Journal of Soil Science and Environmental Management Vol. 2(5), pp. 142-146, May 2011
Available online at http://www.academicjournals.org/JSSEM
ISSN 2141-2391 ©2011 Academic Journals

Full Length Research Paper

Assessment of impacts of charcoal production on soil properties in the derived savanna, Oyo state, Nigeria

Ogundele A. T.[1]*, Eludoyin O. S.[2] and Oladapo O. S.[1]

[1]Department of Geography, Emmanuel Alayande College of Education, Oyo, Lanlate Campus, Lanlate, Oyo State, Nigeria.
[2]Department of Geography and Environmental Management, University of Port Harcourt, Port Harcourt, Nigeria.

Accepted 16 May, 2011

This study evaluated the impacts of charcoal production on soil properties in the derived savanna zone of South Western, Nigeria. Ten soil samples were collected randomly at the depth of 0 to10 cm in each of the charcoal production sites (CPS) and adjacent field sites (AFS) which is the control site. All soil samples collected were subjected to laboratory analysis for soil pH, particle size composition, available phosphorus, organic carbon, total nitrogen, exchangeable potassium, calcium, sodium, magnesium, cation exchangeable capacity and base saturation. The mean of each of these soil properties was used for comparison and t-test was also used to determine the significant difference that exists in each soil property. The results of the analysis showed that the soils are texturally similar at both the CPS and AFS sites. The soil pH under CPS is 6.75 while it is 5.96 under AFS. The mean of the available phosphorous under CPS is 11.21 ppm while it is 2.07 ppm under AFS. The analysis reveals a slight increase in exchangeable calcium, sodium, magnesium, total nitrogen, organic carbon and base saturation contents of the soil in CPS while the amount of cation exchange capacity decreases in CPS with the mean value of 2.32 meq/100 g than the AFS with the mean value of 2.37 me/100 g. It is therefore recommended among others that there should be awareness to consider the age of trees, species and biomass before trees are cut down for charcoal production.

Key words: Charcoal production, soil properties, assessment, derived savanna, Ibarapa East, Nigeria.

INTRODUCTION

In his quest to survive, man has learnt to explore the uses to which resources within his environment can be put. This has culminated in activities such as agriculture, construction, transportation as well as burning of fuel wood to obtain charcoal. Over the years charcoal has been an important domestic product and regardless of how it is produced, its marketability has gained global acceptance.

Rensselear (1995) posited that the value of the charcoal market for 26 sub-Saharan African countries for which there is known data exceeded $1.8 billion per year In energy terms, therefore charcoal consumption is higher than gross electricity consumption. Its production provides a considerable amount of employment in rural areas and allows for a quick return on investments and is often practiced in conjunction with agriculture. Delmas et al. (1991) affirmed that total fuel wood (including charcoal) burnt in tropical Africa is estimated at 230 million tons (dry matter) per year and the amount of charcoal consumed is about 11 million tons. FAO (1995) posited that global production of fuel wood and charcoal increased from 1362.4 million m^3 in 1970 to 1875.9 million m^3 in 1993. This increase especially in tropical Africa is as a result of the fact that most rural dwellers consider charcoal production as supplement of their traditional agricultural occupation, this coupled with the fact that charcoal making provides for a quick return on investment and the raw materials mainly trees or wood

*Corresponding author. E-mail: tundeeludoyin@gmail.com.

are readily available makes it a lucrative business hence a source of income for the people. The production of charcoal is so great that Coomes and Burt (2001) considered charcoal as a valuable cash product in most developing countries.

Despite the economic benefits of charcoal production, much concern has been expressed towards the consequences that follow its production. Allen and Barnes (1985) said about 7.5 million hectares of closed forest and 3.8 million hectares of African forests are cleared yearly for a variety of purposes ranging from timber production, construction purposes, agriculture as well as charcoal production. It is therefore predicted that if the present trend continues the tropical rainforest could completely disappear by the year 2020 due to deforestation induced by fuel wood, charcoal production and conversion of forest to other uses. Taking into consideration the poverty level of the developing nations, occasioned by unemployment and low per capita income, charcoal production has become a mean of livelihood. Hence, many rural dwellers in tropical Africa have taken to charcoal production at alarming proportion as their means of economic survival. Akinbami (2003) even revealed that more than 60% of Nigerian population relied on fuelwood and charcoal as the main energy sources for cooking as a result of extreme high poverty rate in the country. As charcoal production continues, much debate has been generated as whether the economic benefits of charcoal production worth the environmental consequences that trail its production, which include deforestation as a result of cutting down of trees for charcoal production, accumulation of greenhouse gases in the atmosphere due to burning of trees for charcoal and its consequential effects on global energy balance and climate change. Some studies have been carried out in some parts of the world on the effects of charcoal production on soil. A study carried out by Oguntunde et al. (2004) in Ghana observed a significant increase in soil pH, base saturation, electrical conductivity, exchangeable Ca, Mg, K, Na, and available P in the soil at a kiln site as compared to the adjacent soil. Giller (2001) noted that charcoal additions not only affect microbial population and activity in soil, but also plant-microbe interaction through their effects on nutrient availability and modification of habitat. Chidumayo (1991) compared the chemical composition of charcoal made from Miombo woodland and Savanna woodland and concluded that the content of nitrogen, ash and carbon increased from 0.06, 2.7 and 47% respectively in wood to 0.6, 7.7 and 72% in charcoal. The environmental impacts of charcoal production in the derived savanna of South Western Nigeria are felt among the fragile environmental resources in which soil quality is not in exception. Focusing on the impacts of charcoal production would be of immense importance to managing both the trees and soil in the study area specifically and tropical region in general. The study therefore evaluates the impacts of charcoal productions on soil properties at the kiln sites where charcoal production is being carried out in the derived savanna region of South Western Nigeria.

MATERIALS AND METHODS

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 km^2 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. The parent materials are mainly schist and quartzite, hence the main soil consist of brown sandy loams overlaying red brown sandy clay. The red colour and clay composition of the soil are products of the weathered schist. Quartzite stones are also prominent on the surface as well as in the soil profile. The major occupation of the people is farming. Substantial parts of the region offer a variety of opportunity for farming especially in the area with vast expanse of plain fertile land. Other occupations include metal smelting; cloth weaving and trading which is enhanced by presence of big markets such as Maya and Towobowo. Charcoal productions in large scale have been on the increase, most of the charcoals produced are taken to urban centers for sale while smaller proportion is used locally. The local government area has more than one hundred charcoal depots where charcoal produced is stored temporally before being sold or evacuated to consumption centers.

Soil sampling

Two plots of charcoal production sites (CPS) and the adjacent field sites (AFS) which serve as the control plots (plots of land that have not been subjected to charcoal production) were selected for the study (Figure 1) and that the distance between both CPS and AFS is about 100 km apart. Soil samples were collected randomly from ten sampling points in each of the area of the CPS and AFS. Both plots are within the same climatic region, relief, parent material and soil types. This makes comparison of soil properties between the two land use types possible. Thus any difference observed between the soils under charcoal production 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 to10 cm depth which is referred to as topsoil. This depth was taken

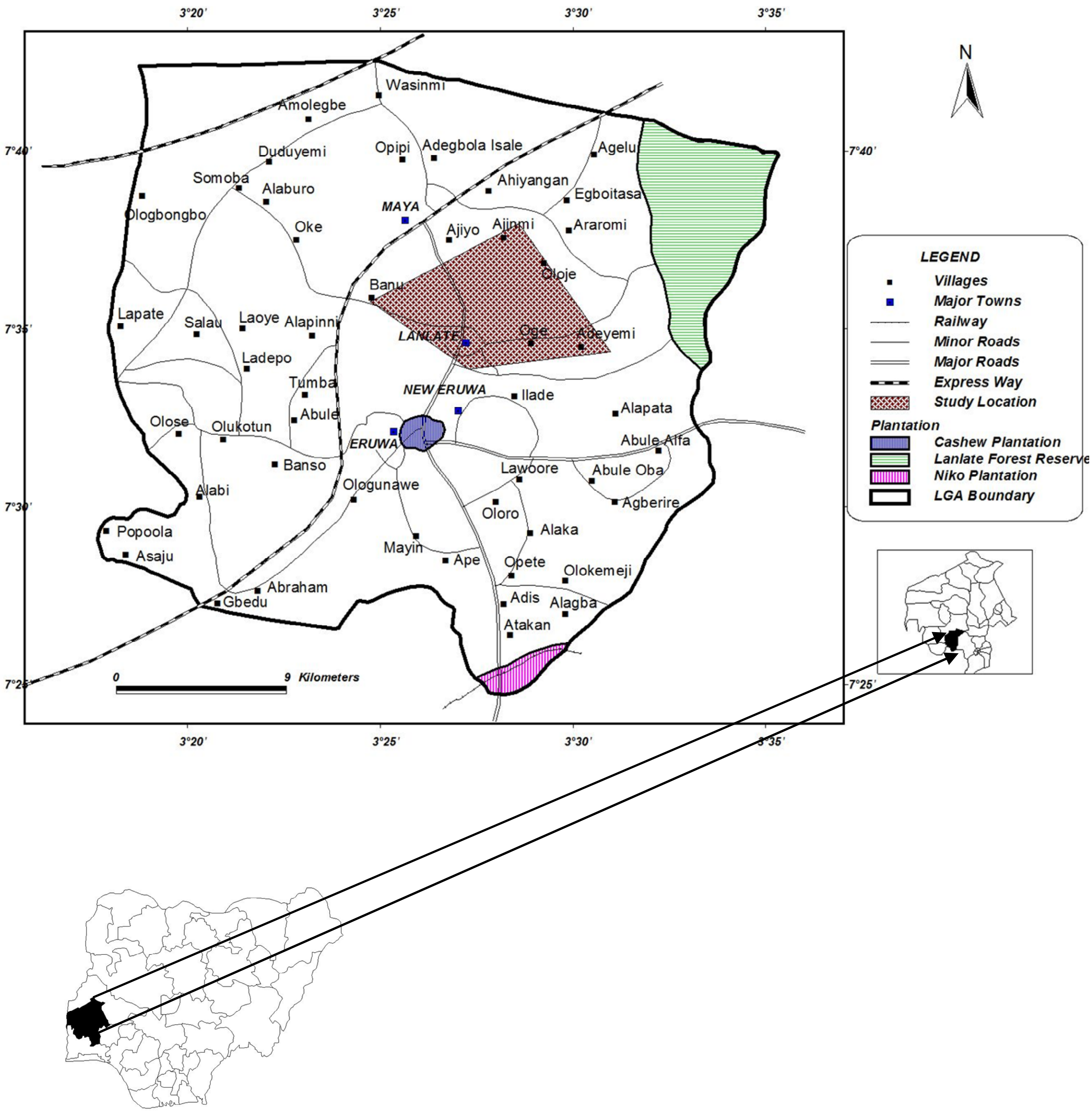

Figure 1. Map of Ibarapa East Local Government Area (IELGA) showing the study location.

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 and packed well into well labeled 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),

Table 1. Properties of soil under both CPS and AFS.

Soil property	CPS Mean ± S.D.*	AFS Mean ± S.D.*	Calculated Students' t-test
Sand (%)	83.82 ± 5.29	84.82 ± 4.67	0.43 NS
Silt (%)	7.60 ± 3.19	7.20 ± 2.74	0.43 NS
Clay (%)	8.58 ± 4.07	7.98 ± 2.78	0.31 NS
Soil pH	6.75 ± 0.53	5.96 ± 0.48	4.71**
Organic carbon (%)	1.58 ± 0.54	1.46 ± 0.42	0.57 NS
Total nitrogen (%)	0.35 ± 0.14	0.34 ± 0.11	0.30 NS
Available phosphorous (mg kg^{-1})	11.21 ± 7.73	2.07 ± 0.56	3.81**
Exchangeable calcium (meq/100g)	1.32 ± 0.06	1.28 ± 0.19	0.69 NS
Exchangeable potassium (meq/100 g)	0.13 ± 0.01	0.13 ± 0.01	0.17 NS
Exchangeable magnesium (meq/100 g)	0.56 ± 0.06	0.55 ± 0.04	0.28 NS
Exchangeable sodium (meq/100 g)	0.16 ± 0.25	0.08 ± 0.00	2.23 NS
Cation exchange capacity (meq/100 g)	2.32 ± 0.14	2.37 ± 0.27	0.57 NS
Base saturation (%)	89.75 ± 3.05	86.08 ± 4.61	1.95 NS

S.D*.Standard deviation, **: Significant under 5% confidence level, NS: Not Significant.

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 CPS and AFS were determined. The t-test technique was used to infer whether there are significant differences in the properties of soil between the CPS and AFS.

RESULTS AND DISCUSSION

The result of the analysis shows that the particle size composition of soils in both CPS and AFS was similar (Table 1). However, the amount of sand in the CPS was slightly lowered compared with the AFS; this is unlike the contents of silt and clay that recorded a slight increase at the CPS. The similarity in the values may probably be due to the formation of the soil the same parent material. The difference in sand, silt and clay content of the soil in both CPS and AFS are not statistically significant at 5% confidence level. The mean of soil pH was higher in the charcoal production sites than in the adjacent field sites. From this result, it can be inferred that the soils under charcoal production had a slight increase in soil pH compared with the control sites (AFS) which have not been subjected to charcoal production. This may be as a result of ash generated during charcoal production which raised the pH of the soil. Similar results had been observed in the topsoil of kiln sites by Oguntunde et al. (2004). It is also shown that there was significant difference in the mean values of soil pH of both sites under consideration at 5% confidence level. However, it is revealed that the mean organic carbon in the CPS showed a slight increase over the adjacent field sites. At 5% confidence level the values are not statistically different (Table 1). The mean nitrogen values for the CPS and the AFS were similar. Consistent burning in the study area may probably account for the low nitrogen content recorded in soils of the two sites. On the other hand, there was increase of available phosphorus in the charcoal production sites with a mean of 11.21 mg kg^{-1} over the adjacent field sites with a mean of 2.07 mg kg^{-1} (Table 1). The result of the t-test showed that there was a significant difference in the mean values at 5% confidence level of phosphorus in CPS and AFS. The phosphorus content of the soil was higher at the charcoal production sites because of the ash deposit in the soil after burning of wood for charcoal production. Increase in the level of phosphorus at the kiln sites was also recorded by Oguntunde et al. (2004). The mean values of exchangeable calcium at the CPS and AFS were similar. Slight increase in the amount of calcium at the CPS is as a result of nutrients addition from ash deposited during the burning of wood for charcoal. It has been observed that ash deposit increases the calcium and phosphorus contents of soil. The analysis also shows that exchangeable potassium in the CPS and AFS were similar and low (Table 1). The low exchangeable potassium can be attributed to low level of potassium in the trees burnt for charcoal. Apart from this, Brady and Weil (2008) concluded that high amount of quartz sand in soil as observed in the study area may also lead to decrease in amount of exchangeable potassium. The amount of magnesium in both sites is generally low and similar also, the mean values are not significantly different at 5% confidence level. Though, the concentration of exchangeable sodium was low in the soils at both sites but the mean amount of exchangeable sodium in the CPS doubles that of the AFS (Table 1). The implication of this is that charcoal generally increases the sodium content of the soil. In another development, the obtained values for cation exchangeable capacity in both the CPS and the AFS were similar but it was slightly lower in the AFS than CPS. The analysis also reveals that the mean of base saturation at the CPS was higher than that of the AFS.

In a nutshell, with exception of soil pH and available phosphorus which were significantly different at 5% confidence level in both CPS and AFS, all other soil properties under these plots are not and the probable reasons for this may relate to the methods of charcoal production employed, species of wood burnt, time frame between burning of woods and collection of soil samples, amount of wood burnt, and ecological factors especially climate. Another important factor may be due to the parent materials over which the soil is formed as quartz is known to be poor in exchangeable bases.

Conclusion

It can be concluded from the study that charcoal production has progressively affected some soil properties which included calcium, magnesium, sodium and base saturation; yet organic carbon, nitrogen and potassium were not significantly affected. It is therefore recommended that there should be further research to evaluate the influence of climate, soil characteristics, duration of time between charcoal burning and collection of soil samples, and chemical composition of wood species on the effects that charcoal production has on soil properties.

REFERENCES

Allen J, Barnes, DF (1985). The Causes of Deforestation in Developing Countries. J. Am. Geogr., 7: 2.

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.

Brady NC, Weil RR (2008). The Nature and Properties of Soils. Singapore. 14th ed., Prentice Hall, Upper Saddle River, NJ, p. 975.

Chidumayo EN (1991). Woody Biomass Structure and Utilization for Charcoal Production in Zambian Miombo wood land. Bio-resour. Technol., 37: 43-52.

Coomes OT, Burt GJ (2001). Peasant Charcoal Production in the PeruvianAmazon. Rainforest Use and Economic Reliance. Ecol Manage., 140: 39-50.

Delmas RA, Loudjaani P, Podaire A, Menaut JC (1991). Biomass Burning in Africa: An Assessment of Annually Burned Biomass. In Global Biomass Burning: Atmospheric, Climatic and Biospheric Implication, Ed., Levine, J.S.. Massachusets, Cambridge MIT Press, pp. 126-132.

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.

FAO (1995). Forest resources assessment 1990: Tropical forest plantation resources. FAO For. Pap., 128: 81.

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

Giller KE (2001). Nitrogen Fixation in Tropical Cropping Systems. 2nd Edition CAB International Wallingford, p. 423.

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.

National Bureau of Statistics (2006). Legal Notice on Publication of the Details of the Breakdown of the National and State Provisional Totals 2006 Census. p. 10

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.

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

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.