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Influence of Land Use Types on Physical and Chemical Properties in Oba Hill Forest Reserve, Iwo, South-western Nigeria

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ABSTRACT: Ecosystems have been affected by series of activities that occurred on lands. The effects of land use change on the physical and chemical properties of the soil in Oba Hill Forest Reserve have been studied using standard instrumentation techniques. Results obtained showed that the texture of the soils ranged from loam to sandy loam while the pH of the soils from the four land use types ranged from 4.92 (acidic) to 7.80 (alkaline).The bulk densities in soils from the four land use types are natural forest (1.01 g/m^3), teak plantation (1.21 g/m^3), farmland (1.55 g/cm^3) and residential (1.66 g/m^3). Concentration of Mn in soils are higher than Zn, Cu and Fe from the all the studied land use types. Higher mean concentration values of Mn is recorded in soils from natural land (98.12±0.99 mg/kg) followed by plantation land with mean value of 74.32±0.52 while soils from residential land had lowest mean value of 19.59±0.13mg/kg. Soils from the natural land also have the highest mean concentrations value of Fe (69.04±0.26 mg/kg), Zn (21.48±0.11mg/kg) and Cu (15.43±0.04 mg/kg) while least mean concentration values of Fe (25.46±0.03 mg/kg), Zn (8.59±0.01mg/kg) and Cu (3.55±0.01mg/kg) are recorded in residential land. The results revealed that changing in land use types from natural forest to residential land decrease the organic matter, available nitrogen, soil moisture, porosity exchangeable cations, micronutrients and increased the bulk density in the soils. This study has shown that land use types can affect soil properties and existence of essential nutrients in the soils.

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Ecosystems have been affected by series of activities that occurred on lands. Soils as an important reservoir for numerous substances, organism and habitat for animals and plants have been exposed to various degradation activities from human disturbance and climate change such as global warming, ozone depletion, pollution have great impact on soils (Pouyat *et al.*, 2002) Deforestation of natural land for farming, buildings, construction of roads, highways and rail lines has become order of the day due to increase in population coupled with urbanization and industrialization. The exposure of soils through deforestation of natural forest has led to the washing away of soil nutrients by action of water and wind leading to degradation of soil structure, negative influence on vegetation and obstructions of water transportation among others (Berger and Hager, 2000). Most of the tropical rain forests like the study area have been depleted in size, degraded and changed to other use. Studies have shown that a change in natural to other usage may encumber forest litters that increase soil nutrients thus enhancing soil erosion rates as well as loss of soil organic matter and nutrients and land degradation (Akintola et al, 2020). The effect of this can result to reduction of soil fertility and biodiversity loss. Since, forest cover plays an imperative role in controlling soil erosion and land degradation, changes in the land cover may significantly affect the quantity and biomass multiplicity in the soil which in turn disturbs the nutrient profile of the soil. Henril et al (2020) reported that the use of forest reserves for other land usage has resulted into sundry and multifarious

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ecological problems. Soil physical and chemical properties have been used by many researchers for assessing the influence of land-use on changes and management of the ecosystem (Mitchel *et al.*, 2010; Agboola *et al.*, 2017; Akintola et al 2020a and b, Akintola et al 2021). The management of soil and the maintenance of its quality depend widely on frequent evaluating of soil properties to farming, cultivation and other land use (Chima *et al.*, 2009)) Thus, it is paramount to understand the effects of land use types on soil properties for environmental sustainability and management. This work therefore assessed influence of land use types on physical and chemical properties of soil in Oba Hill Forest Reserve in Iwo, South-western Nigeria

MATERIALS AND METHODS

Study Location: The study area, Oba Hills Forest Reserve is located within the latitudes 7° 42' to7° 50' N and longitude 4° 3' to 4°10' E in Iwo, Osun State. It falls within the tropical rainforest, South-western Nigeria and covers about 52 km^2 of hilly terrain with deep gorges. UICN (2003) reported that about 12% of the reserve had been planted with teak. This study also noticed that majority of the natural land from the reserve has been changed to plantation and farmland with only two gullies remaining as natural forest-covered.

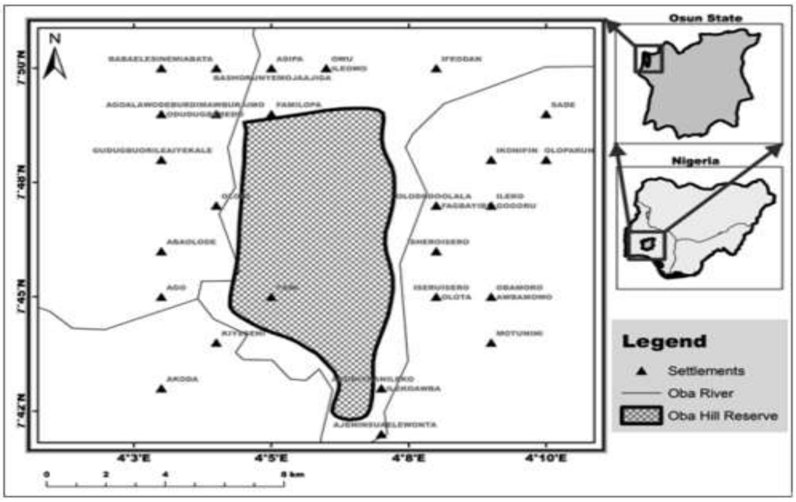

Fig 1: Location map of the study area

Collection, preparation and analysis of soil samples: Soil samples were collected from four different land use areas in this study. From each site five composite sites were collected at the depth of 0-15cm with the aid of an auger. Five undisturbed soil samples each were also collected from the four land use areas with core cutters, sealed at both side with wax to prevent moisture loss and rapped with polythene. The composite samples were also put into sack bags. All the samples were properly labelled. The composite soil samples were air dried at room temperature and sieved with 2mm mesh. Both the air dried composite soil and undisturbed samples were taking to laboratory for analysis.

Soil pH was determined by using a pH meter. The undisturbed soil samples were used for determination of porosity and bulk density.

The bulk density of the soil was determined using core method. The volume of core cutter containing the undisturbed sample before collecting the samples was measured. After drying the core cutter with the samples in an oven at 105°C for 3 hrs, the weight of the dried core cutter with the samples were measured, The bulk density is calculated by dividing the different between the weights by the volume. The value is recorded in g/m^3.

The porosity was determined using the equation 1. The calculated bulk density is expressed in percentage.

$$P = \left(1 - \frac{BD}{PD}\right)100 \qquad 1$$

Where: P- Porosity; BD- Bulk density; PD- Particle density (2.67)

The moisture content of the soils was determined by subtracting the weight of the dried soil samples from the weight of the wet soil, divided it by the weight of the dried soil and multiplied by100.The calculated moisture content is expressed in percentage. Soil texture was determined using hydrometer method of analysis describedbyASTMD7928. Soil organic carbon was determined using the method of Walkleyand Black (1934) method and then multiplied by 1.724 to calculate soil organic matter content while total nitrogen (TN) was estimated by the Kjeldhal digestion and distillation methods (Bramner, 1965). Exchangeable cations ($Ca^{2+,}$ K^{+}, $Mg^{2+}$and Na^{+}) were determined using 1M ammonium acetate at pH of 7.0 as described by (Mehlich, 1953) while available phosphorus was determined by the Bray and Kurtz (1945). The analysis of micronutrients (Zn, Cu, Fe and Mn) using atomic absorption spectrophotometer methods.

Data Analysis: One-way analysis of variance (ANOVA) was used to analysed the data using SPPS (20.0 version) and mean were separated using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effects of land use on physical properties of soils: The results of soil texture, bulk density, moisture content and porosity are presented in Table 1. Mean values of particle size distribution in soil samples from natural forest land is 55% for sand, 24.10% for silt and 20.90% for clay while that of teak plantation is 85.3% for sand, 6.0% for silt and 8.70% for clay. Soils from farmland have the mean particle sizes for sand (85.30%), silt (8.00%) and clay (6.70%) and that from residential land area is 74.30%for sand, 14.00% for silt and 11.70% for clay 11.70%. The soils are loam to loamy sand in texture. The mean values of bulk density in soils (Table 1) from natural forest is 1.01 g/m^3, at teak plantation is 1.21 g/m^3, farmland is 1.55 g/cm^3 and residential is 1.66 g/m^3. It was observed that residential land had the highest bulk density while the natural land had the lowest bulk density, Natural forest soils was found to have higher mean values of porosity (66%)and moisture contents (68%) while soil from residential land had the lowest mean values of porosity (75%) and moisture content(52%). Significant difference was observed among the four land use types studied at P≤ 0.05.

Table 1: Mean values of Physical Properties of the Studied Soils

Physical Properties	**Land use Types**			
	Natural Forest	**Plantation**	**Farmland**	**Residential**
Sand (%)	55.00±1.21^c	85.30±2.10^a	85.30±1.81^a	74.30±1.45^b
Silt (%)	24.10±0.11^a	6.00±0.25^c	8.00±0.31^c	14.00±0.61^b
Clay (%)	20.90±0.51^a	8.70±0.07^c	6.70±0.01^c	11.70^b
Textural Class	Loam	loamy sand	loamy sand	Sandy Loam
Bulk Density (g/m^3)	1.01±0.06^c	1.21±0.01^c	1.55±0.72^b	1.66±0.35^a
Porosity (%)	66±1.23^a	56±0.71^b	44±0.23^c	39±0.15^d
Moisture content (%)	75±0.87^a	68±0.66^b	61±0.11^c	52±0.07^d

Mean Values with the different letter within the same rows are significantly differ from each other at P≤0.05

Table 2: Mean Values of pH, organic matter content, total nitrogen and available phosphorus in soils

parameters	Land use Types			
	Natural forest land	**Teak plantation land**	**Farmland**	**Residential land**
Ph	7.80±0.52^a	6.76±0.21^b	5.99±0.13^b	4.92±0.10^c
Organ Organic matter content (%)	10.11±0.25^a	6.72±0.52b	1.62±0.02^c	1.14±0.01^d
Total Nitrogen (%)	1.26±0.01^a	0.51±0.02b	0.29±0.01^c	0.11±0.03^d
Available phosphorus (mg/kg)	54.12±2.81^a	39.11±1.90^b	25.11±0.51^c	9.28±0.26^d

Mean Values with the different letter within the same rows are significantly differ from each other at P≤0.05

The results of this study agreed with the report by USDA (2017) that loose, porous and good aggregated soils would have high organic matter and lower bulk density while poorly aggregated soil would have low organic matter content and high bulk density making the total pore spaces larger. Nelofer *et al* (2006) on the other hand reported that soil texture, bulk density and porosity are primarily imperative in determining the ability of the soil for saturation of root, water holding, movement of air, and lateral and vertical movement of water into the soil as well as the uptake of water by plants. These in turn are important properties in soil productivity and fertility. The results of this have shown that soils form the natural and tree plantation lands have good structure, can retain more water for plant growth and allow percolation of water into the underground water.

Effect of land use on pH, organic matter content, total nitrogen and available phosphorus: The pH of the soils from the four land use ranged between 4.92 (acidic) and 7.80 (alkaline). There is significant difference among the pH values from the land use types at P≤ 0.05. The acidic nature of soil from the residual may be due to human activities that have taken place over time which have resulted to depletion in soil quality. According to Negasa (2020) nutrients solubility and availability can be affected by soil pH and can differ from one place to another due to nitrification, root activity, and decomposition of organic matter. The mean organic matter content in soils form natural land (10.11%) is significantly higher than plantation land (6.72%), farmland (1.62%) and residential land (1.14%). several researchers have reported that soils from natural land can accumulate significant high amount of organic carbon content that other land use types due to decomposition of various remains of organisms, litters from leaves, stems and grass roots (Rhodes *et al.,* 2000; Mulat *et al.,* 2016, Akintola *et al.,* 2020). This thus explains the high organic matter content in soils from natural and plantation lands. Also, Organic matter found on the soil surface will protect the soil from the action of wind, rainfall and temperature. Soils from natural land had higher mean values of Nitrogen (1.26%), followed by plantation land (0.51%) while the residential land had the lowest mean value of 0.11%. Available phosphorus content is also higher in soils from natural land (54,12mg/kg), plantation land (39.11mg/kg), farmland (25.11mg/kg) while the residential land had the lowest value of 9.28mg/kg. Significant difference was observed among the four land use types studied at $P \leq 0.05$. Bizuhoraho *et al* (2018) reported that organic/inorganic amendments or their mixture can significantly increased the total nitrogen in the farm and stated further that the depletion of total nitrogen in the cultivated lands area may be due to high value of C/N ratio and mineralization of organic matter that resulted that immobilised the microorganism. Aside this, tillage practices can reduced soil nitrogen content by exposing the soil to degradation activities such as erosion, surface run off, leaching and flooding among others.

Effect of land use types on exchangeable cations: The results of exchangeable cations in soils from the four land use types studied are presented in Table 3. The mean concentrations of Ca are higher than the concentrations of Mg, K and Na in the soils. The exchangeable cations in soils from the natural land are higher than those from the other land use types. However, soils from the residential lands recorded the lower mean values in Ca. Mg, K and Na (Table 3).) There was a significant difference ($p \leq 0.05$) in soil exchangeable cations among land use types

Table 3. Mean values of soil exchangeable cations

parameters	Land use Types			
	Natural forest land	**Teak plantation land**	**Farmland**	**Residential land**
Ca (Cmol/kg)	$15.80{\pm}1.11^{a}$	$11.39{\pm}0.88^{b}$	$6.44{\pm}0.35^{c}$	$5.85{\pm}0.18^{d}$
Mg(Cmol/kg)	$8.87{\pm}0.41^{a}$	$2.34{\pm}0.15^{b}$	$1.86{\pm}0.09^{c}$	$1.51{\pm}0.04^{d}$
k(Cmol/kg)	$6.71{\pm}0.24^{a}$	$2.11{\pm}0.01^{b}$	$1.71{\pm}0.01^{c}$	$0.81{\pm}0.02^{d}$
Na(Cmol/kg)	$4.22{\pm}0.05^{a}$	$1.98{\pm}0.01^{b}$	$1.48{\pm}0.01^{c}$	$1.20{\pm}0.01^{d}$

Mean Values with the different letter within the same rows are significantly differ from each other at P≤0.05

Table 4: Mean values of determined micronutrients in soils

parameters	Land use Types			
	Natural forest land	**Teak plantation land**	**Farmland**	**Residential land**
Mn (mg/kg)	$98.12{\pm}0.99^{a}$	$74.32{\pm}0.52^{b}$	$35.67{\pm}0.42^{c}$	$19.59{\pm}0.13^{d}$
Fe (mg/kg)	$69.04{\pm}0.26^{a}$	$49.53{\pm}0.21^{b}$	$35.67{\pm}0.05^{c}$	$25.46{\pm}0.03^{d}$
Zn (mg/kg)	$21.48{\pm}0.11^{a}$	$16.11{\pm}0.03^{b}$	$11.51{\pm}0.02^{c}$	$8.59{\pm}0.01^{d}$
Cu (mg/kg)	$15.43{\pm}0.04^{a}$	$9.76{\pm}0.01^{b}$	$6.98{\pm}0.02^{c}$	$3.55{\pm}0.01^{d}$

Mean Values with the different letter within the same rows are significantly differ from each other at P≤0.05

Effects of land use types on soil micronutrients: The concentrations of the determined micronutrients in the soils from the four land use areas are presented in Table 4. Concentrations of Mn in soils are higher than Zn, Cu and Fe from all the studied land use types. Higher mean concentration values of Mn are recorded in soils from natural land (98.12±0.99 mg/kg) followed by plantation land with mean value of 74.32±0.52while soils from residential land had the lowest mean value of 19.59±0.13mg/kg. Soils from the natural land also have the highest mean concentrations value of Fe (69.04±0.26 mg/kg), Zn (21.48±0.11mg/kg) and Cu (15.43±0.04mg/kg) while least mean concentration values of Fe (25.46±0.03mg/kg), Zn (8.59±0.01mg/kg) and Cu (3.55±0.01mg/kg) are recorded in residential land. The values were significantly different among the four land use areas at $P \leq 0.05$. The reduction in the determined micronutrient from the natural to residential is due to the conversion of natural land to other land use that have exposed the land to various anthropogenic activities such as application of inorganic fertilizers to farmland to crop yield and production, tilling and cultivation of lands, construction of roads and highways, building among others. All these have subjected the land to various degradation processes which result into decline in soil nutrient and fertility.

Conclusion: The study has shown that there is a significant difference in soil properties among different land use types. This study has revealed that conversion of natural land to other usage is affecting the soil structure, fertility and productivity as well as mortifying the natural environment. Thus, afforrestation should be strongly intensified for ecosystem management and sustainability.

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