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RESEARCH ARTICLE

INFLUENCE OF DIFFERENT LAND USE TYPES ON PHYSICAL CHARACTERISTICS OF **SOIL IN EKITI- STATE, NIGERIA**

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ABSTRACT

This research was conducted to assess the physical characteristics of soil as influenced by croplands (CP), forests (FOR), tree crop plantation (TCP) and woodland/grasslands (WGS) land use types in Ekiti State, Southwestern Nigeria. Soil sampling and field experiments were carried out across the different land uses and land cover types. Complete Randomized Design (CRD) was used where there were "within the treatment variation" and "between the treatment variations". Field experiments were carried out in 40 different locations in Ekiti State and surface composite disturbed and undisturbed soil samples were collected to depths of 30 cm from the study areas. Three sampling points were randomly selected per field location (approximately 20 m apart). The soil of the study area was predominantly sandy clay loam. Land use types did not have significant effect on the soil pH (p>0.05). The highest mean porosity value was recorded in FOR soils (45.01%) while WGS had the least mean value (38.87%). The bulk density of the different land uses reduced from WGS to FOR in the order WGS > TCP > CP > FOR. There was significantly higher WHC (p < 0.05) in FOR than other land use types (TCP, CP and WGS). Forest (FOR) land use type had the highest mean VMC, while the WGS land use type had the least. The average DOC of CP, FOR, TCP and WGS is 87.93%, 86.44%, 88.54%, and 89.15%, respectively. Results from the research showed that forest soil is optimum for agricultural practices due its high porosity and low compaction characteristics.

KEYWORDS

Land use types; Soil fertility; Water holding capacity; Degree of compaction; Ekiti-State

1. Introduction

Soil is a complex system where physical and biochemical factors are held in dynamic -equilibrium. Studies of enzyme activities provide information on the biochemical processes occurring in soil. There is growing evidence that soil biological parameters may be potential and sensitive indicators of soil ecological stress or restoration and management induced changes in soil quality (Kızılkaya and Bayraklı, 2005). The physical properties of soils determine their adaptability to cultivation and the level of biological activity that can be supported by the soil. Soil physical properties also largely determine the soil's water and air supplying capacity to plants. Many soils physical properties change with changes in land use system and its management such as intensity of cultivation, the instrument used and the nature of the land under cultivation, rendering the soil less permeable and more susceptible to runoff and erosion losses (Sanchez, 1976). Many practices are known to influence the soil hydro-physical properties such as soil water retention, infiltration, porosity, etc.

These include crop type, cultivation and application of organic residues (Jaiyeoba, 2003; Rachman et al., 2004). The building of infrastructures (urban development), clearing of natural vegetation, and mining can lead to a reduced infiltration rate and high runoff, while agricultural practices such as planting of crops and other vegetation can lead to an improved infiltration rate. When land is put to a certain use such as agricultural practices and mining activities, there is accompanying changes in both

physical and chemical soil properties and therefore the hydrological balance of the soil is altered. Studies in the arid area have demonstrated that water infiltration in the desert is mainly influenced by both biological and physical crusting, and the vegetation cover (Osuji et al., 2010).

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2. MATERIALS AND METHODS

2.1 Study Area

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The study was conducted in Ekiti State in the forest vegetative zone of Nigeria. Ekiti State is located between Longitude 4° 45' to 5° 45' East of the Greenwich Meridian and Latitudes 7° 15' to 8° 5' North of the Equator (EKSG, 2009). The State occupies a land area of about 6, 353 km2 (2, 453 sq ml) (Olorunfemi and Fasinmirin, 2017). Ekiti State is situated in the northern part of old Ondo State, its north – south extent boundary with Kogi State at Iye/Eruku and south boundary with Ikere/Iju boundary along 5, 30° E) is 88 kilometres while the West – East extent borders Osun State at Itawure/Ijebu – Ijesa and east boundary with Omuo/Igasi along latitude 7° 70' is 100 kilometres. The State is mainly an upland zone, rising over 250 meters above sea level. The highest contour line of 540m above sea level is found around the North Eastern limit of the state (Simon – Oke et al., 2012).

It lies on an area underlain by metamorphic rock and is potentially rich in mineral deposits which include granite, kaolin, columbite, channockete, iron ore, barite, aquamine, gemstone, phosphate, limestone, gold among others largely deposited in different towns and villages within the State (www.wikipedia.org). Ekiti State has a rhythmically undulating surface. It has a characteristic landscape that consists of ancient plains broken by steep – sided outcropping dome rocks that may occur singularly or in groups or ridges. The State is dotted with rugged hills (www.wikipedia.org). The State enjoys tropical climate with two distinct seasons. These are the rainy season (April – October) and dry season (November – March. Ekiti State has a small temperature range; the temperature ranges are almost constant throughout the year (www.wikipedia.org). The Temperature ranges between 21°C and 28°C with high humidity.

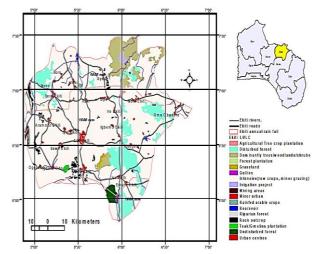


Figure 1: Land use and land cover map of the study area (Source: EKSG, 2009).

2.2 Location of sampling sites

A portable Garmin handheld Global Positioning System (GPS) receiver was used in locating the sampling sites. The locations of the soil samples (in UTMZone 31 N coordinate system) were determined in the field using the GPSMAP 76CSx with an accuracy of less than 5 m. On each field, a subsample of the field (10 m \times 10 m) was delineated for sampling. Each field was sampled through composite sampling "following the '5' on a dice procedure" (Velasquez et al., 2007). At each location, 5 replicates of the soil samples were collected; at four extremes of the delineated field and one at the centre; using a soil auger. All the five samples per field were mixed together to obtain a homogenized sample per field for analysis. From each plot, soil samples were bagged for laboratory analysis and labelled clearly with a permanent maker.

2.3 Experimental procedure and soil sampling

Soil sampling and field experiments were carried out across the different land uses and land cover types. Field experiments were carried out in 40 different locations in Ekiti State to determine the physical properties of soils of the study area. Surface composite of disturbed soil samples to depths of 15 cm were collected from the study areas. Three sampling points were randomly selected per field location approximately 20 m apart. The different land uses studied include oil palm plantation, Teak/Gmelina plantation (TCP), woodlands/shrubs/grasslands (WGS), intensive row crops (CP), and natural forest (FOR). These land uses were categorized under croplands (20 locations), forest (10 locations), woodland and grassland (6 locations) and tree crop plantation (4).

The four land uses represent the treatment with different numbers of replicates (sampling points) as stated. Undisturbed soil samples were collected up to the 30 cm depth at an interval of 10 cm using stainless steel cylindrical cores of height 10 cm and diameter 5.5 cm. Hand trowel was used to dig round the cylinder to ease the removal of the soil core, while maintaining an undisturbed sample The soil extending beyond each end of the sample holder was trimmed to ensure soil is contained in exactly the volume of the cylinder. Thus, the soil sample volume was established to be the same as the volume of the sampler holder. The sampling was performed in segments to reduce the compaction of the fine-textured soil. The samples were packed in plastic container and transferred to the laboratory for further analysis. The samples were allowed to dry in the open air until reaching friability.

2.4 Measurements

2.4.1 Physical Characteristics of Soil

Physical characterization of the various soil samples collected from all locations were conducted at the Soil research laboratories of the Federal University of Technology Akure using standard procedures. Soil particle size distribution was determined using hydrometer method (Bouyoucos, 1963). The bulk density was obtained by the gravimetric soil core method described and the particle density (PD) was assumed to be 2.65 g cm–3 (Osunbitan et al., 2005; Li and Shao, 2006; Price et al., 2010; Blake and Hartge 1986). The total porosity (PT) was obtained from BD and PD using the equation and relationship developed (Danielson and Sutherland, 1986). The micro and macro porosities were obtained following the method described (Fasinmirin and Adesigbin, 2015). The water holding capacity was determined ad describes (Ibitoye, 2006). The "degree of compaction" or "relative compaction" of the soil, DC (%), is defined as:

$$DC = \frac{BD}{BDref} X 100 \tag{1}$$

where, BD is the dry bulk density and BDref is the wet bulk density of the same soil in a reference state obtained at laboratory (Fasinmirin and Adesigbin, 2012).

2.5 Statistical Analysis

Soil physical properties were compared using Pearson correlation coefficient at 1 and 5% significant levels and the existence of interrelationships between data set was tested by linear correlation. Soil properties data were subjected to One-way Anova and Tukey test at 5% level of significance. was used to test for significant difference among the treatments using Minitab 18 statistical software.

3. RESULTS AND DISCUSSIONS

3.1 Soil Textural Classification

The soil particle size distribution of the various land use types (CP, FOR, TCP, WGS) is presented in Table 1. The mean sand contents for CP, FOR, TCP and WGS land use types are 56.40%, 55.40%, 58.80% and 54.80%, respectively while the mean values of clay in CP, FOR, TCP and WGS land use types are 28.70%, 30.80%, 28.20%, and 29.20%, respectively. The mean silt content ranged from 13.00% to 15.33% in TCP and WGS, respectively. Sampled soils did not show significant difference in the sand, silt and clay contents of the various land use types (Table 1). The soils' textural classes ranged from sandy loam to sandy clay loam. The sandy clay loam textural class was the most common across all land use types. It can be deduced from the result that soil textural class in a given land use can influences the kind of vegetation that grows in the area. In areas where we have high clay content, it could be due to sorting of soil materials, clay migration or surface erosion by runoff or combination of these factors (Ojanuga, 2003).

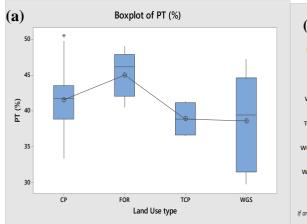
Table 1: Summary Statistics of Soil Particle Size Distribution for Different Land Uses						
Properties Land Uses/Covers						
	CP	FOR	TCP	WGS		
Sand (%)	56.40a	55.40a	58.80a	54.80a		
	(±8.98)	(±9.34)	(±7.66)	(±11.24)		
Clay (%)	28.70a	30.80a	28.20a	29.20a		
	(±6.77)	(±8.04)	(±7.57)	(±9.03)		
Silt(%)	14.10a	13.80a	13.00a	15.33a		
	(±3.972)	(±3.82)	(±2.00)	(±4.68)		

The combined effects of parent materials (Coastal Plain Sands) could result to sandy nature of the soils, land use and climate (Enwezor et al., 1990; Uzoho, 2005; Onweremadu, 2007). Low values of silt and clay is an indication that the soils are highly weathered and pedogenically ferraltic in nature (Essoka and Esu, 2000; Oguike and Mbagwu, 2009). Similar observation has been reported for most Ultisols of varying land use types in Southwestern Nigeria (Anikwe,2003; Onweremdu 2007; Uzoho et al., 2007).

3.2 Total Porosity, Micro Porosity and Macro Porosity

The average total porosity (PT) of the various land use types ranged

between 38.61% and 45.01% and differed significantly among the four (4) land use types (p < 0.05) (Figure 2(a) and (b); Tables 2 and 3). Mean PT values showed a decreasing trend in the order: FOR (45.01%) > CP (41.48%) > TCP (38.87%) > CP (38.61%) (Table 2). FOR soils has higher PT compared to the other land use types because soils rich in biological activity tend to have more total porosity than soil poor in biological activity. This is because soil fauna creates new pore with a high volume, which tends to increase soil porosity (Kay and Angers, 2002). Crop land and other land uses with low porosity may be due to intensive crop cultivation, which tends to increase their compassion level and disrupt the continuity of the soil pore, lowering soil porosity in comparison to forest soils. The decrease in porosity could also be attributed to a decrease in organic matter content.



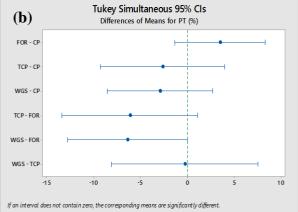


Figure 2: Box plot (a) and difference of means (b) of total porosity (PT) of the various land use types

Table 2: Summary statistics for surface soil parameters under different land uses. Mean (SD)						
Properties	Land Uses/Covers					
	СР	FOR	TCP	WGS		
BD (g/cm³)	1.55 ^{AB} (±1.55)	1.46 ^A (±1.46)	1.62 ^{AB} (±1.62)	1.63 ^A (±1.63)		
PT (%)	41.538 ^{AB} (±4.45)	45.01 ^A (±3.19)	38.87 ^{AB} (±2.47)	38.61 ^A (±6.73)		
MIC (%)	21.30 ^A (±5.99)	22.82 ^A (±6.37)	20.90 ^A (±5.52)	19.41 ^A (±2.59)		
MAC(%)	20.24 ^A (±7.60)	22.19 ^A (±6.87)	17.97 ^A (±4.59)	19.20 ^A (±5.72)		
DOC (%)	87.929 ^A (±3.343)	86.44 ^A (±3.39)	88.54 ^A (±2.97)	89.150 ^A (±2.04)		
VMC (m ³ m ⁻³)	21.62 ^A (±5.67)	23.07 ^A (±6.51)	21.03 ^A (±5.61)	19.61 ^A (±2.65)		
WHC (%)	39.78 ^A (±6.37)	52.27 ^B (±7.73)	41.35 ^A (±5.11)	41.67 ^A (±6.44)		

 $\mbox{CP=}$ Crop land. FOR= Forest. TCP= Tree crop plantation. WGS= woodlands/Grasslands

Table 3: Analysis of Variance of the physical Soil Properties between land uses						
PROPERTIES	MEAN SQUARE	ERROR	F-VALUES	P- VALUES		
BD	0.04402	0.01408	3.13	*		
PT (%)	62.69	20.04	0.44	ns		
MIC (%)	14.30	32.31	0.42	ns		
MAC(%)	20.35	48.64	1.00	ns		
DOC (%)	10.04	10.04	1.00	ns		
VMC (m ³ m ⁻³)	14.83	30.81	0.48	ns		
WHC (%)	361.21	44.27	8.16	***		

*** = $P \le 0.001$; ** = $P \le 0.01$; * = $P \le 0.05$ ns = not significant

Micro porosity (MIC) and macro porosity (MAC) values were not significantly affected by land use types (p > 0.05) (Figures. 3 and 4; Tables 2 and 3). However, FOR has the highest average MIC and MAC values, while the least average MIC and MAC values were recorded in WGS and TCP land use types, respectively (Table 2). The macro-pores characteristically allow readily movement of air and drainage of water.

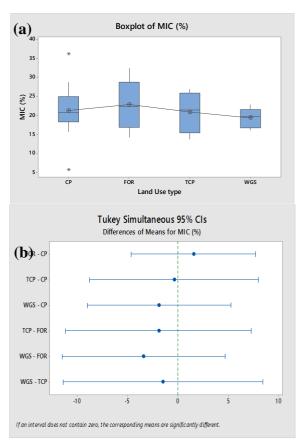
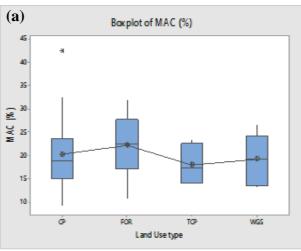


Figure 3: Box plot **(a)** and difference of means **(b)** of micro porosity (MIC) of the various land use types



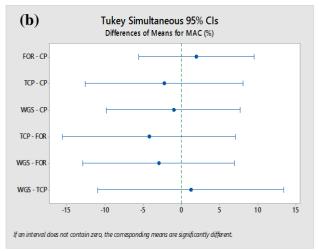


Figure 4: Box plot (a) and difference of means (b) of macro porosity (MIC) of the various land use types

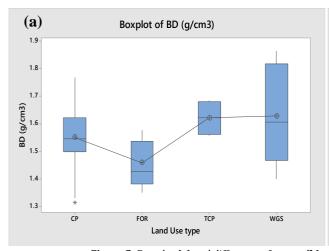
The high PT and MAC values found in FOR soils could be attributed to the activities of macro-organisms such as earthworms, rodents, and insects, which increase soil macropores. Tillage in the other land uses may reduce the macro-pore space and produces a discontinuity in pore space between the cultivated surface and the subsurface soils. According to lke and, there is a close relationship between relative compaction and soil macro porosity (Aremu, 1992). In general, intensive cultivation causes more compaction and degradation of soil properties.

3.3 Bulk density

Bulk density (BD) values were significantly (p < 0.05) affected by land use types (Tables 2 and 3, Fig. 5). Relatively the highest bulk density (1.86 g cm⁻³) was recorded under WGS land use, while the lowest bulk density value (1.46 g cm⁻³) was recorded in FOR land use type. Generally, the bulk density ranged from WGS to FOR in the order WGS > TCP > CP > FOR. (Table 2). WGS land use type has a significantly high mean bulk density

than FOR land use type (p < 0.05). However, the WGS and other land uses show no significant different in BD. (Figure 5). Study by revealed significant difference in bulk density among the different land uses (Fu et al., 2004). Highest BD recorded in the WGS soils might be due to the impact of minor grazing activities observed in the woodlands of the study area.

Animal grazing causes the formation of compacted soil layers because animal trampling exerts significant pressure on the soil (Fasinmirin et al., 2018). On the other hand, undisturbed forest soil had relatively lower bulk density, because of the low human activities in the forest. Higher levels of organic matter (OM) in forest soils make the soil loose, porous, and well-aggregated, which may have reduced BD. Organic matter-rich land was discovered to have a lower soil bulk density value than conventional land (Liebig and Doran, 1999). Others have reported similar patterns of bulk density in forest soils (Lemenih et al., 2005; Lisboa et al., 2009; Islam and Weil, 2000). TCP and CP fell in the middle class because there are human activities that causes increase in bulk density but its effect is minimal to the grazing effect on WGS soil.



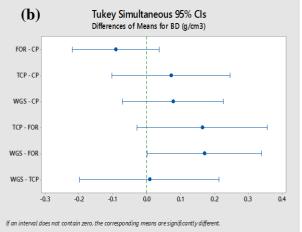
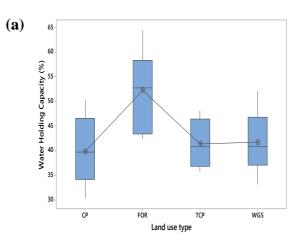
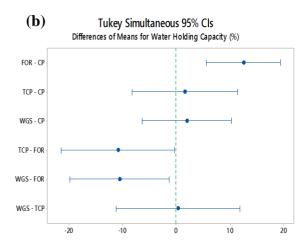


Figure 5: Box plot (a) and difference of means (b) of bulk density (BD) of the various land use types

3.4 Water holding capacity

The mean WHC of the soils under various land use types ranged from 39.78 to 52.27%. Land use types had a significant (p < 0.005) impact on soil WHC (Tables 2 and 3). There was significantly higher WHC in FOR than other land use types (TCP, CP and WGS) (Figure 6). Higher WHC levels in forest soils could be attributed to higher organic matter content, which increases the soil's affinity for water (Olorunfemi et al., 2016). Soil organic matter can store a quantity of water equal to a multiple of the organic matter's weight (De Jong et al., 1983; Hudson 1994; Emerson 1995). Biological activity also improves soil aggregation, aeration, water retention capacity, and infiltration rate (Jastrow et al., 1998). A group researchers discovered that forest soils have a significantly higher VMC at field capacity than pasture and lawn soils by nearly 20% (Price et al., 2010).





If an interval does not contain zero, the corresponding means are significantly different.

Figure 6: Box plot (a) and difference of means (b) of water holding capacity (WHC) of the various land use types

3.5 Volumetric Moisture Content (VMC)

The volumetric moisture content was not significantly (P > 0.05) affected by land use (Tables 2 and 3; Figure 7(b)). The results, however, show that the forest (FOR) land use type had the highest mean VMC, while the WGS land use type had the lowest (Figure 7(a)). The high VMC in FOR could be attributed to its high soil organic matter content (SOM) (Oguike and Mbagwu, 2004). Soil organic matter (SOM) improves the soil's ability to retain moisture (Ugarte et al., 2014). The observed results generally demonstrated that soils with different land uses may differ in their water content at both FC and PWP due to differences in sand, silt, and clay contents, as correctly observed (Yeshaneh, 2015).

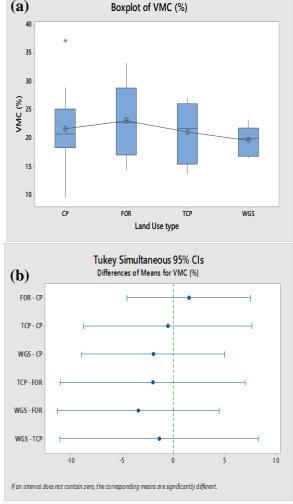


Figure 7: Box plot **(a)** and difference of means **(b)** of volumetric moisture content (VMC) of the various land use types

3.6 Degree of compaction (DOC)

The degree to which soil is compacted is affected by a number of factors, including particle size, density, organic material, and mineralogy (Howard, Singer et al., 1981). The average DOC of CP, FOR, TCP and WGS is 87.93%, 86.44%, 88.54%, and 89.15%, respectively (Table 2 and Figure 8(a)). The DOC was not significantly affected (p > 0.05) by different land uses (Table 3 and Figure 8(b)). The least DOC recorded in FOR soils may be due to the undisturbed nature of the forest and to low bulk density observed in the forest soils. High organic matter content of the study areas may also act to the less degree of compaction in the forest soils. Water content and the degree of compaction had an inverse relationship (Soane et.al., 1981). Increase in volumetric soil moisture decreases the degree of compaction. Soil compaction has long been recognized as a major physical threat to soil fertility. Soil compaction affects nutrient transformations and uptake by altering the soil's hydraulic, aeration, and diffusive properties, as well as root growth and configuration (Soane, 1994).

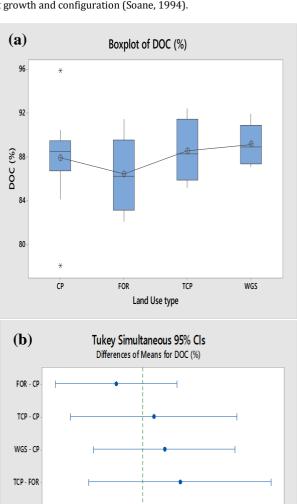


Figure 8: Box plot **(a)** and difference of means **(b)** of degree of compaction (DOC) of the various land use types

5.0

7.5

-2.5

If an interval does not contain zero, the corresponding means are significantly different.

4. CONCLUSION

WGS - FOR

WGS - TCP

Textural class of the study site (Crop plantation (CP) and Forest (FOR) land use types) were predominantly sandy clay loam and clay loam. Soil of the Forest land use type were characteristically high in total porosity (micro and macro porosities) and low in bulk density. The high PT and MAC values found in FOR soils could be attributed to the activities of macroorganisms such as earthworms, rodents, and insects, which increase soil macropores. Highest BD recorded in the WGS soils might be due to the impact of minor grazing activities observed in the woodlands of the study area. Higher levels of organic matter (OM) in forest soils make the soil

loose, porous, and well-aggregated, which may have reduced BD. Higher WHC levels in forest soils could be attributed to higher organic matter content, which increases the soil's affinity for water. The least DOC recorded in FOR soils may be due to the undisturbed nature of the forest and to low bulk density observed in the forest soils. High organic matter content of the study areas may also act to the less degree of compaction in the forest soils. Soil compaction has long been recognized as a major physical threat to soil fertility. The results revealed that different land use types have different effects on soil properties, allowing for a better understanding of soil attributes under various land use types.

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