Physiochemical Characteristics of Soils in Two Sacred Groves of Southwestern, Nigeria.

O. J. OYELOWO
Department of Forest Conservation and Protection
Forestry Research Institute of Nigeria, Ibadan, NIGERIA

A. M. ADURADOLA
Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta, NIGERIA

O. N. SULAIMAN
Department of Forest Technology
Federal College of Forestry, Ibadan, NIGERIA

Abstract: Forest soils consists of the mineral that has been deposited across the topography of the landscape, acted upon by both biotic and abiotic factors. This study assessed soil physical and chemical parameters of two sacred groves of southwestern Nigeria. Each of the 50 x 50m study sites was divided into twenty five 5 x 5m^2 quadrats. Ten out of the twenty five quadrats were randomly selected in each study site for sampling. Soil samples were collected (using soil auger) from the ten randomly selected quadrats at two depths: 0 - 15 and 15 - 30cm, in triplicates. Each set or the triplicate samples was bulked for each depth, enclosed in polybags and taken to the laboratory for analysis. The particle size distribution data showed that sand contents in the Igbo Ile and Igbo Oba sites were high, it ranged from 768 and 856gkg^{-1} and decreased with the depth of the profile. The general interpretation of pH ratings showed that soils from Igbo-Ile and Igbo-Oba are slightly alkaline (7.39, 7.38 & 7.30, 7.55) using at 0 - 15cm & 15 -30cm FFD, 2002 standard. There were significant differences in Available P in both scared groves at 0 – 15cm and 15-30cm, but no significant difference in both N and Organic matter in Igbo-Ile and Igbo-Oba within the two depths (0 – 15cm and 15-30cm). The value of C.E.C showed that there was significant difference between the sacred groves at the two depths (0 – 15cm and 15-30cm). There was significant difference in the K value in the two sacred groves (0–15cm) with significant difference in Igbo-Ile and Igbo-Oba sacred groves at 15-30cm depth. There was significant difference in Ca content in Igbo-Ile and Igbo-Oba at both 0-15cm and 15-30cm depth. The Mg value in Igbo-Ile sacred grove was significantly different from Igbo-Oba sacred grove at 0-15cm but with no significant difference at 15-30cm. The higher values of parameters recorded in the study areas showed that sacred groves are less disturbed as the total soil organic carbon and nitrogen stocks were higher in the soils under both forests which therefore means that forest soils are richer in nutrient.

Key Words: Soils, sacred grove, Igbo-Oba, Igbo-Ile, physical properties, chemical properties, depth, pH, organic carbon.

1. Introduction

Forest soils are comprised of the original geologic mineral substrate that has been deposited across the topography of the landscape, acted upon by various biotic organisms, and over time weathered by the climate conditions of the region. The most biologically active portion of any soil is near the surface, where the levels of oxygen and water are most conducive for plant root growth and microorganism activity. For this reason approximately 90% of all forest tree roots occur within the upper 6 inches of soil. The uppermost soil layer is most heavily influenced by the incorporation of organic matter – mostly from grass, forb and shrub fine root turnover and decomposition, but also the deposition of woody debris on the soil surface.

Soil is a reservoir of nutrients in one form or other and differs from the parent material and among themselves in the morphological, physical, chemical and biological properties (Ramachandra, 2006). It is the loose top layer of the earth’s crust composed of weathered rock, minerals and partly decayed organic matter. According to Alan Wild (1993), soil is responsible for anchoring the plants on to the earth’s surface, supplying it with water and nutrients required for its growth.

Soil physical properties include soil texture, structure, porosity, soil density, drainage and surface hydrology. These properties are very important in influencing what plants can grow on a site and how well they grow. The soil physical properties determine the ease of root penetration, the availability of water and the ease of water absorption by plants, the amount of oxygen and other gases in the soil, and the degree to which water moves both laterally and vertically through the soil.

The tropical forests may be broadly classified as moist or dry, and further subdivided into rainfall (some 66% of the total tropical moist forest), dry deciduous forest, mangrove forests, forest moist deciduous forests, evergreen seasonal forest (SCBD, 2002). The Nigeria tropical forest estate covers a total area of 9,041ha, which represents only 10% of the total land area. The trends in total forest cover within the last 20 years revealed a drastic decline in quantity mainly due to high deforestation rate. The forested ecosystem receives natural inputs of nutrients through atmospheric deposition and geologic weathering. Through the life of a stand, these inputs can be significant. In forest ecosystems, timber harvesting and some site preparation practices remove nutrients and have the potential to create deficiencies if the removal of nutrients through these practices is greater than the replenishment through natural processes during the time between harvests and the amount of nutrients removed from harvest. The direct causes of biodiversity loss in forest are human induced actions that directly destroy the forests or reduce their quality. The driving forces behind direct human impact on forest degradation and deforestation and, consequently, on biodiversity loss are both numerous and interdependent (Pimm *et al.*, 1995).

Nigeria’s rich rainforest ecosystems are indirectly and unknowingly protected through traditional spiritual belief and practices which form the foundation of traditional ecological knowledge. These forests (sacred groves) emerge as a tool for biodiversity conservation, they conserve large numbers of plant and animals species. The south-western Nigeria blessed with diverse of culture has enabled the people to protect their forests. These sacred groves scattered throughout the area have been protected for many years, hence the choice of the locations. The main objective of this study is to assess the physicochemical parameters of the soils from two sacred groves of southwestern Nigeria.

Keywords: Soil, sacred grove, physical properties, chemical properties, nutrients, soil texture

2. Materials and Methods

Description of the Study Area

The study area is part of the tropical rainforest ecosystem occurring in south west Nigeria (Fig. 1). It comprises the following Lagos, Ogun, Oyo, Osun, Ekiti and Ondo States. The ecological zone is a continuous belt around the world between Lat 24^{o}S and 24^{o}N and Longitude 10^{o}E and 20^{o}W. In south-west Nigeria, tropical rainforest begins a few kilometers in land along the coastal vegetation. It is 300km wide in its widest area (Okojie, 1994). There is a distinct dry and rainy seasons, having an average annual rainfall and temperature of 1489mm and 26.5ºC respectively.

Selection and Description of the Study Sites

Igbo-Ile sacred grove (7.9333333°N and 4.2°E) is located in Ibere village in Ogo Oluwa Local Government Area of Oyo State Nigeria. The people in the village are predominantly farmers. Igbo-Ile forest is where the community was first settled before they moved to the present location. Where the community first settled was protected against human activities and they started appeasing the spirit of the buried kings. Igbo-Ile is also a sacred place for king initiation during coronation. The following tree species are distributed to the grove: *Cola gigantea*, *Celtis zenkeri*, *Hildegardia barteri*, *Khaya grandifoliola*. *Steculia rhinopetala*, *Celtis brownie, Celtis mildbreadii*, *Diospyros monbuttensis, Terminalia ivorensis* and *Cola nitida* etc.

Igbo-Oba sacred grove (7^0 54'N and 4^0 35'E) is located in Oba Ile in Olorunda Local Government of Osun State, Nigeria. Oba-Ile is one of the most ancient towns in Yoruba Land according to history. The forest is being worshiped annually during annual festival where the king worships deities to prosper the town. Tree species in the grove include: *Trilepisium madagascariensis, Trichilia prieureana, Triplochiton scleroxylon, Albizia ferruginea*, *Blighia sapida*, *Memecylon afzelli*, *Hylodendron gabunense Blighia sapida*, *Chrysophyllum albidum* and *Celtis brownie* etc.

Fig 1: Map of South-western states, Nigeria, showing the location of the sacred groves with maps of Africa and Nigeria in inset

Collection of Soil Samples

Each of the 50 x 50m study sites was divided into twenty five 5 x 5m^2 quadrats. Ten out of the twenty five quadrats were randomly selected in each study site for sampling. Soil samples were collected (using soil auger) from the ten randomly selected quadrats at two depths: 0 - 15 and 15 - 30cm, in triplicates. Each set or the triplicate samples was bulked for each depth, enclosed in polybags and taken to the laboratory for analysis.

Laboratory analysis

The soil sampled were analyzed for particle size analysis using the hydrometer method as described by Bouyoucos (1957). Soil pH was determined in water and KCl using a pH meter with glass electrode (Mclean, 1982). Total N was determined by modified micro kjedhal digestion technique described by Jackson (1962). Organic carbon was determined by wet oxidation method of Walkey and Blacky (1934) which was modified by Allison (1965). Available P was extracted by Bray 1 method (Bray and Kutz, 1945) and total acidity was determined by titrimetry (IITA, 1979). Exchangeable bases was determined with one normal ammonium acetate buffered at pH 7, Sodium and potassium in the extract were determined by flame photometry while calcium and magnesium were determined by Atomic absorption Spectrophotometry (IITA, 1979). Effective cation exchange capacity was determined by summation method (Braize, 1998) of total exchangeable bases and total acidity.

3. Results

Soil physical properties

The physical properties of the soils were presented in Table (1). The particle size distribution data showed that sand contents in the Igbo Ile and Igbo Oba sites were high, it ranged from 768 and 856gkg^{-1} and decreased with the depth of the profile. The silt contents fall between 56 and 152gkg^{-1} and these values fluctuated irregularly down the profile in the two sites. The clay contents were low in all the soils. It ranged from 15 to 88gkg^{-1}, these values fluctuated irregularly down the depth in nearly in the two sites.

Available Phosphorus, Total Nitrogen, Organic Matter

Table (2) revealed that the value of P increased down the depth in Igbo-Ile and Igbo-Oba. The available P in the sacred groves ranged from 9.65 to 41.14mg kg^{-1} within 0-15cm depth while at 15 – 30cm depth, the values ranged from 21.34 to 41.14mg kg^{-1}, which is above the critical value range. The values of N was generally high in 0-15cm depth than 15-30cm, while the soil N decreased down the depth in two sacred groves. At 0 -15cm depth, the N values ranged from 3.00 to 3.50gkg^{-1} while the N values ranged from 2.60 to 2.70gkg^{-1} within 15-30cm depth. The N value was generally high (2.1-2.4gkg^{-1}) using FFD, 2002 standard. In the two sacred groves, the soil organic matter within 0-15cm ranged from 52.40 to 59.70gkg^{-1}, while at 15-30cm depth ranged from 44.50 to 46.40gkg^{-1}. Organic matter was generally high in 0-15cm depth than 15-30cm.

Soil pH

The pH is a measure of soil acidity or alkalinity that gives an indication of the activity of the hydrogen ion (H^+) and hydroxyl ion (OH^-) in a water solution. Table (3) showed that the pH values within 0 -15cm soil depth ranged from 7.30 to 7.39 in the two sacred groves. The highest pH value (0 -15cm) was recorded in Igbo-Ile (7.39) followed by Igbo-Oba (7.30). Variability of soil pH values within 15-30cm soil depth ranged from 7.38 to 7.55. The highest pH value was recorded in Igbo-Oba (7.55) followed by Igbo-Ile (7.38). The general interpretation of pH ratings showed that soils from Igbo-Ile and Igbo-Oba are slightly alkaline (7.39, 7.38 & 7.30, 7.55) using at 0 -15cm & 15 -30cm FFD, (2002) standard

Exchangeable Cations

At 0-15cm, the values for Na ranged from 0.29 to 0.36c mol. Kg^{-1}, K (0.32 to 1.29c mol. Kg^{-1}), Ca (11.82 to 15.06c mol. Kg^{-1}), Mg (1.22 to 3.40c mol. kg^{-1}), H^+ (0.04 to 0.05) and CEC (3.77 to 20.16c mol. Kg^{-1}). At 15-30cm, the values for Na ranged from 0.28 to 0.35c mol. Kg^{-1}, K (0.33 to 1.28c mol kg^{-1}), Ca (11.64 to 21.42c mol.kg^{-1}), Mg (2.44 to 2. 84c mol. Kg^{-1}), H^+ (0.03 to 0.04) and CEC (14.73 to 25.92c mol kg^{-1}). Na contents were generally high in Igbo-Oba at 0 -15 and 15 – 30cm depth.

Effect of Soil Properties on the two sacred groves

The soil physical properties at depth 0 – 15cm and 15-30cm (top soil) showed that there was no significant difference in sand fraction in both Igbo Ile and Igbo-Oba. The silt fraction for Igbo-Ile was significantly different from Igbo-Oba (0 – 15cm), but no significant difference at 15-30cm. The clay fraction in Igbo-Ile has no significant difference compared to Igbo-Oba at 0-15cm depth but there was significant difference between the two sacred groves at 15-30cm. There were significant differences in Available P in both scared groves at 0 – 15cm and 15-30cm, but no significant difference in both N and Organic matter in Igbo-Ile and Igbo-Oba within the two depths (0 – 15cm and 15-30cm). There was no significant difference in the pH values in the two sacred groves at 0 – 15cm and 15-30cm, the same applies to Na and H^+. There was significant difference in the K value in the two sacred groves (0–15cm) with significant difference in Igbo-Ile and Igbo-Oba sacred groves at 15-30cm depth. There was significant difference in Ca content in Igbo-Ile and Igbo-Oba at both 0-15cm and 15-30cm depth. The Mg value in Igbo-Ile sacred grove was significantly different from Igbo-Oba sacred grove at 0-15cm but with no significant difference at 15-30cm. The value of C.E.C showed that there was significant difference between the sacred groves at the two depths (0 – 15cm and 15-30cm).

Table 1: Particle size distribution of soils in two sacred groves

Soil Depth (cm)	Sacred grove	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Texture
0-15	Igbo-Ile	856^a	56^c	88^b	Loam Sand
	Igbo-Oba	788^a	132^b	80^b	Loam Sand
15-30	Igbo-Ile	768^a	152^a	152^a	Loam Sand
	Igbo-Oba	768^a	152^a	80^b	Loam Sand

Means with the same superscript alphabet in a column are not significantly different ($p<0.05$)

Table 2: Available P, Total N and Organic C in two sacred groves

Soil Depth (cm)	Sacred grove	Available P (mg/kg)	N (g/kg)	Organic matter (g/kg)
0-15	Igbo-Ile	9.65^c	3.00^a	52.40^b
	Igbo-Oba	22.27^b	3.50^a	59.70^b
15-30	Igbo-Ile	21.34^b	2.70^a	46.40^b
	Igbo-Oba	41.14^a	2.60^a	44.50^b

Means with the same superscript alphabet in a column are not significantly different ($p<0.05$)

Table 3: Exchangeable cations and pH in two sacred groves

Soil Depth (cm)	Sacred grove	pH	Na (c mol/kg)	K (c mol/kg)	Ca (c mol/kg)	Mg (c mol/kg)	H+ (c mol/kg)	C.E.C (c mol/kg)
0-15	Igbo-Ile	7.39[a]	0.29[a]	0.32[b]	11.82[a]	1.22[c]	0.04[b]	13.69b
	Igbo-Oba	7.30[a]	0.36[a]	1.29[a]	15.06b	3.40[a]	0.05[b]	20.16a
15-30	Igbo-Ile	7.38[a]	0.28[a]	0.33[b]	11.64a	2.44[b]	0.04[b]	14.73b
	Igbo-Oba	7.55[a]	0.35[a]	1.28[a]	21.42[c]	2.84[b]	0.03[b]	25.92a

Means with the same superscript alphabet in a column are not significantly different (p<0.05)

4. Discussion

Soil texture can have a profound effect on many other properties and is considered among the most important physical properties and this is the proportion of three mineral particles, sand, silt and clay, in a soil. The textural classes in all the sacred groves fall to loam sand. The results of the soil physical properties agree with Oguntala (1980) and Isikhuemen (2005). Similar trends in particle size distribution have been reported by Muoghalu and Awokunle (1994). The pH of soils vary widely and between sacred groves from moderate acidity to slight alkalinity. Higher pH values recorded in nearly all the sacred groves might be due to the presence of higher exchangeable Ca and Mg in the soil. According to Isikhuemen (2005) the presence of carbonates in soil can affect soil productivity by influencing soil pH. Also Alloway and Aryes, (1997), the higher value is expected as most soil in the tropics have their ranging from acidic to slightly neutral. The relatively high organic matter content in the soil of the sacred groves may be due to decayed products of underground root biomass which predictably was higher. The soil organic matter accumulation has been shown to be proportional to the extent of canopy closure (Gupta *at al.*, 1991). There was general decrease in organic matter content with depth in the sacred groves. Soil organic matter are the summation of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and well decomposed substances (Brady and Weil, 1999). The tree leafs and other plants components may have contributed significantly to the topsoil's levels of nitrogen, organic carbon, exchangeable calcium and magnesium. This study is consistent with the findings of Abegaz and Adugna (2015). The decrease in Organic matter with soil depth may be due to the decrease in the abundance of fine roots with depth; at greater depths, larger diameter roots predominate. The most important role of the vegetation on soil, is the accumulation of organic matter. The tree leaves represent the most important source of carbon in the soil. The occurrence of higher topsoil organic carbon in both forest can be due to the litter fall addition from trees and shrubs to the surface soil (Nsabimana *et al*., 2008 The type of vegetation is also an important factor because it affects the soil acidity. For example, litter from conifer trees require more time to be decomposed, having as result a slow recycling of nutrients. On the other hand, litter from deciduous trees are easily decomposed due that they contains more less strong carbon bonds, that microorganisms can brake faster. As result, microorganisms release organic acids that promote the soil formation by the desegregation of rocks. This process requires time, and at the long term, it will determine the thickness of the soil horizons and the fertility of the forest soil. Using soil fertility class rating (FFD, 2002), Organic matter content was high (>30g kg^{-1}) at all soil depths. The mean value of organic matter content in the sacred grove was high in Igbo –Ile (49.4g kg^{-1}) and Igbo–Oba (52.1g kg^{-1}). The mean values of K is rated medium in Igbo –Ile (0.33c mol/kg), while rated high in Igbo –Oba (1.29c mol/kg).

Calcium (Ca) is the dominating plant nutrient among the cations. It contributes to give the plant strong cellular walls, aid in the cell-division and is responsible for the activation of different enzymes (Marschner & Marschner, 2012).The exchangeable concentrations of Ca, Mg, and K in the various depth intervals are noteworthy. Baillie and Aghton (1983) suggested that Ca and Mg should be more variable than K in forest soils, as K occurs exclusively on soil organic matter exchange sites.

Potassium (K) is the plant macronutrient that is responsible for the regulation of the osmotic potential of the cells. Lack of K leads to a decreased ability to regulate the osmotic potential, which leads to an inadequate capacity to withstand cold and aridness (Marschner & Marschner, 2012). Available P is widely considered important in primary productivity in tropical forest (Tanner *et al.*, 1998). Using class rating (FFD, 2002), the mean value of P in the two sacred groves were rated. P content is considered medium (8 – 20mg kg^{-1}) in Igbo –Ile (9.65mg kg^{-1} at 0 – 15cm depth), while the P content is high (>20mg kg^{-1}) in Igbo –Ile (21.34mg kg^{-1} at 15 – 30cm depth), Igbo-Oba (22.27mg kg^{-1} and 41.14mg kg^{-1} at 0 -15cm and 15 – 30cm respectively). The dynamic nature of soil organic phosphorus in tropical forest was demonstrated recently by the relatively rapid changes that occurred following experimental addition or removal of leaf litter in large experimental plots of low land forest in Central Panama (Vincent *et al*, 2010). Soil organic P occurs in a variety of chemical forms that differ markedly in their behaviour and bioavailability in the soil environment (Condron *et al.*, 2005) and may influence the distribution and co – existence of plant species in low land tropical forests (Turner, 2003). The result provided strong evidence for the importance of available P in regulating soil organic phosphorus in tropical forests.

5. Conclusion

The soil texture of the two sacred groves are the same, i.e. sandy loam. It is well drained which implies that nutrient elements and water will readily available for the plant uptake. There was no much difference in the chemical properties of sacred groves in terms of pH, Na, N, H^+ and organic matter. The higher values of parameters recorded in the study areas showed that sacred groves are less disturbed as the total soil organic carbon and nitrogen stocks were higher in the soils under both forests which therefore means that forest soils are richer in nutrient.

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