

Impact of Charcoal Production on Nutrients of Soils under Woodland Savanna Part of Oyo State, Nigeria.

Emmanuel Oriola (Ph.D)* and Olayiwola Omofoyewa.
Department of Geography and Environmental Management,
University of Ilorin,Ilorin, Nigeria.
E-mail: lolaoriola@gmail.com
* Corresponding Author

Absract

This study examines the consequences of charcoal production on soil nutrients in woodland savanna vegetation. Forty soil samples were collected from charcoal production site and adjacent fallow land at 0-20cm depth for analysis and comparison. Essential soil parameters were analyzed using standard laboratory analytical procedures. Coefficient of variation and student "t' test analysis were used to summarize and draw inferences from the results. The results show that most of the soil properties analyzed are generally homogeneous except those of silt and phosphorous in both sampled sites and total Nitrogen of the Fallow land. The 't' test result revealed that the mean values of all analysed soil properties in charcoal production environment are significantly different from those of the fallow land except sand Silt and Total Nitrogen. This suggests that charcoal production effect some changes in the values of these soil properties. The changes reflect an increase in the values of these parameters, it then implies that charcoal material can serve as soil amendment apparatus in this ecological zone. The study therefore recommends that selective tree harvesting and aggressive wood plantation should be rigorously pursued. This will in fact generate employment at local level.

Key words: soil nutrient, charcoal production, woodland, savanna, soil properties

1. Introduction

Charcoal production and demand are on the increase in developing countries and international market respectively. However, the production and use of charcoal have greatly degraded the physical environment. Aside from loss of woodland and accompanied change in potential terrestrial carbon sequestration and ecosystem benefit, it also facilitates climate change and global warming which modifies soil nutrient status, where charcoal production is widespread. Most rural dwellers in Tropical Africa 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 are readily available, hence a source of income for the people(Ogundele et al, 2011). Uroko (2011) reported that in Oyo State, about 40 containers of charcoal are sold per month at the rate of N450, 000 per container.

Charcoal greatest use is for home and outdoor recreational cooking and more importantly, when Kerosene is not readily available as observed by Adelakun and Jerome (2006). The use of charcoal has made it more commercialized and the nature of charcoal markets typically lead to greater woodland exploitation than fuel wood (Ribot 1993). For example, Uroko also reported that Britain currently imports 60,000 tonnes of charcoal every year. To meet this demand, over 11,000tons was estimated to be exported in a year by one exporter and in a community in Oyo State, up to 400 trees are cut down on a daily basis (Uroko, 2011) According to Martin (1991), the contribution of fuel wood and charcoal consumption to tree stock decline in Africa is believed to be significant. For instance, Food and Agriculture Organization in its 1990 forest assessment, reported that the world fuelwood and charcoal production has increased from1362.4million cubic meter in 1970 to 1875.9million cubic meters in 1993(F.A.O, 1995). Firewood and charcoal production induced deforestation occurs as a result of overpopulation and the demand for wood and charcoal as an energy source. Large scale deforestation may be the first of the major global changes that humans made to their biological and physical environment base on the fact that global forest area has fallen by approximately 50%. In Nigeria, over the last two decades, the rate of deforestation has grown considerably. Ibrahim (2005) reported that annual deforestation is estimated at about 400,000 hectares, compare to reforestation of about 1.043 hectares. His document also showed that average annual rate of deforestation grew from 0.7% in 1980/1990 to 0.9% in 1990/1995 and 2.6% in 1990/.2000. This actually accelerates the development of woodland savanna in this region. A woodland Savanna can be described as an area that was originally of forest characteristics but has been transformed into Savanna by Man's interference; lumbering, farming and grazing and favourable climatic condition (Alex, 2000). That is, the forest is opened up and woodland vegetation evolved.

The zone is covered by ferruginous tropical soil with high sandy surface horizon (Agboola, 1979). The soil is considered naturally fertile because of the climate and presence of trees. However, intensive cultivation and past use of fire to clear vegetation have led to the degradation of lands in general. Also, the degradation process is being accelerated by charcoal production. This has in turn led to a negative impact in the natural arrangement of the soil, the development and the environmental conditions under which the soil is formed the impact of charcoal production on the physiochemical properties of soil in woodland savanna can be traced to the heat generation during production and ash that always accompany the charcoal in the production site. It is therefore pertinent to examine the cumulative effect of charcoal production on soil properties particularly those that enhance its fertility, since more than 70% of the people living in this ecological zone are farmers and depend on soil for their livelihood.

2. Study Area

This study was carried out in Shaki-West Local Government Area (L.G.A) of Oyo State. Shaki is located at Oke-Ogun part of Oyo state on the Latitude $8^{0}41$ North and Longitude $30^{0}42$ East (fig.1). The Local Government Area is bounded in the North by Kwara state, in the East by Shaki East and Republic of Benin and Atisbo L.G.A are to the West and South respectively (fig. 2).

Saki-West local Government has a population of 350,000. It comprises 1,909 villages and eleven political wards with 103, 417 households. This area is basically an agrarian community where the people are living in rural villages and engaged in cultivating crops such as maize soybeans, cowpea, yam, sorghum, pigeon pea and others and livestock such as cattle, sheep, goat poultry and pigs (Kolajo, 2007). In other words, they are predominantly farmers. The area is open woodland vegetation similar to derived savanna ecological zone with two distinct seasons, wet and short dry seasons. The rainfall ranges between 1000mm and 1500mm with an average of 83 rainy days starting from the month of March to October and the dry season from the month of November to February, this period is characterized with the harmattan and high temperature during the day and very cold nights and temperature between 68^{0}F and $86\,^{0}$F (Alex,2000). Geological formation of Shaki is of basement complex rock (Kolajo, 2007) and the rocks are heavily faulted to form low inselbergs. The zone as reported by Agboola (1979) is covered by ferruginous tropical soil with high sandy surface horizon. The soil is considered naturally fertile because of the climate and presence of trees. However, intensive cultivation and past use of fire to clear vegetation have led to the degradation of lands in general. Also, there has been degradation due traditional management practices as reported by Agboola (1979).

3. Materials and Methods

Materials required for this study include settlement map of Shaki West LGA, Soil map of Oyo State, soil sample from charcoal production sites and adjacent fallow land with no antecedent of charcoal production.

Reconnaissance of the settlements where charcoal production is predominant occupation within Shaki West LGA was embarked upon, with a view to identify ideal sites for soil sample collection. A 5m x 5m quadrat was demarcated in each soil sample points, and 20 soil samples were collected from the production sites and another 20 soil samples from adjacent fallow land with no antecedent of a charcoal production at0-20cm depth this was in recognition of the observation of De Bano, (2000). Soil samples were taken excluding the ash released by the burnt biomass (Ogundele et al, 2011). The Soil was sampled in order to ensure similar soil properties for comparison (Oguntunde et al, 2004 and Ajayi, et al 2009). A total of 40 samples were collected and treated before laboratory analysis was embarked on. Important soil properties that directly aid nutrient status of soil as documented by Brady and Weil (1999) were analyzed. They include soil particle size distribution, total nitrogen, soil pH and organic matter, others are cation exchange capacity and phosphorous.

Particle size distribution was determined by Hydrometer Method (Reddy, 2002), Soil pH potentiometrically in distilled water ratio 1:1, Total Nitrogen by Micro-Kjeldahl digestion method (Bremna, 1965), Organic Matter through Chronic Digestion Method (Walkey and Black, 1934)and Exchangeable cations : Ca^{++}, Na^{+} and K^{+} by Atomic Absorption Spectrophotometer (Chapman, 1965) and Mg^{++} by Flame photometer, Available Phosphorous by Bray No1 Method (Olsen and Dean, 1965)and Cation Exchangeable Capacity by summation method.

Coefficient of variation and student "t' test analysis were used to summarize and draw inferences from the results respectively. The Coefficient of variation was used to test the homogeneity and variability of the soil nutrients while Student 't' test was employed to establish significant differences in the mean values of soil nutrients o the charcoal production sites and adjacent fallow land. The soil nutrient status under charcoal production was assessed in terms of the level organic matter and exchangeable bases.

4. Results and Discussion

The results revealed textural similarity in the charcoal and the fallow sites. The soil is predominantly loam sand with a higher proportion of sand in the fallow site. The soils exhibit a homogeneity in all the examined parameters of the charcoal production site except silt and phosphorous. A similar trend was seen in the fallow site, but total nitrogen is variable in this site (table 2). The similarity exhibited can be attributed to the pedogenesis similarity (Ogundele, et al 2012) and the fact that the soils are formed from the same geologic formation, with similar climatic condition and in the same environment. However, there are appreciable increase in the contents of soil pH, organic matter, calcium, magnesium and phosphorous in the charcoal production sites as reported in similar studies by Oguntunde et al, 2008 and Fontodji,et al 2009).

The results of the student 't' test however revealed significant differences in the mean values of the charcoal production site and the adjacent fallow site used as control (table 2). For instance, Glazer et al (2002) observed that calcium, magnesium and potassium contents were higher with hard wood than with conifer charcoal addition to soil. Moreover, charcoal production lead to a significant increase in the soil nutrients content of the soil in the production site, this reiterate that charcoal can be used as a soil amendment apparatus in woodland savanna where farming, burning and grazing over centuries have led to reduction in soil nutrient content.

5. Implications of Charcoal Production on Soil Properties

Soil is a highly complex and dynamic habitat for organisms, containing many different niches due to its incredibly high level of heterogeneity at all scales. On the micro scale, soil is often an aquatic habitat, as micro pores in soil are full of water at all times, apart from the very extreme drought due to the high water tension which exist there. This is vital for the survival of many microbial species which require the presence of water for mobility as well as to function. Indeed, many soil organisms specifically nematodes and micro organisms such as protozoa enter a state of cryptobiosis, whereby they enter a protective cyst form and all metabolism stop in the absence of water. When charcoal is produced with the require temperature for combustion, it leads to well drained soils, and consequently have negative effect on soil organism activity which may lead to concurrent decrease in soil functioning and the ecosystem services which it provides.

Although, if charcoal production sites receive rainfall after charcoal has been harvested, it implies that the biomass materials will turn to biochar for soil amendment which often cause a significant increase in microbial efficiency as a measure of units of Co_2 released per microbial biomass carbon in the soil as well as a significant increase in basal respiration (Steiner, et. al. 2008). It also implies that biochar can function as valuable component of the soil system, especially in fertilized agricultural systems. Nevertheless, there is experimental evidence that microbial communities are directly affected by the addition of biochar to soils.

For a sustainable environment and economic stability of the people, the study recommends selective tree harvesting and that aggressive wood plantation should be rigorously pursued by both government and non-governmental organization. This will generate employment and ensure sustainable livelihood for the people at local level.

6. Conclusion

This study observes increase in soil nutrients and organic matter as reported by Fontodji et al (2009) and Oguntunde et al (2008) in Ghana and Togo respectively. However it differs from the work of Ogundele et al (2012). This is likely be a result of differences in the latitudinal position and slight climatic differences between the two study areas, Ibarapa and Shaki and the areas being more humid and drier respectively.

This study further gives credence to scientific investigation as against the traditional believes and negative impression of soil reaction to heat and burning in tropical environment. It has also reaffirmed the necessity of scientific investigation for planning and decision making. In other words, extensive testing is needed before scientifically sound predictions can be made regarding the effects of charcoal production on soil properties. More importantly because more than 70% of the people living in this ecological zone are farmers and depend on soil for their livelihood.

References

Adelakun, I.O and Jerome, A.T (2006), Dynamics of Household Energy Consumption in a Traditional African City, Ibadan. *Environmentalist* 26, 99 – 110.

Agboola, S.A. (1979), *An Agricultural Atlas of Nigeria.* Oxford University Press.

Akintola, F.O. Aweto, A.O. Gbadegesin, A.S. Daura, M.M (1998): *Rural Energy Consumption Patterns and Deforestation in Nigeria.* A Publication of NISEP/SSCN. National Research Network on Liberalization Policies in Nigeria.

Alex, P (2000), *Savanna Climate* http://www.bleuplant biomes.org (retrieved on 24/05/2012)

Ajayi,A., Oguntunde, P, Abiodun, J and Moacir de Souza, D. jnr. (2009), Numerical Analysis of Impact of Charcaol Production on Soil Hydrological Behaviour, Run Off Response and Erosion Susceptibility. *Revista Brasileira de ciencia do Solo* 33(1)137-145

Brady, N.C. and Weil, R.R. (1999), *The Nature and properties of soil. (*12th Edition) Prentice Hall, New Jersey.

Bremmer, J.M. (1965), “Total Nitrogen” in Black, C. A. (eds) Methods of soil Analysis. *American Society of Agronomy Monograph,* 9, (2) 162-164.

Chapman, H.D. (1965), “Cation Exchange” in Black, C. A. (eds) *Methods of Soil Analysis .America soil of Agronomy Monograph,* 9(2) 891-901.

Comes, O. T and Burt, G .J. (2001), Peasant Charcoal Production in the Peruvian Amazon. Rainforest use and Economic Reliance. *Ecol Manage* 140: 39-50.

De Bano, L.F(2000), The Role of Fire and Sun Heating on water Repellance in Wildilfe Environments; A Review. *Journal of Hydrology* 231: 195-206.

F.A.O. (1995), Forest Resources Assessment 1990. Tropical Forest Plantation Resources. F.A.O. Forest Paper 128:81.

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, West Africa. *International Journal of Biology and Chemistry Science.*3(5):870-879

Glaser B, Guggenberger, G. and Zech, W (2002), Past Anthropogenic Influence on the Present Soil Properties of Anthropogenic Dark Earths (Terra Preta) in Amazonia (Brazil) *Geoarchealogy* 228.

Ibrahim, D.C (2005), The Role of Aforestation in Preserving the Environment of Bauchi State in Nigeria. International Journal of Environmental Issues 3(2):156-161. The Development Universal Consortia.

Kolajo, A.A. (2007), The History of Saki. Spectrum Books Ltd. Ibadan. Nigeria.

Martin, Claude. (1991), *The rainforests of West Africa : ecology, threats, conservation*. Basel; Boston : Birkhauser Verlag.

Ogundele, A. T. Eludoyin A.S. and Oladapo, O. S. (2011), Assessment of Impact of Charcoal Production on Soil Properties in the Derived Savanna, Oyo State, Nigeria. *Journal of Soil Science and Environmental Management* 2(5):142-146.

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

Oguntunde, P.G Fosu, M; Ajayi, A.E and Vande Giesen, N. (2004), Effects of charcoal production on maize yield, chemical properties and texture of soil. *Biology and Fertility of Soils.* 39. 295 – 299.

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.* 171, 591 – 596.

Olsen, S.R. and Dean, L.A. (1965), "Phosphorus" in Black, C.A. (eds) *Methods of soil Analysis. Amer. Soc. Agronomy Monograph,* 9 (2), 1035-1048.

Oriola, E.O & Bamidele, I.O (2012), Impact of Cropping Systems on Soil Properties in Derived Savanna Ecological Zone of Kwara State, Nigeria *Confluence Journal of Environmental Studies,* 7: 34-41 http://www.journalhome.com/cjes

Reddy, K.R. (2002), *Engineering Properties of Soils based on Laboratory Testing.* Department of Civil and Material Engineering, University of Illinois. Chicago (available at: www.uic.edu/classes/cemm/cemmlab/). Pp.1-159

Ribot, J.C. (1993), Forest policy and charcoal production in Senegal. En. Pol. 14;23-41.

Steiner C., Glaser B., Teixeira W.G., Lehmann J., Blum W.E.H. and Zech W.(2008), Nitrogen Retention and Plant Uptake on a Highly Weathered Central Amazonian Ferralsol amended with Compost and Charcoal. Journal of Plant Nutrition and Soil Science, 000, 1–7 DOI: 10.1002/jpln.200625199 .www.plant-soil.com

Tryon. E H. (1948), Effects of charcoal on Certain Physical, Chemical and Biological properties of forest. *Soils Eco. Monograph* 18: 81 – 115.

Uroko, C. (2011), Rising global demand fuels charcoal production. *Business Day, September 2011*http;//www.businessdayonline.com/NG/Index (retrieved 2/23/2012)

Walkley A, and Black IA (1934), An Examination of the Degtjareff Method for Determining Soil Organic matter and proposed Modification for the Chronic Acid Titration Method *Soil Sci*ence. 102: 275-277.

Table 1. Variability and Homogeneity of Soil Properties in Charcoal Production Site and Adjacent Fallow Land

Soil Parameters	Charcoal Production Site			Adjacent Fallow Land		
	Mean	S.D	C.V	Mean	S.D	C.V
Sand %	83.92	1.17	1.39	87.93	2038	2.71
Silt%	4.52	1.51	33.41*	4.59	1.75	38.13*
Clay%	11.56	1.03	9.36	7.48	1001	13.50
pH	6.01	0.27	4.49	5.91	0.48	8.21
Total Nitrogen %	1.82	0.39	21.43	1.78	1.50	84.27*
Organic Matter %	5.90	0.60	10.16	2.88	0.52	18.06
Exchange Calcium (Ca^{++}) cmol/kg	2.18	0.52	23.85	1.38	0.32	23.19
Exchange Magnesium (Mg^{++})cmol/kg	1.21	0.39	32.23	0.78	0.19	24.36
Exchange Sodium (N^{+})	1.85	0.28	15.14	2.65	0.28	10.57
Exchange Potassium (K^{+})cmol/kg	0.98	0.16	16.33	0.73	0.16	21.92
Available Phosphorous Mg/kg)	3.36	1.27	37.80*	0.94	0.32	34.04*
Cation Exchange Capacity	7.54	0.94	12.47	5.39	0.61	11.31

*Significant C.V > 33% S.D= Standard Deviation, C.V. = Coefficient of Variation.

Table 2. Result of Student "t" Test

Soil Properties	"t" value
Sand	-4.20
Silt	-0.93
Clay	9.00*
pH	4.04*
Total Nitrogen	-0.31
Organic Matter	14.00*
Exchange Sodium (Na^{+})	4.22*
Exchange Calcium (Ca^{++})	5.95*
Exchange Magnesium (Mg^{++})	2.41*
Exchange Potassium (K^{+})	4.22*
Available Phosphorous	10.13*
C.E.C	7.13*

*Significant at $p < 0.05$ $P > 2.10$

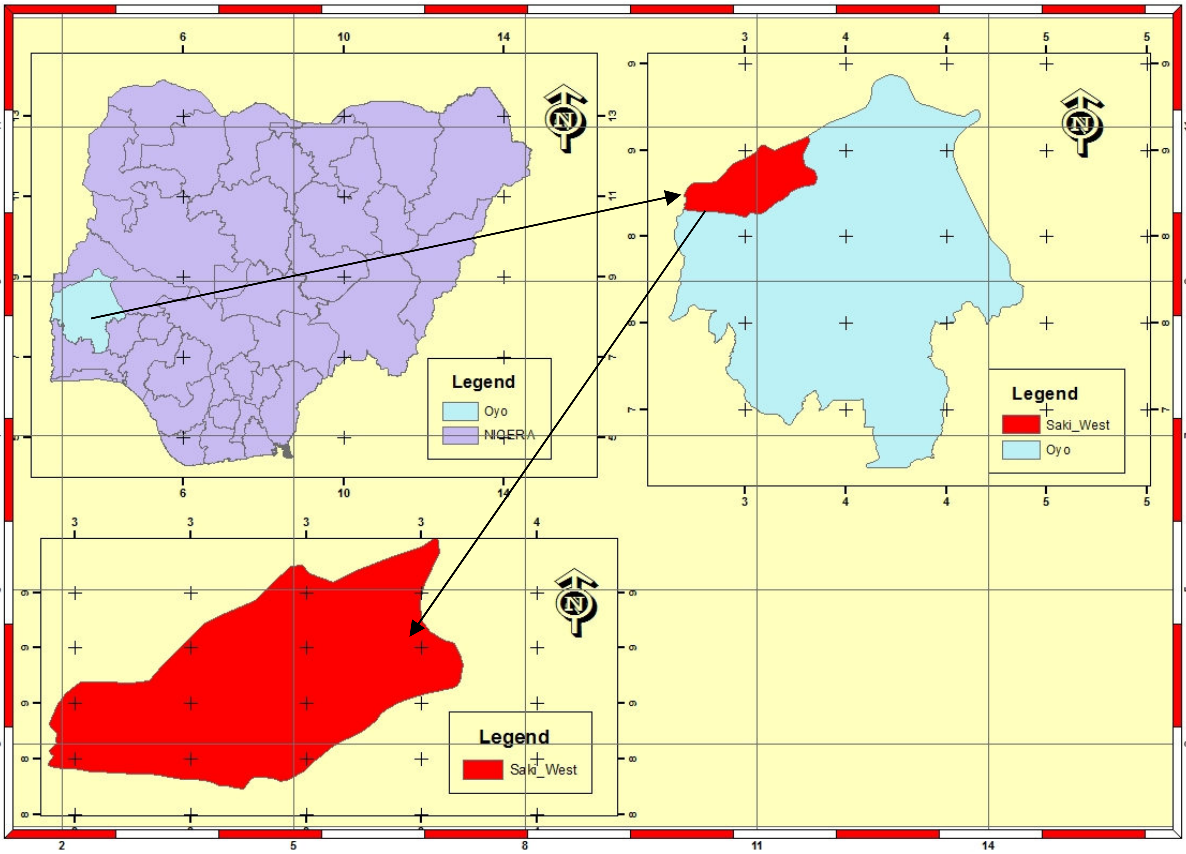

Fig 1. Map of the Study Area

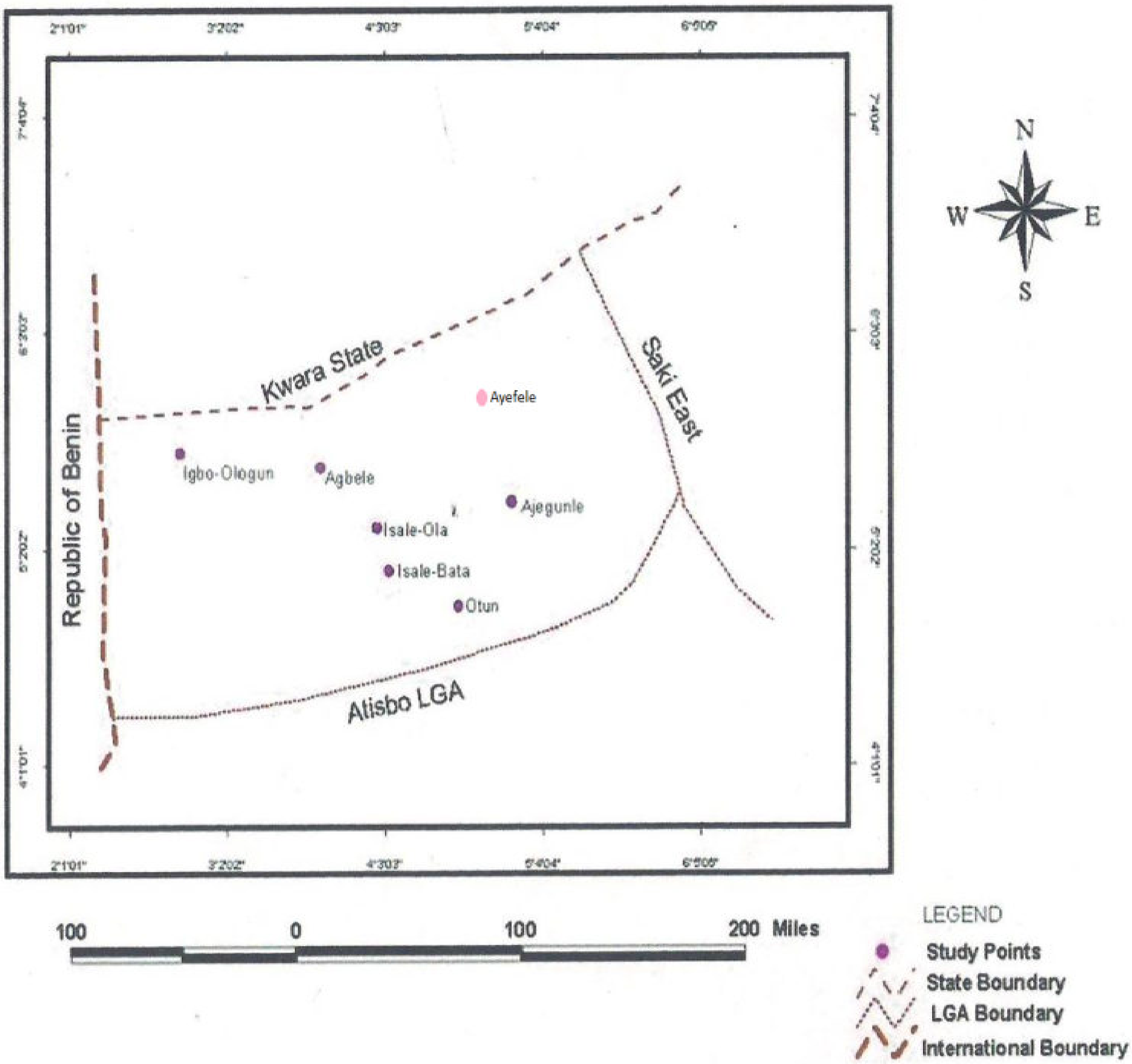

Figure 2. Soil Sample Locations in the Study Area.
Source: Adapted from Oyo State Ministry of Land and Housing, Ibadan.