0.03), at BSS 0.60-1.80 (1.03±0.66) and CSS ranged from 0.35-0.60 (0.45±0.13).

The value of **Cu** within the 15-30 cm depth of soil at LSS, BSS and CSS, **Cu** has a variation of 1.20-1.50 at LSS (Mean ± S.D, 1.33±0.15), at BSS 1.18-1.95 (1.65±0.41) and CSS ranged from 0.40-0.61 (0.48±0.10).

P. ZINC Zn

The value of **Zn** within the 0-15 cm depth of soil at LSS, BSS and CSS, **Zn** has a variation of 3.60-24.80 at LSS (Mean ± S.D, 17.40±11.96), at BSS 1.21-2.50 (1.67±0.75) and CSS ranged from 1.00-1.02 (1.01±0.11).

The value of **Zn** within the 15-30 cm depth of soil at LSS, BSS and CSS, **Zn** has a variation of 2.15-20.90 at LSS (Mean ± S.D, 8.65±10.61), at BSS 0.70-1.20 (0.90±0.26) and CSS ranged from 0.40-1.60 (0.60±0.34).

Generally, when compared to the control soil sample, many of the parameters exceeded their limits and showed significant difference most especially in the loading soil sample site, this shows that activities and practices around the vicinity of the charcoal production area contribute significantly to the soil degradation in the Ibarapa area. Apart from the parameters observed under this study, similar researches such as the one conducted by (Oguntunde et al., 2008) have established substantial links between soil degradation and charcoal production activity especially with regards to its effects on the bulk density of the soil, porosity, infiltration, and even soil erosion. It is no doubt that the bulk density and shear strength of the soil is overwhelmed by this practice.

IV CONCLUSION

In this study, key findings have been made regarding the impact of charcoal production on the socio-economy and environment of Ibarapa axis. Evidence from the study showed that charcoal production has significant impact on physical and chemical soil properties. The analysis of soil particle size shows a significant difference between active sites and non-active sites of charcoal production in the top 0-15 cm in clay and silt but showed no similar difference in the 15-30 cm. This however, was different in the case of sand which showed no significant difference in both active and non active (control) or at the two different levels of soil samples. The results also showed significant difference in the mean values of soil properties like organic carbon, total nitrogen, calcium, potassium, copper and zinc of both between the active and non-active sites at the top 0-15 cm under consideration at 5% confidence level. Except in the case of total nitrogen which has shown significant difference at both two sample levels, the significant difference seems to be limited to the top soils in all the other cases. The results of the analyses of variance of soil parameters shows significant difference in pH, Org.C, Ave.P, Ex-Acidity, Ca, Mg, K, Na, Zn in the top 0-15cm, Mg, Na, Fe, and Cu in the 15-30cm layer at ($P < 0.05$). It was revealed that charcoal production in Ibarapa axis largely depends on natural forests in which natural regeneration is the main source of forest recovery. This common pattern of almost complete dependence on natural forests for charcoal production and the observed unsustainable harvesting, poor post-harvest forest management, and uncontrolled grazing by livestock are the primary reasons why there is widespread concern about the environmental impacts of charcoal production in the study area. The broad claims of a significant link between wood fuel use and deforestation, as well as forecasts of widespread wood fuel shortages advocated in the past are supported by current knowledge about charcoal production in Ibarapa axis. However, the spatial scale of analysis is needed to determining whether charcoal production causes deforestation or not. At production sites clear cutting of trees tends to be non-selective in terms of size of needed species and production often leads to temporary deforestation while at landscape level production leads to forest degradation characterized by a mosaic of patches exhibiting variable levels of disturbance. Making charcoal production sustainable is still faced with policy challenges that must be effectively addressed. There was no evidence of government presence in the control and management of forest and regulation of activities of charcoal producers, relevant government authorities are expected to up their game to protect our already degraded forest ecosystems from further deterioration.

V. RECOMMENDATION

- There should be Sound policies and strategies to ensure that charcoal production are not only environmentally sustainable but also increase its role as an agent of sustainable rural development, making charcoal production sustainable is still faced with policy challenges that must be effectively addressed.
- There should be improved awareness and sensitization on dangers of charcoal production, deforestation and their attendant consequences on the health and environment of Ibarapa Axis.
- Government should pursue dissemination of information and awareness creation on improved charcoal techniques to the informal sector. The efficiency of household energy consumption needs to be improved.
- Investment in good post-harvest forest management should ensure sustainable charcoal production and improving the nature of our forest and tree species will further enhance their sustainability.
- There should be a significant shift from open-access forests towards secure tenure to sustainable forest management because sustainable forest management presupposes clear and secure long-term forest tenure through the awarding of appropriate property rights to land owners, including communities.

In all this, enhancing policy and program legitimacy through multi-stakeholder participation of communities, government, civil society organisations, community based organisations, faith based organisations and demonstration of coherence with globally recognized principles, goals and relevant international regimes, such as the Sustainable Development Goals (SDGs), will play a pivotal role in ensuring environmental and socio-economic sustainability of charcoal production in affected forest ecosystems.

REFERENCES

Agarwal, B., (1986). Cold hearths and barren slopes: the woodfuel crisis in the Third World. Zed Books, London.

Akinbami JFK (2001). Renewable energy resources and technologies in Nigeria: Present situation, future prospects and policy framework, mitigation and adaptation strategies for global change. The Netherlands. Kluver Academic Publishers;165-181.

Arnold, J. E. M., Köhlin, G., & Persson, R. (2006). Woodfuels, livelihoods, and policy interventions: Changing Perspectives. *World Development*. *34*(3), 596–611.

Aweto AO, Dikinya O (2003). The beneficial effects of two tree species on soil properties in a semi-arid savanna rangeland in Botswana, Land Contam. Reclam., 11(3): 1-6.

Ayodele, A., P. Oguntunde, A. Joseph & M. D. Dias (2009). Numerical Analysis of the Impact of Charcoal Production on Soil Hydrological Behavior, Runoff, Response and Erosion Susceptibility. RevistaBrasileira De Ciencia Do Solo, 33, 137-145.

Bailis, R., Ezzati, M., & Kammen, D. M. (2005). Mortality and greenhouse gas impacts of biomass and petroleum energy futures in Africa. Science. 308(5718), 98–103.

Benjaminsen, T.A. and C. Lund. (2003). Securing Land Rights in Africa. *European Journal of Development Research*. 14, 1-175.

Byer, T., 1987. Review of Household Energy Issues in Africa, Bank Internal Memorandum. World Bank, Washington, DC.

Cuvilas, C. A., Jirjis, R., & Lucas, C. (2010). Energy situation in Mozambique: A review. *Renewable and Sustainable Energy Reviews*, *14*(7), 2139–2146.

Dietrich H (2005). Standard Operating Procedure: Procedure for Determining Soil Particle Size Using the Hydrometer Method. California Department of Pesticide Regulation, Environmental Monitoring Branch, pp. 1-10.

Eniola P. O. and Odebode S. O. (2018). Rural Dwellers' Perception of Effect of Charcoal Production on the Environment in Guinea Savannah Zone of Nigeria. *Journal of Scientific Research & Reports 19(1): 1-12; Article no.JSRR.39422 ISSN: 2320-0227*

Eniola PO, Odebode SO, Ogunsanwo OY, Ajewole OI (2012). Species selectivity for charcoal production in three ecological zones of Nigeria. Journal of Tropical Forest Resources;28(1).

FAO (1996). "Policy Statement on Gender and Wood Energy", Regional Wood Energy Development Programme in Asia, (www.fao.org/sd/egdirect date accessed 04/06/2010).

FAO (2000). "The challenge of rural energy and poverty in developing countries", World Energy Council/Food and Agriculture Organization of the United Nations, London.

Gana, J.N. and Amodu, M.V. (2008). The Implications of Irregular Electricity and Kerosene Supply in Keffi Town. In Mammam, A.B; Chup, C.D. and Mashi, S.A. (eds). *Urbanization, Resource Exploitation and Environmental Stability in Nigeria.* Book of Proceedings of the 49th Annual Conference of the Association of Nigerian Geographers (ANG). Joyce Graphics Printers & Publishers. Pg. 398 & 399.

Gbadegesin A, Olabode MA (1999). The Soils of the Ibadan Metropolis: Nature and Characteristics. Land Contam. Reclam., 7(3): 2.

Izekor DN & Amiandamhen SO (2017) Utilization of Fuelwood as Household Energy among Residents of Benin Metropolis, Edo State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment* 13(2): 174– 178.

Kammen, D. M., & Lew, D. J. (2005). Review of technologies for the production and use of charcoal. *Renewable and Appropriate Energy Laboratory Report*, *1*.

Lattimore, B., Smith, C. T., Titus, B. D., Stupak, I., & Egnell, G. (2009). Environmental factors in woodfuel production: Opportunities, risks, and criteria and indicators for sustainable practices. *Biomass and Bioenergy*. 33(10), 1321–1342.

Larson, A. M., & Ribot, J. C. (2007). The poverty of forestry policy: double standards on an uneven playing field. *Sustainability Science*. 2(2), 189–204.

Maes, W. H., & Verbist, B. (2012). Increasing the sustainability of household cooking in developing countries: Policy implications. *Renewable and Sustainable Energy Reviews*. *16*(6), 4204–4221.

Muhammad T. Salam, Joshua Millstein, Yu-Fen Li, Frederick W. Lurmann, Helene G. Margolis and Frank D. Gilliland. (2005). Birth Outcomes and Prenatal Exposure to Ozone, Carbon Monoxide, and Particulate Matter: Results from the Children's Health Study. *Environmental Health Perspectives.* 113(11), 1638-1644.

Mwampamba, T. H. (2007). Has the woodfuel crisis returned? Urban charcoal consumption in Tanzania and its implications to present and future forest availability. *Energy Policy*. 35(8), 4221–4234.

Nakano K, Miyauchi N (1996). Changes in Physical and Chemical Properties of Surface Soil in a Swidden and Subsequent Fallow in a Northwestern Region of Malaita Island, Solomon Islands, S. Pac. Stud., 17(1): 6.

Namaalwa, J., Hofstad, O., & Sankhayan, P. (2009). Achieving sustainable charcoal supply from woodlands to urban consumers in Kampala, Uganda. *International Forestry Review*. 11(1), 64–78.

Olarinde O. and Olusola J. A. (2018). Socio-economic impacts of charcoal production in Oke-Ogun area of Oyo State, Nigeria. *International Journal of Tropical Plant Research.* 5(1): 46–52]. *https://doi.org/10.22271/tpr.2018.v5.i1.008*

Ogara JI (2011) Preliminary studies on charcoal production and producers‟ knowledge of environmental hazards in Nasarawa State, Nigeria. *Production Agriculture and Technology* 7(2): 68–75.

Ogundele A. T., Eludoyin O. S. and Oladapo O. S. (2011). Assessment of impacts of charcoal production on soil properties in the derived savanna, Oyo state, Nigeria. Journal of Soil Science and Environmental Management Vol. 2(5), pp. 142-146, Available online at http://www.academicjournals.org/JSSEM ISSN 2141-2391

Oguntunde PG, Fosu M, Ajayi AE, Giesen N (2004). Effects of Charcoal Production on Maize yield, Chemical Properties and Texture of Soil. Biol. Fert. Soils, 39: 295-299.

Oladapo OS, Ogundele AT, Akindele KI (2008). Defining Ibarapa Region. In Ibarapa Region, Nigeria. Ed., Adeniran L.A., Geography Dept., EACOED.

Pennise, M., Smith, K. R., & Kithinji, P. (2001). Emissions of greenhouse gases and other airborne pollutants from charcoal making in Kenya and Brazil. *Journal of geophysical research*, 106(24), 143–155.

Post, J., & Snel, M. (2003). The impact of decentralised forest management on charcoal production practices in Eastern Senegal. *Geoforum*, *34*(1), 85–98.

Rensselear R (1995). Charcoal Production in the Democratic Republic of Congo, p. 498.

Ribot, J. C. (1998). Theorizing Access: Forest Profits along Senegal's Charcoal Commodity Chain. *Development and Change*. 29, 307–341.

Smith, K. R. (2002). Indoor air pollution in developing countries: recommendations for research. *Indoor Air*. 12(3), 198–207.

Stassen, H.E., 2002. Nuevas tecnologias de produccion de carbon vegetal. Unasylva 211(53): 34-35.

Subramanian, M. (2000) Whose Interests? Gender Issues and Wood-fired Cooking Stoves. *American Behavioral Scientist*. 43(4), 707-728.

United Nations Food and Agricultural Organization (FAO) (2005). Industrial Charcoal Making. Report.

Walkey AB, Black IA (1934). An examination of the Detjareff Method for determining Soil Organic Matter and a Proposed Modification to the Chromic Acid Titration Method. Soil Sci., 37: 29-38.

World Bank. (2012). Overview of harvesting Non-productive rubber trees and charcoal production in Liberia. Report