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VARIATION IN SOIL PHYSICO-CHEMICAL PROPERTIES IN THREE LAND USE TYPES OF OGUN RIVER WATERSHED

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ABSTRACT

Conversion of watershed to other Land Use Types (LUTs) has implications on soil nutrients. Therefore, this study investigated the effects of three LUTs on soil physico-chemical properties of Ogun River watershed. The Ogun River watershed was stratified into Guinea Savannah (GS), Rainforest (RF) and Swamp Forest (SF) Ecological Zones (EZs). Three LUTs: Natural Forest (NF), Disturbed Forest (DF) and Farmland (FL) were purposively selected in GS: GSNF, GSDF, GSFL; RF: RFNF, RFDF, RFFL and SF: SFNF, SFDF, SFFL, respectively. Five out of sixteen plots laid along the transects lines were randomly selected in each of LUTs in the three ecological zones for soil sampling. In each of the selected plots, 5 soil samples were collected at the four corners and centre of the plot at two depths: 0-15 cm, 15-30 cm. Physico-chemical properties of soil samples were determined following standard procedures. Data were analysed using descriptive statistics and Analysis of variance (ANOVA) was used to test for differences in Physico-chemical variables of Ogun River soil samples using 3 x 3 x 2 factorial experiments. There were significant differences in Physico-chemical properties among land use types, Ecological zones and between soil depths of Ogun River watershed ($P < 0.05$). Soil Cation Exchange Capacity ranged from 2.37±0.01 (GSFL) to 8.50±0.04 (GSNF); Total Nitrogen increased from 0.88±0.01 (RFFL) to 4.79±0.05 (GSNF) while Soil Organic Matter ranged from 1.48±0.01 (GSFL) to 13.12±0.21 (GSNF). It was found that continuous changes in land vegetative cover Ogun River watershed through human activities negatively affected soil physico-chemical properties. Therefore, other anthropogenic activities that will intercept nutrient cycling in the watershed ecosystem must be discouraged.

Keywords: Conservation, Soil nutrient, Ogun River Watershed, Physico-chemical properties, nutrient cycling.

INTRODUCTION

The effects of Land and soil degradation on the agricultural production in developing countries have attracted the interest of research workers (Dumanski and Pieri 2000). Land quality with more emphasis on soil nutrient status dictates the condition of the land relative to what is needed to meet quantity and quality of water requirements for human uses and to protect aquatic and riparian ecosystem (Dumanski and Pieri 2000, Pieri *et al*. 1995). The quality of land is measured as the amount of land remaining in its natural state and as the ability of all land in an altered or natural state to perform basic water-related roles such as resisting erosion, filtering runoff, regulating the storage and discharge of runoff, and give room for groundwater recharge (Dumanski and Pieri 2000). On the other hand, land use is any human use of land that alters it from its natural state (Sisk 1998). Land use is thereby measured as the amount of altered land as well as other aspects of human activities on a watershed land base (Sisk 1998).

Land use activities in watersheds are important because they affect surface and ground water. Surface water is affected when land use changes the volume of water running off the land and the quantity as well as concentration of materials that can contaminate water carried by the runoff (Tong and Chen 2002). Groundwater in turn is affected when land use changes the amount of water infiltrating the surface (Di *et al.* 2005). Bare soils resulting from the effects of agriculture, industrialization and urbanization activities enhance runoff rate and erosion because precipitation is not intercepted by vegetation and the soil surface becomes saturated very quickly. On the vegetated soil, plants and organic materials intercept and absorb precipitation and release it slowly into the ground. Plants also reduce the amount of runoff by removing water from the soil through evapotranspiration (LeBlanc *et al.* 1997, FAO 2001).

Forest disturbances have been known to be an important factor affecting soil organic matter. They affect the quantity and quality of litter inputs, the decomposition rates and the processes of soil organic matter stabilization (Di *et al.* 2005). Cultivation of natural lands in tropical areas has led to negative effects on soil organic matter components (Di *et al.* 2005). Continuous cultivation commonly reduces physical properties and productivity of soils due to decrease in organic matter content and pH. Intensive cropping also leads to dis-aggregation in surface soil due to organic matter depletion. A study of soil status in the watershed will therefore establish the relationship between vegetation status and soil properties (Oguike and Mbagwu 2009).

Soil properties deteriorate with land use practices such as conversion of forest to arable land, urban development and industrialization. Many cropping systems lead to erosion and leaching of soil nutrients and adversely affect the physico-chemical properties of the soil (Sisk 1998). As removal of vegetation by various human activities enhances run-off, heavy metals such as zinc (Zn), cadmium (Cd), lead (Pb) and copper (Cu) are eroded freely from industrialized and other commercial areas to watershed ecosystems and percolate into the soil (Moussa *et al*. 2003, Oguike and Mbagwu 2009). Therefore, it is essential to determine how and the level with which the human activities (as bothered on land use types) affect soil nutrients. The study therefore investigated variation in soil physico-chemical properties in three land use types of Ggun river watershed with a view to establishing the relationship between vegetation status and soil properties and provides essential information towards sustainable management.

MATERIALS AND METHODS

The study area

Ogun River is located in the Southwestern part of Nigeria, between latitudes 8° 41' N and 9° 10' N and longitudes 3° 28' E and 4° 8' E. The river flows through three Southwestern States (Oyo, Ogun, and Lagos). Ogun River took its source from Igaran Hills at an elevation of about 530 m above mean sea level and flows directly southwards over a distance of about 480 km before discharging into the Lagos Lagoon (Fig. 1). Its major tributaries are the Ofiki and Opeki rivers (Amartya and Akin-Bolaji, 2010). There are two seasons, a dry season (from November to March) and a wet season (from April and October). Mean annual rainfall ranges from 900 mm in the north to 2000 mm towards the south. The estimate of total annual potential evapotranspiration is between 1600 and 1900 mm (Ikenweirwe *et al*. 2007). The three major vegetation zones that the river meanders through include the Guinea Savannah (GS) in the north, the Rain Forest (RF) in the central part and the swamp forests in the southern coastal and flood plains, next to the lagoon (Amartya and Akin-Bolaji 2010). The geology is a rock sequence that starts with the Precambrian Basement; which consists of quartzites, biotite schist, hornblende-biotite, granite and gneisses. (Ikenweirwe *et al*. 2007).

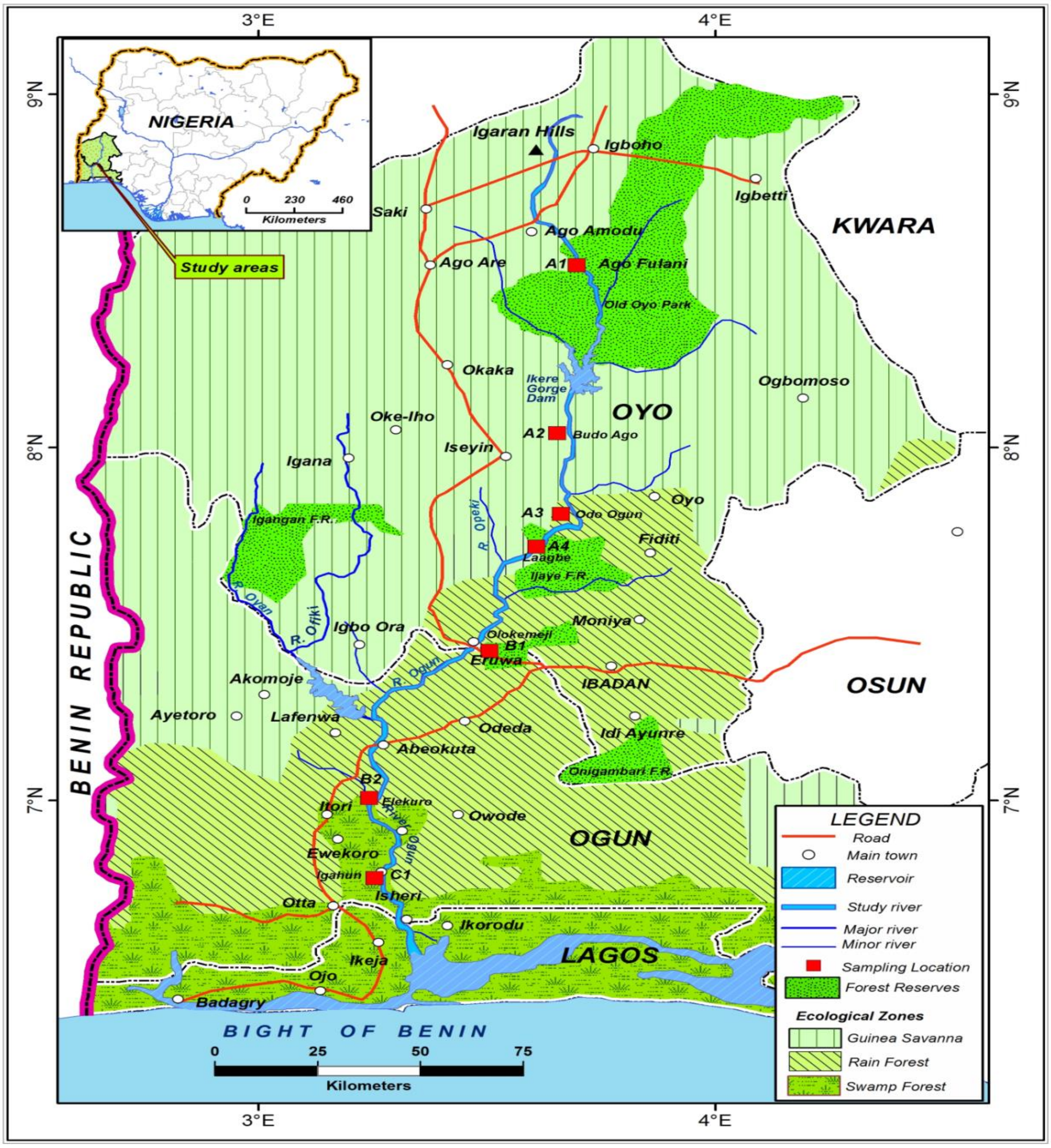

Figure 1: The study area showing study locations (inset: map of Nigeria).

Methods of data collection

Sampling procedure

The study area was divided into different ecological zones (Guinea Savannah, Rain Forest and Swamp Forests). The guinea savannah covers 68.5% (about 329 km) of the total length of the river while rain forest and swamp forest cover 27.5% (132 km) and 4% (19 km), respectively (Berga 2006). Based on proportion to size, each ecological zone was purposively sampled by selecting four (4), two (2) and one (1) study locations in the guinea savannah, rain forest and swamp forest ecological zones respectively, representing about 1% of coverage area of each ecological zone (Table 1). Having considered activities on the land cover, each location in the three ecological zones was stratified into Natural Forest (NF: relatively less disturbed forest), Disturbed Forest (DF) and Farm land (FL) for soil properties investigations.

Table 1: Geo-referenced Coordinates of Sampled Locations along the Ogun River water course (Sampling based on area covered by the river in each ecological zone).

		GPS Coordinates	
Ecological zones	Locations/Villages	Latitude	Longitude
Guinea savannah	A_1	8º 49' and 8º 47'N	3º 40' and 3º 43'E
	A_2	8º 06' and 8º 03'N	3º 31' and 3º 34'E
	A_3	7º 53' and 7º 49'N	3º 43' and 3º 45'E
	A_4	7º 45' and 7º 43'N	3º 46' and 3º 48'E
Rain forest	B_1	7º 20' and 7º 50'N	3º53' and 3º 58'E
	B_2	7º 08' and 7º 05'N	3º 19' and 3º 17'E
Swamp forest	C_1	6º 42' and 6^0 38'N	3º 23' and 3º 20'E

Soil sampling procedure

Systematic line transects as described by Osemeobo (1992) was used in the laying out the sample plots in the selected locations along the river. A setback of 10 m from the riverbank was measured and then two transects of 1,000 m in length parallel on either side of the river were laid. Then, sample plots of 25 m x 25 m were established in alternate positions along the two transects at 100 m interval (8 sample plots per transect and a total of 16 sample plots in each of NF, DF and FL. Five out of sixteen plots laid along the transects lines were randomly selected in each of NF, DF and FL in the three ecological zones for soil sampling. In each of the selected plots, 5 soil samples were collected using a soil auger (5 cm diameter × 15 cm depth) at the four corners and centre of the plot at two depths: 0-15 cm, 15-30 cm. The soil samples from different depths in each plot were pooled to obtain composite samples. Therefore, there were 5 soil samples for each of NF, DF and FL in the three ecological zones making 45 samples for each of 0-15 cm level and 15-30 cm level for subsequent analysis.

Laboratory analyses of soil samples

The soil samples were air dried and sieved to pass through 2 mm sieve. The fine earth fraction was analysed for the following parameters: Particle size assessment by hydrometer method as described by Orndorff *et al*. (2008). Soil pH was obtained in 1: 25 soil/water extract of the composite samples. Available Phosphorous was determined by the Bray 2 extract. Cation Exchange Capacity (CEC) was determined by the NH_4OAC displacement method and exchangeable acidity by titrimetric method after extraction with 1.0 N KCl (Mclean 1965). Total exchangeable bases (Ca^{2+}, Mg^{2+}, Na^+ and K^+) were determined using IN NH_4OAC extractant method, where Ca^{2+} and Mg^2 were determined on an Atomic Absorption Spectrometer; Na^+ and K^+ by flame photometer. Base saturation was calculated from TEB/CEC x 100, where TEB = total exchangeable bases. Soil organic carbon (OC) was determined by dichromate method. Soil organic matter was determined by multiplying percentage carbon by 1.724. Total nitrogen was determined by the macro- Kjeldahl method (Bremmer, 1996). Spectrophotometric method was used to analyze zinc using 5,7-diiodo-8-hydroxy-quinoline rhodamine 6G as main reagent while Iron was determined by atomic absorption of the filtrate of soil using N ammonium acetate pH 7.0, N ammonium acetate pH 3.0, and Morgan's reagent. Copper was determined with the use of Atomic absorption flame spectrophotometry as well (Nair *et al*. 2001)

Data Analysis

Analysis of variance (ANOVA) was used to test for differences in Physico-chemical Variables of Ogun River soil samples with the use of 3 x 3 x 2 factorial experiments in Completely Randomized Design where the first factor was the three (3) ecological zones, the second factor was three (3) different land use types and the third factor was two soil depths (0-15 cm and 15-30 cm). Where significant differences were detected, Duncan Multiple Range Test (DMRT) was used for mean separation**.** Descriptive analysis which includes cross tabulation, percentages and frequency distribution were also used to analyze the data.

RESULTS

Physical Properties of soils in different Land use types and Soil depths of Ogun River Watershed

Soil sand particle size was higher at both soil depths in all the Land use types. At 0-15 cm depth, it ranged from 41.58±0.37% to 75.31±0.02 while at 15-30 cm, it ranged from 43.30±0.11% to 77.30±0.04%. At both depths in the three ecological zones, FL had the highest sand compared to DF and NF, and the values were higher at 0-15 cm than 15-30 cm. The silt content ranged from 10.92±0.02 % to 39. 11±1.63% at 0-15cm and from 8.92±0.02% to 33. 11±1.63% at 15-30 cm. The clay content was low at all the locations. It ranged from 13.74±0.16% to 19.77±0.05% at 0-15cm and 11.75±0.03% to 23.74±0.14% at 15-30 cm. Particle size distribution were significantly different among land use types, Ecological zones and between soil depths (Table 2).

Table 2: Particle size distribution of soils in different Land use types and Soil Depths of Ogun River Watershed.

Ecological Zones	Soil depths	Land Use Types	Sand (%)	Clay (%)	Silt (%)	Texture
Guinea savannah	0-15cm	NF	41.58±0.37^{b}	19.77±0.05^{b}	39.11±1.63^{a}	Loam soil
		DF	67.23±0.04^{a}	15.53±0.87^{ab}	16.72±1.30^{ab}	Sandy soil
		FL	61.29±0.03^{ab}	13.74±0.16^{ab}	24.76±2.20^{b}	Sandy loam
	15-30cm	NF	43.30±0.11^{b}	23.74±0.14^{a}	33.11±1.63^{a}	Loam soil
		DF	71.33±0.03^{a}	11.75±0.03^{ab}	16.76±1.33^{ab}	Sandy loam
		FL	71.29±0.03^{a}	11.78±0.04^{ab}	17.22±1.08^{ab}	Sandy loam
Rain Forest	0-15cm	NF	49.30±0.01^{b}	19.73±0.21^{a}	30.92±0.01^{a}	Loam soil
		DF	59.27±0.03^{ab}	17.74±0.20^{ab}	23.11±1.68^{ab}	Sandy loam
		FL	73.25±0.14^{a}	15.77±0.10^{b}	10.92±0.12^{c}	Sandy loam
	15-30cm	NF	51.14±0.08^{b}	17.73±0.20^{ab}	30.92±0.02^{a}	Loam soil
		DF	59.27±0.03^{ab}	19.72±0.28^{a}	21.11±1.63^{b}	Sandy loam
		FL	61.30±0.00^{ab}	13.74±0.16^{b}	24.92±0.02^{ab}	Sandy loam
Swamp Forest	0-15cm	NF	47.30±0.05^{b}	19.72±0.28^{a}	32.92±0.01^{a}	Loam soil
		DF	75.31±0.02^{a}	13.74±0.16^{b}	10.92±0.02^{b}	Sandy loam
		FL	71.33±0.03^{ab}	13.75±0.18^{b}	14.92±0.12^{ab}	Sandy loam
	15-30cm	NF	49.33±0.05^{b}	19.72±0.28^{a}	30.91±0.01^{a}	Loam soil
		DF	71.32±0.03^{ab}	15.76±0.10^{ab}	12.92±0.10^{b}	Sandy loam
		FL	77.30±0.04^{a}	13.75±0.18^{b}	8.92±0.02^{c}	Sandy loam

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

Soil pH in different Land use types and Soil depths of Ogun River Watershed

The pH values within 0-15 cm soil depth ranged from 5.59±0.04 to 7.27±0.2 [moderately acidic to slightly alkaline (SSN, 2011)] while it ranged from 5.56±0.04 to 6.58±0.01 [moderately acidic to neutral (SSN, 2011)] at 15-30 cm. The highest pH values were recorded in NF of the three ecological zones (7.27±0.04, 7.24±0.03 and 7.12±0.02), while the lowest (5.56±0.04) was recorded in FL of rainforest. Soil pH values different significantly among land use types, Ecological zones and between soil depths (Table 3).

In the three ecological zones, calcium content at 0-15 cm ranged from 0.86±0.02 to 2.21±0.14 Cmol (+)kg^{-1}, magnesium ranged from 1.49±0.11 to 1.84±0.4 Cmol(+)kg^{-1}, potassium ranged from 0.71±0.03 to 1.38±0.02Cmol/kg, Sodium ranged from 0.49±0.03 to 0.67±0.01 Cmol(+)kg^{-1} and CEC ranged from 2.41±0.02 to 9.35±0.02 Cmol(+)kg^{-1}.

Table 3: Soil pH of soils in different Land use types and Soil depths of Ogun River Watershed.

Ecological Zones	Soil depths	Land Use Types	pH	Ratings
Guinea savannah	0-15cm	NF	7.12±0.02^{a}	Neutral
		DF	6.6±0.02^{ab}	Neutral
		FL	6.38±0.03^{b}	Slightly acidic
	15-30cm	NF	6.34±0.04^{b}	Slightly acidic
		DF	5.97±0.01^{c}	Moderately acidic
		FL	6.18±0.01^{c}	Slightly acidic
Rain Forest	0-15cm	NF	7.24±0.03^{a}	Slightly alkaline
		DF	6.42±0.02^{b}	Slightly acidic
		FL	5.59±0.04^{c}	Moderately acidic
	15-30cm	NF	6.32±0.02^{b}	Slightly acidic
		DF	6.58±0.01^{c}	Neutral
		FL	5.56±0.04^{c}	Moderately acidic
Swamp Forest	0-15cm	NF	7.27±0.04^{a}	Slightly alkaline
		DF	6.38±0.02^{b}	Slightly acidic
		FL	5.69±0.04^{c}	Moderately acidic
	15-30cm	NF	6.36±0.02^{b}	Slightly acidic
		DF	6.57±0.01^{ab}	Neutral
		FL	5.66±0.04^{c}	Moderately acidic

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

At 15-30 cm, calcium content ranged from 0.72±0.02 to 1.85±0.11 Cmol(+)kg^{-1}, magnesium ranged from 1.11±0.05 to 1.45±0.1 Cmol(+)kg^{-1}, potassium ranged from 0.21±0.02 to 1.28±0.01 Cmol(+)kg^{-1}, sodium ranged from 0.43±0.02 to 0.63±0.01 Cmol(+)kg^{-1} and CEC (2.17±0.01 to 6.19±0.01 Cmol(+)kg^{-1}. Calcium, Mg, K, Na and CEC contents were generally high in NF at both 0-15 and 15-30 cm depth, while they were low in FL (Table 4).

Table 4: Calcium, Magnesium, Potassium, Sodium and Cation Exchange Capacity of soils in different Land use types and Soil Depths of Ogun River Watershed.

Ecological Zones	*Soil depths*	*Land Use Types*	*Ca (Cmol(+)kg^{-1})*	*Mg (Cmol(+)kg^{-1})*	*K (Cmol(+)kg^{-1})*	*Na (Cmol(+)kg^{-1})*	*CEC (Cmol(+)kg^{-1})*
Guinea savannah	0-15cm	NF	1.85±0.02^{a}	1.67±0.13^{a}	1.31±0.02^{a}	0.66±0.01^{a}	8.50±0.04^{a}
		DF	1.01±0.03^{ab}	1.60±0.4^{ab}	1.07±0.01^{b}	0.59±0.01^{b}	3.99±0.01^{ab}
		FL	0.89±0.02^{b}	1.51±0.12^{b}	0.73±0.03^{c}	0.51±0.03^{c}	2.81±0.02^{c}
	15-30cm	NF	1.57±0.11^{a}	1.45±0.1^{bc}	1.28±0.01^{ab}	0.54±0.01^{ab}	6.07±0.01^{b}
		DF	0.92±0.12^{ab}	1.39±0.21^{c}	1.01±0.01^{b}	0.52±0.01^{c}	2.83±0.03^{c}
		FL	0.75±0.02^{b}	1.27±0.06^{c}	0.21±0.02^{c}	0.49±0.02^{c}	2.37±0.01^{cd}
Rain Forest	0-15cm	NF	2.01±0.02^{a}	1.64±0.03^{a}	1.28±0.02^{ab}	0.64±0.01^{a}	8.41±0.02^{a}
		DF	1.11±0.2^{ab}	1.59±0.22^{b}	1.17±0.01^{b}	0.56±0.01^{b}	3.91±0.01^{ab}
		FL	0.86±0.02^{b}	1.50±0.01^{b}	0.71±0.03^{c}	0.49±0.03^{c}	2.41±0.02^{cd}
	15-30cm	NF	1.77±0.01^{a}	1.43±0.3^{b}	1.21±0.01^{ab}	0.55±0.01^{ab}	6.03±0.01^{b}
		DF	0.98±0.2^{b}	1.40±0.01^{bc}	1.01±0.01^{b}	0.48±0.01^{c}	2.43±0.03^{cd}
		FL	0.72±0.02^{b}	1.33±0.02^{b}	0.41±0.02^{c}	0.43±0.02^{c}	2.17±0.01^{d}
Swamp Forest	0-15cm	NF	2.21±0.14^{a}	1.84±0.4^{a}	1.38±0.02^{a}	0.67±0.01^{a}	9.35±0.02^{a}
		DF	1.41±0.02^{a}	1.57±0.22^{b}	1.10±0.01^{b}	0.58±0.01^{b}	4.61±0.01^{ab}
		FL	0.87±0.02^{b}	1.49±0.11^{bc}	0.81±0.03^{c}	0.52±0.03^{c}	3.13±0.02^{c}
	15-30cm	NF	1.85±0.11^{a}	1.33±0.01^{b}	1.22±0.01^{ab}	0.63±0.01^{a}	6.19±0.01^{b}
		DF	1.14±0.2^{ab}	1.21±0.13^{c}	0.96±0.01^{b}	0.49±0.01^{c}	3.17±0.03^{c}
		FL	0.73±0.05^{b}	1.11±0.05^{c}	0.43±0.02^{c}	0.47±0.02^{c}	2.88±0.01^{c}

Means with the same superscript in a column are not significantly different ($p>0.05$)
Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, CEC = Cation Exchange Capacity

Available Phosphorous, Total Nitrogen, and Organic Matter of soils in different Land use types and Soil depths of Ogun River Watershed.

There were significant differences in P, Total N, and Soil Organic Matter (SOM) among land use types, Ecological zones and between soil depths of Ogun River watershed (Table 5). Available P ranged from 7.24±0.12 to 15.21±0.11mgkg^{-1}within 0-15 cm depth while at 15-30 cm depth, the values ranged from 6.18±0.01 to 10.16±0.21 mg^{-1}. The value of Phosphorous decreased down the depth in all the three land use types. Phosphorous was generally higher in NF followed by DF and low in FL. The soil Total Nitrogen decreased with depth and varied and among land use types. Natural Forest had the highest Total Nitrogen value while FL had the lowest. At 0-15 cm depth, the Total Nitrogen ranged from 1.15±0.01 to 5.82±0.1 6 gkg^{-1} but ranged from 0.88±0.01 to 4.32±0.02 gkg^{-1} at 15-30 cm depth. Soil organic matter within 0-15 cm ranged from 2.17±0.01 to 13.12±0.21 gkg^{-1}, while at 15-30 cm depth ranged from 1.48±0.01 to 7.82±0.13 gkg^{-1}. Soil Organic matter was higher in NF followed by DF and lowest in FL at both soil depths (Table 5).

Table 5: Available Phosphorous, Total Nitrogen, and Organic Matter of soils in different Land use types and Soil depths of Ogun River Watershed.

Ecological Zones	Soil depths	Land Use Types	Available P (mgkg^{-1})	TN (gkg^{-1})	OM (gkg^{-1})
Guinea savannah	0-15cm	NF	13.90±0.04^{a}	4.79±0.05^{a}	10.23±0.17^{a}
		DF	10.79±0.02^{b}	2.37±0.03^{ab}	4.29±0.1^{b}
		FL	8.24±0.01^{c}	1.15±0.01^{c}	2.17±0.01^{bc}
	15-30cm	NF	8.25±0.02^{c}	3.09±0.04^{b}	5.33±0.04^{b}
		DF	7.42±0.02^{cd}	2.19±0.11^{ab}	2.71±0.03^{bc}
		FL	6.18±0.01^{d}	0.98±0.01^{c}	1.48±0.01^{c}
Rain Forest	0-15cm	NF	14.54±0.01^{a}	5.74±0.56^{a}	12.13±0.01^{a}
		DF	11.88±0.01^{b}	3.13±0.03^{b}	5.87±0.02^{b}
		FL	7.24±0.12^{cd}	1.65±0.01^{c}	3.10±0.01^{bc}
	15-30cm	NF	9.45±0.01^{ab}	4.13±0.02^{a}	6.71±0.06^{b}
		DF	8.31±0.02^{c}	1.87±0.01^{ab}	3.56±0.03^{bc}
		FL	6.24±0.01^{d}	0.88±0.01^{c}	1.88±0.01^{c}
Swamp Forest	0-15cm	NF	15.21±0.11^{a}	5.82±0.16^{a}	13.12±0.21^{a}
		DF	12.32±0.01^{ab}	3.71±0.03^{b}	6.15±0.01^{b}
		FL	8.12±0.32^{c}	1.88±0.01^{ab}	4.18±0.01^{bc}
	15-30cm	NF	10.16±0.21^{b}	4.32±0.02^{a}	7.82±0.13^{b}
		DF	9.11±0.02^{ab}	1.68±0.01^{bc}	3.91±0.04^{bc}
		FL	7.08±0.06^{cd}	0.99±0.02^{c}	2.28±0.01^{c}

Means with the same superscript in a column are not significantly different ($p>0.05$)
P = Phosphorous, TN = Total Nitrogen, OM = Organic Matter

Micronutrients in different Land use types and soil depths of Ogun River Watershed.

The concentration of Fe in the soil samples at 0-15 cm ranged from 0.90±1.49 to 2.43±1.62 mgkg^{-1}, Cu ranged from 0.24±0.02 to 1.59±0.01 mg/kg and Zn ranged from 0.96±0.15 to 1.81±0.24 mgkg^{-1}). At 15-30 cm, the values for Fe ranged from 0.62±1.80 to 2.11±1.60 mgkg^{-1}, Cu ranged from 0.21±0.02 to 1.48±0.02 mgkg^{-1}and Zn ranged from 0.91±0.04 to 1.61±0.23 mgkg^{-1}. Fe, Cu and Zn values were generally high in NF at both 0-15 and 15-30 cm depth, while they were low in FL. There were significant differences in Fe, Cu and Zn among land use types, Ecological zones and between soil depths of Ogun River watershed (Table 6).

Table 6: Micronutrients in the soil of different Land use types and Soil depths of Ogun River Watershed.

Ecological Zones	Soil depths	Land Use Types	Fe (mgkg^{-1})	Cu (mgkg^{-1})	Zn (mgkg^{-1})
Guinea savannah	0-15cm	NF	2.01±1.62^{a}	1.59±0.01^{a}	1.62±0.14^{a}
		DF	1.63±0.96^{ab}	1.33±0.26^{a}	1.12±0.24^{b}
		FL	0.90±1.49^{c}	0.28±0.02^{b}	1.10±0.15^{b}
	15-30cm	NF	1.98±1.60^{a}	1.48±0.02^{a}	1.59±0.02^{a}
		DF	1.42±1.66^{ab}	1.01±0.01^{ab}	1.11±0.23^{b}
		FL	0.62±1.80^{c}	0.28±0.02^{b}	1.02±0.04
Rain Forest	0-15cm	NF	2.43±1.62^{a}	1.49±0.01^{a}	1.72±0.24^{a}
		DF	1.68±0.96^{ab}	1.02±0.26^{abb}	1.62±0.14^{a}
		FL	0.92±1.41^{c}	0.27±0.02^{b}	0.98±0.15^{b}
	15-30cm	NF	2.01±1.60^{a}	1.47±0.02^{a}	1.61±0.23^{a}
		DF	1.43±1.66^{ab}	0.96±0.01^{ab}	1.49±0.02^{a}
		FL	0.67±1.80^{c}	0.25±0.02^{b}	0.92±0.04^{b}
Swamp Forest	0-15cm	NF	2.21±1.62^{a}	1.42±0.01^{a}	1.81±0.24^{a}
		DF	1.48±0.96^{ab}	1.01±0.26^{ab}	1.67±0.14^{a}
		FL	1.43±1.66^{ab}	0.24±0.02^{b}	0.96±0.15^{b}
	15-30cm	NF	2.11±1.60^{a}	1.39±0.03^{a}	1.58±0.23^{a}
		DF	1.37±1.66^{ab}	0.93±0.01^{ab}	1.45±0.02^{a}
		FL	0.63±1.80^{c}	0.21±0.02^{b}	0.91±0.04^{b}

Means with the same superscript in a column are not significantly different ($p>0.05$)
Fe = Iron, Cu = Copper, Zn = Zinc

DICUSSION

Soil Physical Properties of Ogun River Watershed

Soil textural class which is the proportion of three soil particles, sand, silt and clay, in a soil influences other properties and is considered among the most important physical properties (Ewing and Singer 2012, Oyelowo 2014). The textural classes in all the land use types of the study areas were between sandy loam and loam soil. Soils from NF were loamy soil compared to the soils of other land use types which were sandy loam. This implies that continuous change in land vegetative cover through human activities can disrupt soil structure which in turn affects the soil properties. Marcotullio *et al*. (2008) reported that human activities alter the physical characteristics of soils which drastically affect the sustainability of the ecosystems. The textural class of the NF could be as a result of addition of more organic matter from falling leaves and the greater shielding effect of the canopy formed by the mature shrubs and under storey vegetation from the erosive energy of the falling raindrops (Palm *et al*. 2007). The increase in the clay contents with soil depth could be attributed to leaching of the fine clay particles to lower soil depths while the decrease in Sand content with depth could be attributed to the inability of the larger sand particles to be leached to lower depths by percolating water (Muoghalu and Awokunle 1994; Beyer *et al*. 1995 and Chima *et al*. 2009).

Soil Chemical Properties of Ogun River Watershed

The soil pH varied among the ecological zones, depths and land use types, ranging from moderately acidic to slightly alkaline (Foth and Ellis, 1997). The lowest pH value in the FL and DF might be either as a result of the depletion of basic cations by crop being harvested and drainage of the ions to streams in runoff generated from accelerated erosions or due to higher microbial oxidation that produces organic acids, which provide H^{+} ions to the soil solution and thereby lowers soil pH (Isikhuemen 2005, Norra *et al*. 2008). The decrease of pH values with increase in soil depth could be as well attributed to the same reasons. This corroborates the findings of Gebeyaw (2015) who observed higher values of pH in surface soil than in sub-soil. Soils from NF that had pH values within the optimum range indicated that organic matter from decomposed litter of trees have a buffering effect on soil (Montgomery, 2007 and Marcotullio *et al*. 2008).

Exchangeable cations: Mg, K, Na and Ca are soil properties whose concentration could be affected by human activities on the soil (Palm *et al*. 2007and Norra *et al*. 2008). The impact of deforestation and farming practices such as continuous tillage and intensive grazing contribute indirectly to the changes in chemical properties particularly in the surface layers as a result of removal of soil by sheet and rill erosions and mixing up of the surface and the subsurface layers (Toleti 2011, Gebeyaw 2015, Asinwa *et al*. 2018). It was also observed that the concentration of cations was related to soil pH in all land use types and decreased with increase in soil depth. This agrees with the findings of Muoghalu and Awokunle (1994) that the depletion of cations decreased pH levels of the soil with depth in degraded forest and farmland. The lower concentrations of Mg, K, Na and Ca in DF and FL indicate the influence of vegetation cover removal for other land uses while the highest level of cations in NF may be as a result of relatively undisturbed ecosystem where there is no extraction of residues that remove these cations. This is in agreement with report by Sanchez *et al*. (1985) that changes in land use alter the fluxes to or from the soil system and/or impose additional stresses on the ecosystem.

Available P, Total N, Organic C and organic matter were lower in DF and FL and significantly higher values in NF suggesting that the changing of land use from natural forest to farmland or other land use depletes specific nutrients and organic matter. According to Amsalu *et al*. (2007), cultivation of native soils reduces soil organic matter by facilitating interactions of physical, chemical and biological soil processes that increases decomposition rate of soil organic matter. This reduction of organic matter was also observed by Kosmasm *et al*. (2000) where soil in cultivated land was compared to soils under natural vegetation. The considerably lower value of soil organic matter in DF and FL compared to NF is related to the low biomass returned back to the soil because the majority of above ground biomass is lost due to forest cover removal and intensive land cultivation (Harvey *et al*. 1985, Millward *et al*. 2011). Also, Veldkamp (1994) found that conversion of forest land to pasture and grasslands causes a decline in soil organic carbon and loss of organic matter which results in the release of carbon dioxide to the atmosphere. This implies that continuous production of CO_2 as a result of oxidation of organic matter enhances concentration of CO_2 in the atmosphere and invariably contributes to global warming. Therefore, the conversion of forest lands to other human managed land uses will aggravate climate change

Cations Exchange Capacity (CEC) measures amount of cations which can be extracted from soil samples by a high concentrated cation usually dominated by Ca, Mg, Na, K, Al, and protons while available P is influenced by organic matter (Ewing and Singer 2012). The decrease in CEC, available P and total N with increasing depth could be attributed to the decrease in organic matter content of soil down the soil depth since organic matter has been known to influence the concentration of available P and total N (Millward *et al*. 2011; Ewing and Singer 2012). Awotoye *et al*. (2011) attributed increase in Total N and Available P to improved organic matter content through litter decomposition and mineralization in various land use practices in humid agro-ecological zones of Nigeria.

The concentrations of available micronutrients (Fe, Mn, Zn and Cu) were higher in NF than DF and FL, and decreased with increase in soil depth. These variations among land use types indicate that human interference on forest ecosystem has effects on the nutrient status of the soil (Norra *et al*. 2008; Asinwa *et al*., 2018). This therefore implies that there is need to employ proper conservation techniques which will enhance integrated soil fertility management. Similarly, soil micronutrients are influenced by organic matter of the soil. Sharmal *et al*. (2000) reported a strong correlation between organic matter and extractable micronutrients (Zn, Cu, Mn and Fe). The concentration of extractable micronutrients particularly Zn, Fe and Mn in the surface soil is enhanced by decomposed organic materials on the soil surface (Chima *et al*. 2009, Toleti 2011).

CONCLUSION

Watershed disturbances by human activities such as tree exploitation, continuous land cultivation and intensive grazing contribute to disruption of soil structure and changes in chemical properties particularly in the surface layers as a result of removal of soil by sheet and rill erosions. This inherence justified the soil nutrients status of Natural Forest which was much higher than what were observed in DF and FL. The results from this study indicate that continuous changes in land vegetative cover through human activities can negatively affect soil physico-chemical properties. It is therefore recommended that indiscriminate tree exploitations for timber, poles or charcoal production and any other anthropogenic activities that will intercept nutrient cycling in the watershed ecosystem must be discouraged.

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