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EFFECTS OF CHARCOAL PRODUCTION ON ENVIRONMENTAL DEGRADATION IN GUINEA SAVANNAH ECOLOGICAL ZONE OF NIGERIA.

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Abstract
The study examines the effects of charcoal production on soil properties around mound sites in guinea savannah region of Nigeria. Soil samples at 10cm depths were collected at equidistance position of 1 meter over a distance of 8 meters away from 3 mound sites. The collected soil samples were subsequently analyzed at University of Ilorin laboratories for physical and chemical characteristics. Unlike findings reported in previous studies biomass burning at the mounds in this study did not result in increase of soil micro nutrient, rather an increase in soils chemical characteristics were observed as distance increases from the mounds. The implication of this finding is that charcoal production in the study area is robbing the soil of its essential minerals. Reason for this may however not be unconnected with dry season period the data was collected when rain has not fallen to leach the nutrients from the burnt biomass into the soil. The study also revealed that heat influence at the study sites were only limited to 5 meters distance away from the mounds. This might be because the soil in the area is basically sandy and poor conductor of heat. The general implication of the findings of this research is that, at local level, the damage done to the environment by wood combustion into charcoal may not be as terrible as the havoc caused by the cutting down of trees. The study thus concludes that, the effect of the charcoal production on soil will vary with climatic region.

Keywords: Mound, Combustion, Charcoal, Degradation and Biomass.

Introduction

Charcoal production has gained popularity in Nigeria in recent time and its demand for fuel is on the increase (Babalola and Opii, 2013). Rate of charcoal consumption has been noted to be growing faster than the use of firewood and also bearing a much larger part of deforestation in Africa and South America (Barnes et al.; 2002; Wurster, 2010). According to Oyetunji (2011), trade in charcoal has a huge market with a very high profit margin. It is estimated that over two billion people in developing countries rely on biomass energy in the form of charcoal, firewood, crop residues and animal wastes to meet cooking and heating requirements (Maryland Energy Administration, 2005). This figure according to International Energy Agency (2002) is expected to increase significantly in Africa by year 2030 and globally in line with population growth (Amous, 2000). Emissions of greenhouse gases from charcoal production in tropical ecosystems in 2009 according to Emmanuel et. al (2013) are estimated at 71.2 million t for carbon dioxide and 1.3 million t for methane. Good quality charcoal burns clearly and produces high heat (Babalola and Opii, 2003), qualities which has combined with in-affordability and in-availability of alternative sources of energy such as gas, kerosene, and electricity to endear its usage to high percentage of the population. Adelekan and Jerome (2006) observed that there has been long years of unreliable supply of electricity while kerosene and cooking gas are faced with persistent scarcity and high prices well beyond the reach of the low and medium income classes that constitute high percentage of the population. According to Douglass (1977), business of charcoal production in Africa is worth over $4 billion dollars and employs more than a million people. Studies such as Babalola and Opii (2013), Agyeman et. al (2012), Iroye (2010), Yakubu and Zagga (2006), Odunawo and Adeyemi (1977) have also projected increase in use of charcoal for fuel due to persistent increase in price of alternatives. Despite the importance of charcoal in meeting the energy need of the people, its production has a high negative effect on the environment (Jeffrey, 1984). Although there are other activities of man that result in environmental degradation, process of charcoal production which usually commence with tree felling to burning of logs in the ground is a major catalyst of this degradation (Smith, 1996). According to Uroko (2011), up to 400 matured trees are cut down daily in a small rural community of Oyo state to meet the increasing demand of charcoal. While deforestation affect both the quality and quantity of water from a given catchment (Maidment, 1993), it also causes soil erosion, sedimentation, soil infertility, desertification shortage of food and fibre reduction in wood and wood related products amongst others (Iroye, 2010 and Ijatuyi, 2005). Progressive reductions in forest area have also been observed to have a direct impact on rainfall-runoff relationship (Iroye, 2008). Problem of deforestation cannot be over-emphasized in Nigeria. Evidences of desertification abound in different parts of the country (Bello, 1996 and Olanrewaju, 2004) even most in south-western Nigeria, area often described as wet region (Adeyemi, 2002). Other factors responsible for deforestation activities in Nigeria apart from charcoal production include intensive grazing, persistent bush burning and extension of agricultural activities into less favoured, often environmental fragile areas (Otegbeye and Oyeanusi, 2006). According Tunde, et. al (2013), involvement in economic activities of charcoal production and its usage as energy source is one of the subtle ways man inadvertently degrades the environment. Soil mineral resources and soil microorganism vital for crop production are lost to fervent heat generated though combustion of logs to charcoal; the resultant effect of which is soil impoverishment leading to decline in crop production. Not only that, several local effects of charcoal production pool together can easily upset the delicate balance of climate system hence the examination in this study, the following objectives: examination of the method of charcoal production in the study area, assessment of the spatial variations in physical and chemical properties of the soils at the mounds; and, evaluation of the impacts of charcoal production on physical and chemical properties of the soil at charcoal production sites. This is with a view to suggesting ways of mitigating disaster pose by charcoal production in the ecosystem of man.

Study Area

The study area in this investigation is guinea savannah ecological zone of Nigeria and data collection points are three settlements of Oloro-Ile, Ilupeju; and Ilepupa located in Ifelodun, Ilorin East and Moro Local Government Areas of Kwara State as shown in Figure 1.

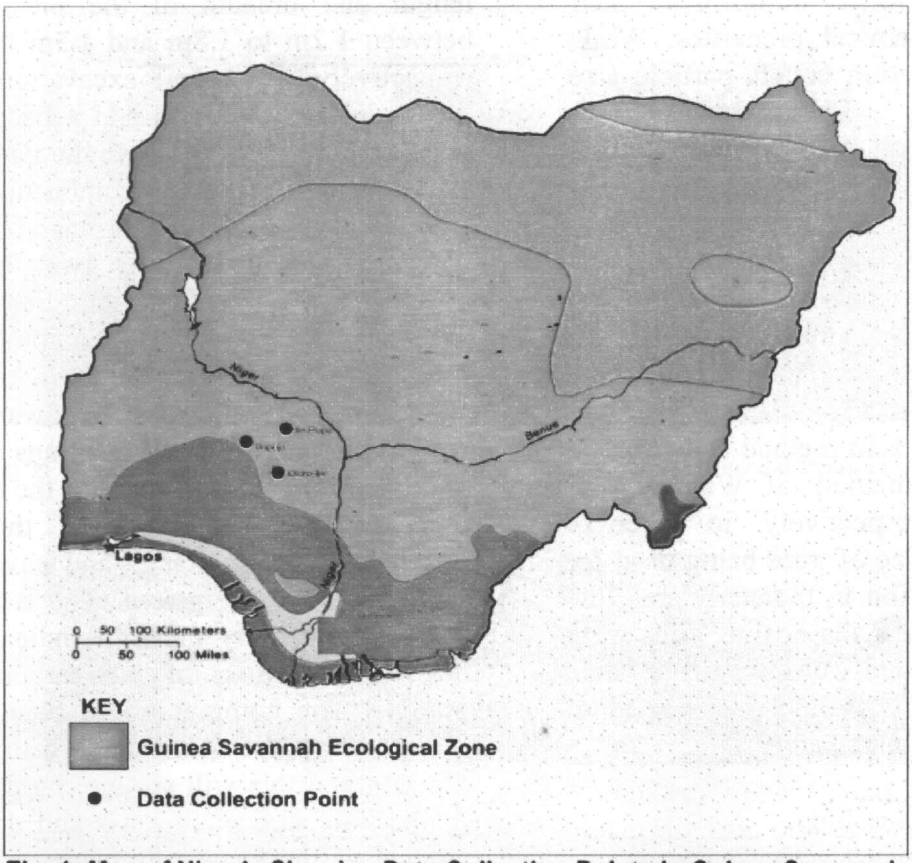

Fig. 1: Map of Nigeria Showing Data Collection Points in Guinea Savannah

Source: Google (2014).

This region which is located between latitude 8^0 and 11^0 falls within a transition zone; between the rain forest of the south and Sudan savannah in the north. Annual rainfall here is moderate (between 100 and 1,500mm) and last for between 6 to 8 months. Mean temperature is high (between 20^0C and 30^0C) and humidity is about 60 percent. The natural vegetation found in this region comprises of tall grasses which are interspersed with scattered trees such as *lophira lanceolata, terminaalia glauscens, afzelia Africana, terminaalia macroptera, mitragyna inermis and daniellia oliveri*. These trees have long tap root which make them tap water from deep down during the dry season. Examples of the common grass species in the region include *andropogon gayanus, monocymbium cresilforme and panicum* maximum. Primary economic activities of the people in the region include crop production, livestock rearing, lumbering and charcoal production.

Research Methods

Data used in this study were collected from the field personally by the researchers. Eight (8) soil samples were taken at equidistance position of 1 meter away from three mounds. At each of the sampling points, reading of soil temperature and acidity were also taken with the aid of soil thermometer and pH meter. The collection of soil samples and readings of soil temperature and acidity were carried out at 10cm depth. This is because, studies have revealed that soil organic matter is mostly located within this depth; and any changes in organic matter will in turn, affect several chemical, physical and microbiological properties of the underlying soil (De Bano, 1990). The collected soil samples were subsequently analyzed at the soil laboratory of the

Department of Agronomy, Faculty of Agriculture, University of Ilorin for their physical and chemical properties. While physical examination entails particle size analysis using Bouyoucos (1962) hydrometer method, the chemical analysis on exchangeable cations such as Potassium, Sodium and Calcium were conducted using flame photometer. Soil Magnesium was analyzed using titration method while soil available Nitrogen, Phosphorous, and organic carbon were determined using regular micro-kjeidahl method ascorbic acid method and chromic acid digestion method of Walkley and Black (1934) respectively. In order to investigate the size of trees being used for charcoal production in the study area, the girth of the logs at the coaling sites were measured in meters using tape rule. Data collected were subsequently subjected to descriptive statistical analysis.

Results and Discussion

Method of Coaling

Charcoal production in the study area is carried out using the mound method. This process which is undertaken in a number of stages takes place over a period of time depending on the size of production pit and the season in which the coal production is being carried out. Instruments used in the production process include digger, shovel, hoe, cutlass, green leaves and grasses.

Charcoal production processes usually begin with soil excavation, dimension of which vary depending on the producers scale of business. While the depth of the pit may range between 0.3m and 1.2m, the length and breadth of the pit can be between 1.2m to 1.8m and 1.5m to 3.6m respectively. After soil excavation, trees for coaling are selected and subsequently cut into pieces depending on the size of the pit already prepared for combustion. The selected woods are neatly arranged into the pit with bigger sized logs lying beneath and a number of stakes protruding out of the kiln to help in controlling combustion process. A small hole where the kiln will be ignited is left at the windward side while a number of small openings are left at the leeward sides to monitor the coaling process. The whole pile is thereafter covered with green grasses and leaves after which the kiln is ignited. The nature of smoke emitted by the kiln indicates the degree of success of the carbonization process. The coming out of blue smoke indicates that too much air is getting into the kiln and this will require the covering of the kiln with more grass and dirt. The change of the smoke from blue to white indicates good carbonization process, and this may last for between 4 to 8 days depending on the size of the logs, the amount of moisture in the wood, amount of air passing through the kiln, size of the kiln and the season. When carbonation process is completed, the emission of white smoke stops and the charcoal is extracted from the Kiln.

Plates 1, 2 and 3 show typical guinea savannah vegetation, charcoal production process and piles of charcoal bags ready for market.

Plate 1: Typical View of Savannah Vegetation

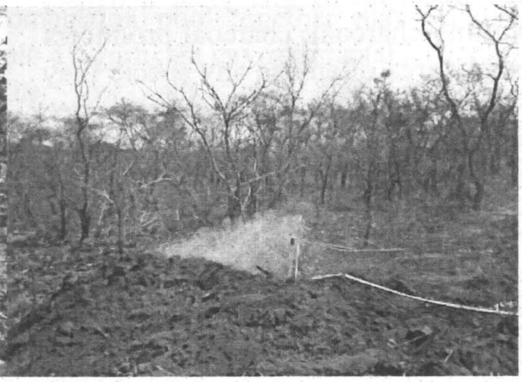

Plate 2: Charcoal Production Process

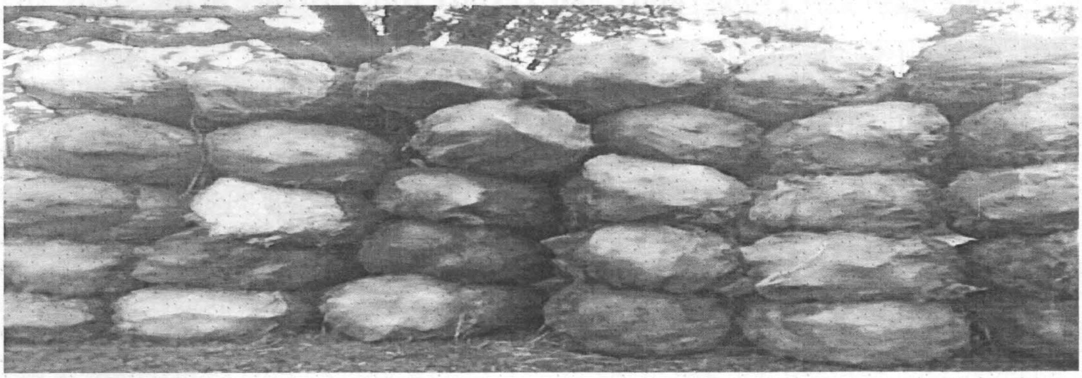

Plate 3: Piles of Charcoal Bags Ready for Market

Nature of Trees Used in Coaling

A total number of ten (10) tree stands were monitored for coaling in the study area. Three tree stands were monitored in Ilupeju, three in Oloro-Ile and four in Ile-Pupa. All the ten trees were big and economically valuable with girth ranging between 0.68 and 1.9 meters (Table I).

Table 1: Girth Size of Trees used in Coaling

Study Site	No of Trees Used	Size of Tree Girths (Meters) (i)	(ii)	(iii)	(iv)	Total	Mean	Coefficient Of Variation
Oloro Ile	3	1.7	1.4	1.8	-	4.9	1.6	0.21
Ilupeju	3	1.6	1.9	1.0	-	4.5	1.5	0.31
Ile-Pupa	4	0.68	0.84	1.10	0.80	3.42	0.86	0.21

Source: Researchers' Findings (2014)

The mean girth of tree used for coaling in Oloro-Ile is 1.6 meters while the mean girth used for coaling in Ilupeju and Ilepupa were 1.5 and 0.86 meters respectively. Coefficient of variation shows low variability in girths of trees used for coaling in the study area.

The ten (10) trees used in charcoal production in this study falls under wide variety of species. Though investigation revealed that charcoal producers often preferred tree species that yield a dense, slow burning charcoal; charcoal producers in the study area often use any specie they come across when the preferred tree species cannot be found due to over exploitation and the fact that such trees are slow growing. It is this problem that makes charcoal producers to combine variety of tree species while some producers even make use of fruit trees or cash crop trees that may be found around provided such trees are big and matured.

Physio-Chemical Characteristics of Soil at Charcoal Production Sites

Soil temperature texture and chemical properties were examined with increasing distance away from the coaling sites. Analysis and results obtained are as presented in the following subsections.

Effect of Charcoal Production on Soil Temperature and Texture

Table 2 indicates the variation in soil temperature and texture with increasing distance away from the three charcoal production sites.

Table 2: Variations in Soil Temperature and Texture with Distance at the Study Sites

Distance from Charcoal Production Sites (M)	Oloro Ile				Ilupeju				Ilepupa				Mean	Mean Soil Texture		
	Soil Temp. (^{0}C)	% Sand	% Silt	% Clay	Soil Temp. (^{0}C)	% Sand	% Silt	% Clay	Soil Temp. (^{0}C)	% Sand	% Silt	% Clay	Soil Temp. (^{0}C)	% Sand	% Silt	% Clay
1.	110	82.0	9.2	8.8	100	81.6	6.8	11.6	106	83.8	7.0	8.1	105	82.5	7.7	9.8
2.	85	78.2	11.8	10.0	70	80.8	7.2	12.0	86	81.8	7.4	10.8	80.3	80.3	8.8	10.9
3.	50	70.0	13.9	16.1	43	72.4	13.6	14.0	51	71.1	13.4	15.5	48.0	72.1	13.6	15.2
4.	46	69.2	11.1	19.7	40	71.6	12.0	16.4	45	70.0	12.0	18.0	43.7	70.3	11.7	18.0
5.	42	67.6	16.8	21.6	36	69.9	9.7	20.4	38	62.1	18.8	19.1	38.7	66.5	15.1	20.4
6.	40	64.4	13.6	22.0	36	68.4	5.6	26.0	38	62.5	17.9	19.6	38.0	65.1	12.4	19.7
7.	40	64.1	7.7	28.2	36	64.9	8.2	26.9	-	-	-	-	38.0	64.5	8.0	27.6
8.	40	64.0	8.0	28.0	-	-	-	-	-	-	-	-	38.0	64.0	8.0	28.0

Source: Researchers' Findings (2014)

Soil temperature at the coaling sites ranges between 100 and 110^{0}C with a mean value of 105^{0}C. The high soil temperature however dropped significantly within a distance of 3m away from the mound at the three study sites (Fig. 2)

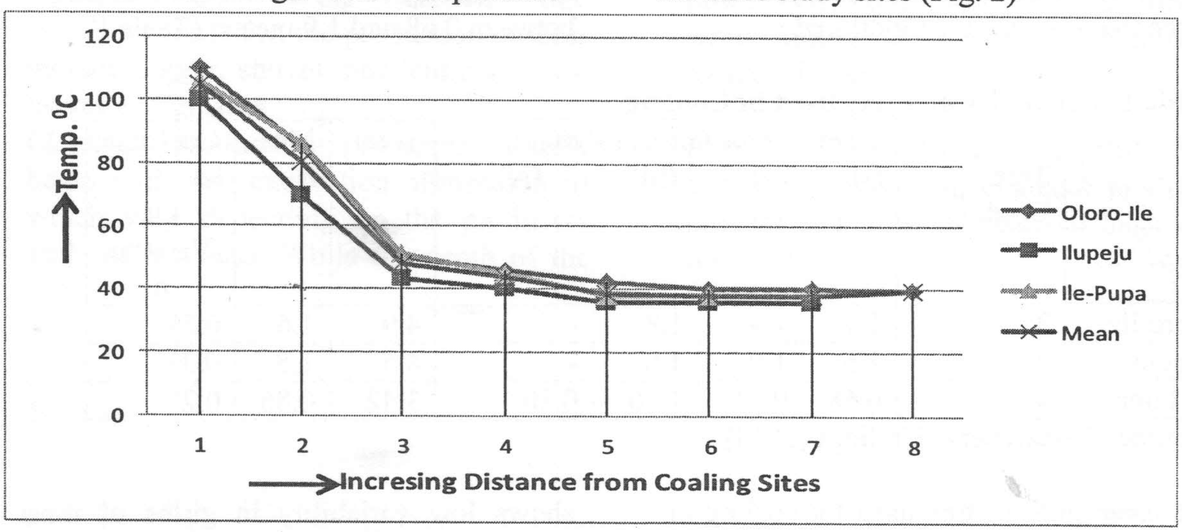

Fig. 2: Variations in Soil Temperature with Distance from Coaling Sites
Source: Author's findings (2014).

The sharp drop in soil temperature with distance from the mound however dropped significantly as from 4m away from the mounds. Soil temperature maintained constant low values of 36 and 38^{0}C at Ilupeju and Ilepupa respectively as from 5m away from the mounds while the same assumed a constant value of 40^{0}C as from 6m away from the mound at Oloro Ile. This result is expected as soil is a poor conductor of heat. Not only that, the nature of soil at the study sites supports rapid heat loss. Charcoal production which is usually carried out at temperature of between 850^{0}C and 1000^{0}C poses negative effects on the activities of soil organism, hence decrease in soil functioning and the ecosystem services it provides (Steiner et al. 2008). According to Kettering (2000), severe burning have drastic effects on soil texture and mineralogy while Ogundele (2009) also reported negative effects on soil physical and chemical properties from low, moderate and severe fires.

Particles size analysis revealed that soil in the study area is generally sandy with very low silt and clay percentage composition especially at the coaling sites. Sandy soils have high volume of pore spaces, a characteristic which causes it to lose heat rapidly. The implications of this is that in the study area damage done to the environment by wood combustion to charcoal may not be as terrible as the havoc caused by the cutting down of trees. However, various local effects of such combustion pool together may build up into a significant environmental hazard.

The low silt and clay percentage compositions at the production sites however increases with increasing distance away from the coaling sites while the high percentage sand composition reduces, though minimally with increasing distance. This result is expected and can be explained by the swelling-shrinkage characteristics of clay minerals (Doerr, 2007). Increase in soil temperature usually leads to shrinkage of clay minerals content in soil; thus reducing its proportion in relation to sand and silt. This development can have great repercussion on cation exchange capacity of such soil. Soil texture according to Thomas (2002) is an important characteristic which determine infiltration rate, hydraulic conductivity, amount of aeration and soil fertility. Correlation analysis between soil texture and temperature as shown in Table 3 revealed a strong positive relationship between soil temperature and percentage sand composition and a strong negative relationship between soil temperature and percentage clay contents at the 3 study sites.

Table 3: Correlation Result between Soil Temperature and Soil Physical Properties

Coaling Sites	% Sand	% Silt	% Clay
Oloro-Ile	0.80*	-0.77*	-0.76*
Ilupeju	0.82*	0.006	-0.81*
Ile-Pupa	0.97**	-0.60	-0.96**

*Significant at 0.01 confidence level
** Significant at 0.01 confidence level
Source: Researchers' Computation (2014)

The correlation between soil temperature and percentage silt composition in two of the three coaling sites examined (Oloro Ile and Ilepupa) revealed a negative relationship while a weak positive relationship (r= 0.006) was observed in Ilupeju, the third study site. This result thus support Doerr (2007) finding on swelling-shrinkage of clay minerals.

Effects of Charcoal Production on Soil Chemical Properties

Chemical properties of soil play vital role in soil fertility; maintenance of soil chemical properties is thus a prerequisite to sustainable crop production (Hartemunk, 2003). Though studies such as Oriola and Omofoyewa (2013), Fontodji, et. al. (2009), Oguntunde, et. al. (2004), Uvarou (2003) Lawrence and Schlesinger (2001) and Giardina, et. al. (2000) have reported large releases of quantities of ash, rich in exchangeable nutrient cations such as calcium, magnesium, potassium and sodium into the soil due to biomass burning, thereby leading to elevated levels of exchangeable cat ions, the current study did not indicate the enrichment of soil exchangeable cat ions

Compositions of soil chemical characteristics examined in this study were found to increase with increasing distance away from coaling sites. Table 4 shows that the closer the distance to the coaling sites, the lower the composition of soil chemical characteristics. This is understandable; the closer the distance to the coaling site, the higher the soil temperature as shown in Table 2. Increase in soil temperature due to combustion of wood affect the level of organic matter in soil, which in turn, affect several chemical, physical and microbiological properties of the underlying soil (De Bamo, 1990). Result obtained in this study which shows an increase in soil chemical properties with increasing distance from coaling sites support Ogundele, et. al (2012) and Bird, et al (2000). While Bird, et. al (200) reported that savannah burning in south western Zimbabwe resulted in decline of organic matter level in the 0-5cm soil layer, Ogundele, et. al (2012) observed that charcoal production reduces soil chemical properties in kiln sites in Ibarapa area of south western Nigeria.

Table 4: Variations in Soil Properties with Distance from the Mounds

Distance from mounds (m)	% Nitrogen			% Organic Carbon			% Organic Matter			Ca++ (mol/kg)			Mg++ (mol/kg)			Na++ (mol/kg)			K++ (mol/kg)			Available Phosphorus (mol/kg)		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
1.	0.025	0.040	0.01	0.77	0.33	0.4	1.34	1.07	1.31	0.75	1.21	0.97	1.42	1.05	1.27	0.013	0.128	0.121	0.051	0.138	0.077	0.36	0.60	0.41
2.	0.53	0.69	0.097	0.79	1.04	0.93	2.05	2.31	1.39	1.30	1.96	1.01	0.172	0.212	0.152	1.75	0.212	0.152	0.115	0.141	0.129	1.98	2.02	0.76
3.	0.114	0.113	0.106	2.30	2.36	3.38	3.79	3.94	3.38	2.80	2.78	3.11	2.14	3.01	2.69	0.209	0.297	0.152	0.153	0.166	0.196	2.75	3.86	2.44
4.	0.170	0.140	0.013	2.31	2.37	2.0	4.11	3.96	2.00	3.30	3.25	3.68	2.77	3.52	3.01	0.217	0.382	0.343	0.153	0.184	2.30	2.79	3.97	3.40
5.	0.171	0.138	0.112	2.63	2.74	2.3	4.67	3.99	4.16	3.7	3.71	3.71	3.49	3.93	3.23	0.239	0.306	0.383	0.192	0.217	0.250	2.79	4.27	3.78
6.	0.183	0.137	0.920	2.90	2.70	2.52	4.68	4.09	4.16	3.60	3.75	3.88	3.60	3.91	3.46	0.256	0.317	0.385	0.194	0.205	0.256	2.92	4.42	4.20
7.	0.79	-	-	2.93	-	-	5.0	-	-	4.2	-	-	3.64	-	-	0.259	-	-	0.223	-	-	3.47	-	-
8.	0.21	-	-	2.93	-	-	5.01	-	-	4.2	-	-	3.7	-	-	0.304		-	0.243	-	-	0.80	-	-

Key

I.	Oloro Ile	K++	=	ml/100g (Milli-Equivalent per 100 grams of soil)
II.	Ilupeju	Ca++	=	ml/100g (Milli-Equivalent per 100 grams of soil)
III.	Ile-Pupa	Mg++	=	ml/100g (Milli-Equivalent per 100 grams of soil)
		Na++	=	ml/100g (Milli-Equivalent per 100 grams of soil)
		P	=	lig/g (Microgram/grams)

Andriesse and Schelhass (1987) observed that, the effect of soil temperature on chemical composition of soil is not the same for all climatic regions. According to them different result may be obtained in humid rainforest climate where the temperature may not be sufficiently high enough to thermally decomposed soil organic matter.

Reasons that can be adduced for the present result may not be unconnected with the fact that data analyzed in the study were collected during the dry season when there was no rain to leach the nutrients into the soil. Not only that, though charcoal production releases some nutrients to the soil, such nutrients according to Kleinman et al (1995) may only short-lived. Another reason for the pattern of result obtained in the study may be due to process of site shifting which is caused by inaccessibility to wood materials needed for good quality product. Charcoal producers usually migrate from one place to another in search of good wood materials. This is because Nigeria forest is free frost which is not under any strict control. The fact that charcoal production at the study sites may have only began of recent may have accounted for the observed pattern.

Conclusion and Recommendations

Charcoal production and usage is fast gaining popularity in Nigeria first as in other developing countries of the world. Its increasing usage as source of fuel in most nations is due to non-affordability and unavailability of alternative sources of energy such as modern fuel, electricity and gas supply. Charcoal production thus remains a major source of employment generation to millions of people in these parts of the world. Despite the importance of charcoal in generating income and in meeting the energy requirement of the people, its production and usage has been observed to have several environmental impacts. Production of charcoal has been linked to deforestation activities, environmental degradation and modification and destruction of soil natural resources. Effect of charcoal production on the soil however varies with climatic zone, season of the year, when charcoal production took place and period of time over which burning of vegetation biomass has been taking place. Charcoal production through modification of soil properties at kiln sites can aid in developing human-induced spatial heterogeneity of soil within a geographical region.

Based on the findings from this research and given the increasing demand for charcoal due to unaffordability and in availability of alternative sources of energy, the following recommendations are thus put forward towards ensuring a sustainable environment as charcoal production cannot be completely stopped.

i. government through its various agencies should facilitate availability and affordability of alternative energy sources, especially kerosene and gas.
ii. help in providing charcoal producers with a range of suitable technical methods that are friendly to the environment from which to choose, rather than the mound method being currently used in the study area.
iii. develop seedlings of fast growing tree species and encourage the charcoal producers to replant such for every tree fell.
iv. train charcoal producers on sustainability use of trees and the right felling principle of tree cutting at 45 degree angle, 15cm above the ground.
v. enforce Nigeria energy policy on fuel wood, forestry and environment.

References

Adelekan, I.O. and Jerome, A.T (2006) Dynamics of Household Energy Consumption in a Traditional African City, Ibadan. *Environment 26:* 99-100.

Agyeman, K.O. Amponsah, O., Brimah, J. and Lurumuah, S. (2012). Commercial Charcoal Production and Sustainable Development of the Upper Western Region, Ghana. *Journal of Sustainable Development in Africa.* 5(4) 17-25

Amous, S. (2000) Review of Wood Energy Report from ACP African Countries. *EC-FAO Partnership Programme Working Document Report.*

Andriesse, J.P and Schelhaas, R.M. (1987) A Monitoring Study on Nutrient Cycles in Soils used in Shifting Cultivation under Various Climatic Conditions in Tropical Asia.

Ecosystem & Environmentalist 19:311-322

Babalola, F.D and Opii, E.E. (2013) Charcoal Versus other Domestic Cooking Fuels: Survey of Factors Influencing Consumption in Selected Household of Benue State, Nigeria. *Journal of Sustainable Development in Africa* 15 (4) 25-37

Barnes, D.F., Krutilla, K., Hyde, W. (2002) The Urban Energy Transition: Energy Poverty and the Environment in Developing World. *World Bank Report* Washington, DC.

Bird, M.I., Veenendal, E.M., Moyo, C., Lloyd, J. and Frost, P. (2000) Effects of Fire and Soil Texture on Carbon in a Sub Humid Savannah of Zimbabwe *Geoderma* 94:71-90.

Bouyoucos, G.J. (1962) Hydrometer Method Improved for Making Particle Size Analysis for Making Particle Size Analysis of Soil. *Agronomy Journal* 54:464-465.

De Bano, L.F (1990) Effect of Fire on Soil Properties. Paper Presented at the *Symposium on Management and Productivity of Western-Montane Forest Soils,* Bosie, Idaho.

Douglasm E.M. (1997) Charcoal Production and Environmental Degradation in Developing Countries. *The Environmentalist* 7(1): 68-75

Emmanuel, N.C. and Davison J.G. (2013) The Environmental Impacts of Charcoal Production in Tropical Ecosystems of the World: A Synthesis. *Journal of Energy for Sustainable Development.* 17(2): 85-94

Fontodji, F., Mawussi, G., Nuto, Y and Kokou, K. (2009) Effects of Charcoal Production on Soil Biodiversity and Soil Physical and Chemical Properties in Togo. *International Journal of Biological and Chemical Sciences* 3: 870-879

Giardina, C.P., Sanford, R.L. and Dockersmith, I.C. (2000) Changes in Soil Phosphorous and Nitrogen during Slash and Burning Clear of a Dry Tropical Forest *Soil Science Society of America Journal* 64: 339-405.

International Energy Agency (2002). World Energy Outlook. *International Energy Agency Report*

Ijatuyi, O.A. (2005) Trees as Forest Resources: Their Conservation, Efficiency and Effectiveness in Environmental Sustainability. *International Journal of Environmental Issues* 3 (2): 175-183.

Iroye, K.A (2010) Deforestation and Sustainable Watershed Management in Nigeria: A Reflection. *Journal of Environmental Issues* 3 (1): 74-81.

Iroye, K.A (2008) Effects of Landscape and Climatic Parameters on Basin Management in Ilorin, Kwara State Nigeria. *Unpublished Ph.D Thesis* University of Ilorin.

Kettering, C.K (2000) Effects of Severe Burning on Soil Texture and Mineralogy Lawrence, D and Schelesinger, W.H (2001) Changes in Soil Phosphorous. During 200 years of Shifting Cultivation in Indonesia. *Ecology* 82:2769-2780.

Maidment, D.R (1993) *Handbook of Hydrology*, Mc Graw-Hill Inc.

M.E.A (2005) Timber; Fuel and Fiber. In Ecosystems and Human Well Being. Hassan, and Ash, N. (eds.) Washington Dc, 243-269.

Odunawo, S. and Adeyemi, M. (1997) Story of Illegal Wood Business. *The Guardian Newspaper* July 26th, 17-18pp.

Ogundele, A.T. (2009) Effects of Charcoal Production on Soil Properties in Ibarapa East Local Government of Oyo State Nigeria. *Unpublished M.Sc Dissertation*, University of Ibadan.

Ogundele, A.T., Oladipo, O.S., Aweto, A.O. (2012) Effects of Charcoal Production on Soil in Klin Sites in Ibarapa Area, South Western Nigeria. *Ethiopian Journal Studies and Management* 5(3) 296-304

Oguntunde, P.G; Abiodun, B.J., Ajayi, A.E. and Van de Giesen, N. (2008) Effects of Charcoal Production on Soil Physical Properties in Ghana. *Journal of Plant Nutrition and Soil Science* (7) 591-596.

Olanrewaju R.M. and Ogunleye C.(1999). *"Women and Environmental Degradation"* in H.I. Jimoh and I.P Ifabiyi (eds), Contemporary Issues in Environmental Studies, Haytee press and Publishing Co. Ltd, Ilorin. pp148 – 157.

Olanrewaju, R.M. (2004). The Role of Rural Women in Environmental Modification: Food Processing Perspective. *Gender Discourse, (A Journal of the University of Ilorin Women Academics* (1) 124-184.

Otegbeye, G.O. and Oyeanusi, A.E. (2006 The Impacts of Reforestation on Soil Erosion and Economic Life of Nigerians In: Ivbijaro, M.F.A; Akinola, F. and Okechukwu, R.U (eds.) *Sustainable Environmental Management in Nigeria* Mattivi Publishers, Ibadan 465pp.

Oriola, E. and Omofoyewa, O. (2013). Impact of Charcoal Production on Nutrients of Soil under Woodland Savannah Parts of Oyo State, Nigeria.*Journal of Environment and Earth Science.* 3(3): 46-53

Smith, K. (1996) *Environmental Hazards: Assessing Risks and Reducing Disaster*. Routledge, London and New York 387 pp.

Steiner, C, Glaser, B., Teixeira, W.G., Lehamann, J. Blum, W.E.H and Zech, W. (2008) Nitrogen Retention and Plant Uptake on the Highly Weathered Central Amazonian Ferralsol Amended with Compost and Charcoal *Tropical Science*.

Tunde, A.M., Adeleke, E.A. and Adeniyi, E.E. (2013). Impact of Charcoal Production on the Sustainable Development of Asa Local Government Area, Kwara State Nigeria. *African Research Review.* 7(2): 1-15

Tilakasiri, S. L. Raheem, U.A and Olanrewaju, R.M (2012) *Environment and Development: Sustainable Development in Perspective* in H. M Bandara et al(eds). Issues in Development,Stamford Lake(Pvt) Ltd, Sri Lanka. 105-129

Uroko, C. (2011) Rising Global Demand Fuels Charcoal. *Business Day* September,2011.http;//www.businessdayonline.com NG/Index (Retrieved 12/17/2014)

Uvarov, A.U (2003) Effect of Smoke Emissions from a Charcoal Klin on the Functioning of Forest Soil Systems: A Microcosm Study. *Environ Moint Assess* 60: 337-357.

Walkley, A. and Black, I.A (1934) An Examination of the Detjareff Methods for Determining Soil Organic Matter and a Proposed Modification to the Chromic Acid Titration Method. Soil Science 37:29-38.

Wurster, K.W. (2010) Management Matter? Effects of Charcoal Production Management on Woodland Regeneration in Senegal *Unpublished Ph.D.* Thesis, University of Maryland.

Yakubu, A.A and Zagga, A.D. (2006) Use of Fuel Wood and Health Hazards in Sokoto City, Nigeria. *International Journal of Environmental Issues* 4 (1 and 2): 200-25