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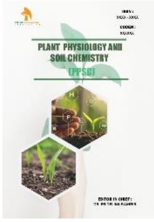

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RESEARCH ARTICLE

LAND USE MANAGEMENT IMPACTS ON SOIL CHEMICAL PROPERTIES IN EKITI REGION, FOREST VEGETATIVE ZONE OF NIGERIA

Akinola, Florence Funke

Department of Agricultural and Bio-Environmental Engineering, Federal Polytechnic, Ado Ekiti. Ekiti-State.
****Corresponding Author Email: funkeakinola93@gmail.com***

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ABSTRACT

The study was conducted to assess the impacts of varying land use/land cover types (croplands, forests, tree crop plantation and woodland/grasslands) on the chemical properties of soils in Ekiti State, Southwestern Nigeria. Soil sampling and field experiments were carried out across the different land uses and land cover types. Completely 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 (20 m apart). The textural classification of the study areas was predominantly sandy clay loam. Land use types did not have significant effect on the soil pH ($p>0.05$). The Total N for all the land uses ranged from 0.04 - 0.86 %. Mean concentrations of SOC differed significantly among the various land uses. Mean SOC decreased in the order FOR > TCP > WGS > CP. The results of chemical properties of the soils of the study sites showed that the soil properties vary with different land use types.

KEYWORDS

Ekiti-State, Land use, Soil fertility, Soil conservation, Soil organic matter

1. INTRODUCTION

Land-use and land-cover change studies have provided critical inputs to large-scale biomass and forest cover assessments; future aims include reducing uncertainties in biomass estimates, understanding regional heterogeneities in changes, and quantifying linkages and feedbacks between land-use and land-cover changes, climate change, and other human and environmental components. Therefore, land-use and land-cover change will be the focus of scientific researches for a long time to come (Matson *et al*., 1997; Gol, Dengiz, 2008). Many researchers reported that the conversion of natural forest to other forms of land use can provoke soil erosion and lead to a reduction in soil organic content, lost soil quantity and modification of soil structure (Lichon, 1993; Chen et al., 2001). In their study, they indicated that soil organic matter content decreased from 38.02 g kg^{-1} to 25.76 g kg^{-1} in the past 20 years (1982–2003) after transformation of forestland into cultivated lands. These changes in organic matter content following land transformation can connect distribution and stability of soil aggregates (Elliott, 1986). Soils sustain the forest and provide raw materials for its life by recycling fallen leaves, woody debris, and dead animals. The soil in order to supply the main needs to trees has to be a mixture of air, water, decaying organic and inorganic material and billions of living organisms within the surrounding ecosystem. Land use changes such as forest clearing, cultivation and pasture introduction are known to result in changes in soil chemical, physical and biological properties, yet the sign and magnitude of these changes vary with land cover and land management (Baskin, Binkley, 1998; Celik, 2005; Houghton et al., 1999). Therefore, the objective of this study was to identify the varying land use types and determine the effects of land use/cover changes on the chemical characteristics of soils in Ekiti State, Nigeria.

2. METHODOLOGY

2.1 Study Area

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 km^2 (2, 453 sq ml). 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.

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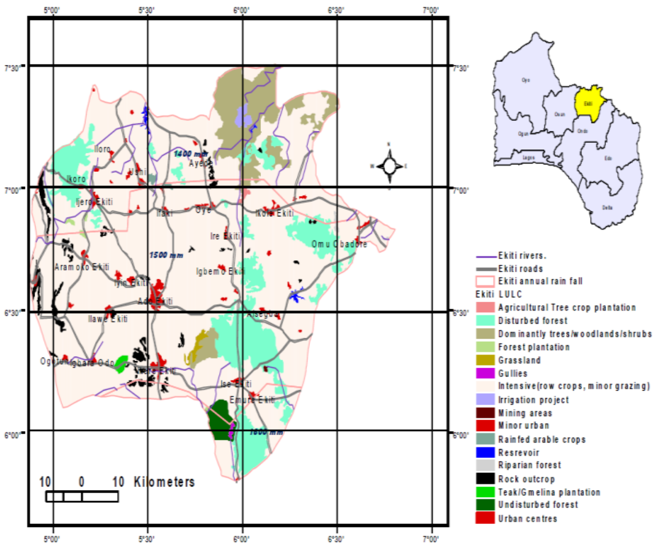


Figure 1: Land use and land cover map of the study area (Source: EKSG, 2009).

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 × 10 m) will be delineated for sampling. Each field will be sampled through composite sampling "following the '5' on a dice procedure" (Velasquez et al., 2007). At each sampling point, 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 chemical properties of soils of the study area. Surface composite disturbed and undisturbed soil samples to depths of 30 cm were collected from the study areas. Three sampling points were randomly selected per field location (20 m apart). The different land uses studied include Teak/Gmelina plantation (TCP), oil palm plantation and banana plantations (CP), dominantly trees/woodlands/shrubs/grasslands (WGS), intensive (row crops and minor grazing), and natural forest (FOR). These land uses were categorized under croplands (20 locations), forest (10 locations), woodland, grassland and shrubs (6 locations) and tree crop plantation (4). The four land uses represent the treatment with different numbers of replicates (sampling points) as stated. Completely Randomized Design (CRD) was used where there were "within the treatment variation" and "between the treatment variations". Disturbed soil samples were collected using soil environmental auger. Undisturbed soil samples were collected using stainless steel cylindrical cores of height 10 cm and diameter 5.5 cm. The samples were packed in plastic bags, 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 Chemical characterization of soils

Chemical characterization of the collected soil samples included the analysis of organic matter (SOM), organic carbon (OC), cation exchange capacity (CEC) at pH 7.0, base saturation, Al^{3+} saturation and soil pH. Six samples were collected at each location and bulked together for soil chemical characterization. The organic carbon was determined using the Walkley - Black wet oxidation procedure and the soil organic matter content was determined from the organic carbon (Nelson and Sommers, 1996). The cation exchange capacity (CEC) at pH 7.0 was determined following the procedure compiled and described by (Reeuwijk, 2002). Extractable phosphorus (P) and exchangeable cations were also determined by Bray-1 extraction followed by molybdenum blue colorimetry (Frank et al., 1998). The exchangeable potassium (K^+) and sodium (Na^+) was extracted with HCl solution and their levels determined by flame photometry and exchangeable magnesium (Mg^{2+}) and calcium (Ca^{2+}) by atomic absorption spectrophotometer (Vogelmann et al., 2010; Senjobi and Ogunkunle, 2010). Soil pH was determined in distilled water using the pH meter with water ratio of 1:2.

2.5 Statistical Analysis

Soil chemical properties were compared for the A horizon using Pearson correlation coefficient at 1 and 5% significant levels and the existence of inter-relationships between data set was tested by linear correlation. Soil properties data were subjected to the Tukey test at 5% level of significance. One-way Anova was used to test for significance among the treatments and post hoc comparison was used to compare the chemical properties and the existence of inter-relationships between data set was tested by linear correlation and the correlation coefficients determined at the 5% level significance.

3. Results and Discussion

3.1 Soil pH

Land use types did not have significant effect on the soil pH ($p>0.05$). However, TCP has the highest soil pH of 5.09 (±0.49) while FOR has the least mean soil pH of 4.78 (±0.14) (Figure 2). The high acidity observed under the forest soil types might be due to severe base leaching by the high tropical rainfall (Lal, 1996; Ndukwu et al., 2009). On the other, the high pH values recorded under the TCP is because of high rainfall water retention. In general, the pH of the soils for the various land use ranged from 4.45 - 5.75%. The soil pH of the different land use types was moderately acidic following the classification of soil pH according to the United States Department of Agriculture Natural Resources Conservation Service (soil survey manual, 1993).

The pH of the soils for CP ranged from 4.47 - 5.62% (±0.26), the pH of the soils for FOR ranged from 4.45 - 4.91% (±0.15), the pH of the soils for TCP ranged from 4.57 - 5.75% (±0.49), the pH of the soils for WGS ranged from 4.82 - 5.31% (±0.16). Low pH values of the various land use types could be ascribed to inorganic fertilizer application and It could also be due to the abundance of Iron and Aluminum ions and the resultant net reduction in the soil pH (Olson and Sommers, 1990).

Table 1: Summary Statistics for chemical properties for different land use

Properties	Land Uses/Covers			
	CP	FOR	TCP	WGS
pH	4.9435^{a}(±0.2564)	4.7760^{a}(±0.1504)	5.090^{a}(±0.4890)	5.0683^{a}(±0.1633)
P (mg/kg)	15.22^{a} (±39.30)	8.54^{a} (±4.03)	7.70^{a} (±3.14)	10.36^{a} (±0.1633)
TN (%)	0.1930^{a}(±0.1416)	0.4500^{ab}(±0.1998)	0.2575^{b}(±0.1721)	0.2167^{b}(±0.1341)
OM (%)	2.012^{a} (±0.173)	4.008^{b} (±0.974)	2.370^{b} (±1.104)	2.258^{b} (±1.013)
K (cmol/kg)	0.4405^{a}(±0.1446)	0.14820^{a}(±0.1348)	0.3950^{a}(±0.0926)	0.4683^{a}(±0.1584)
EC (cmol/kg)	68.900^{a}(±3.095)	68.300^{a} (±4.030)	66.170^{a} (±5.250)	64.750^{a} (±3.190)
Na (cmol/kg)	0.3450^{a}(±0.1242)	0.3740^{a} (±0.1456)	0.4125^{a}(±0.1775)	0.4400^{a}(±0.2057)
Ca (cmol/kg)	1.945^{a}(±0.519)	2.890^{ab} (±1.577)	1.900^{ab}(±0.753)	1.417^{a}(±0.560)
Mg (cmol/kg)	0.8450^{A}(±0.2395)	1.320^{AB} (±0.1781)	0.850^{B} (±0.311)	0.650^{B} (±0.281)
CEC (cmol/kg)	3.576^{A} (±0.803)	5.066^{B} (±2.269)	3.558^{AB}(±1.085)	2.975^{B} (±0.913)

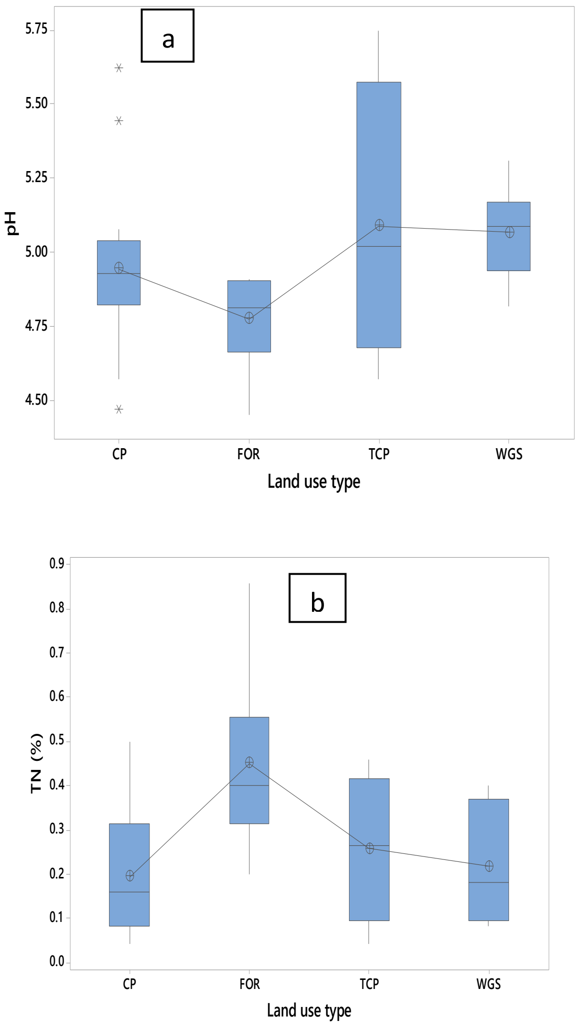


Figure 2: Mean difference of (a) pH and (b) Total Nitrogen for different land uses

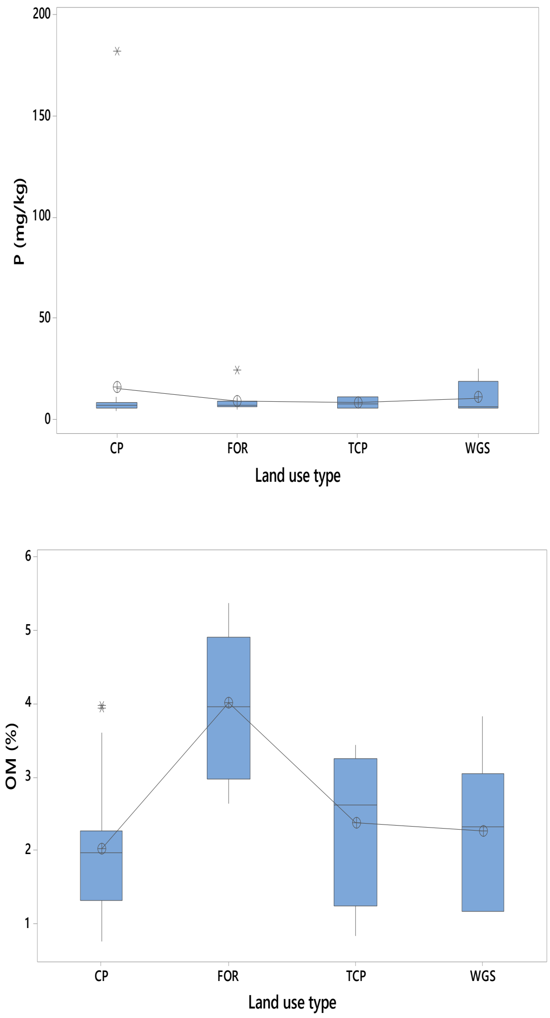


Figure 3: Mean difference of (a) P and (b) Organic matter (OM) for different land uses

3.2 Total Nitrogen

Land use types has significant effect on the soil Total Nitrogen ($p<0.05$). However, FOR has the highest soil TN of 0.45% (±0.20) while FOR has the least mean soil TN of 0.19% (±0.14) (Figure 2b). Total N for CP ranged from 0.04 - 0.5% (±0.14), Total N for FOR ranged from 0.2 - 0.86% (±0.20), Total N for TCP ranged from 0.04 - 0.46 (±0.1721), Total N for WGS ranged from 0.08 - 0.4 (±0.13). In general, the Total N for all the land uses ranged from 0.04 - 0.86% (Table 1). It has been indicated that total N constitutes the bulk of soil organic carbon in the tropics (Akamigbo 1999; Igwe et al., 1999; Noma et al., 2005; Anikwe, 2010). Mean N values in soils of the various land uses were below critical value of 0.15% (1.5%) for soils (Agboola and Corey, 1973; Senjobi and Ogunkunle, 2011). Low N values of the soils could be due to the rapid mineralization of soil organic matter, intense and leaching and erosion due to the high tropical rainfall (White and Reddy, 1999; Anikwe, 2003; Isirimiah et al., 2003; Senjobi, 2007; Uzoho et al., 2007). Variation amongst land uses were at decreasing sequence of FOR (0.450 and 0.35%) > TCP (0.26 and 0.09%)> WGS (0.22 and 0.09%) > CP (0.193% and 0.13%). The FOR was significantly (LSD 0.05) higher than the other land uses.

3.3 Available Phosphorus

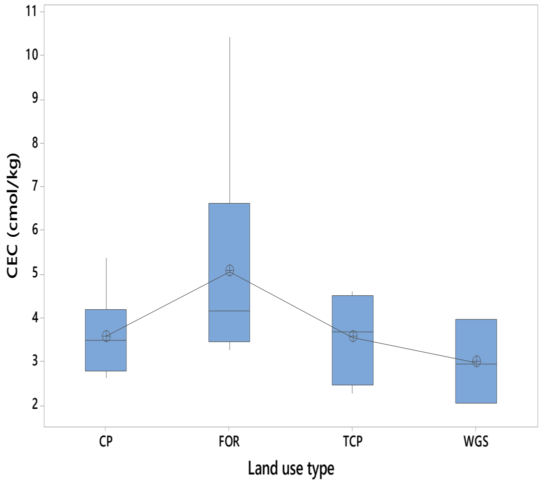
Land use types has no significant effect on the soil P ($p>0.05$). However, CP has the highest soil P of 15.22 mg/kg (±39.30) while TCP has the least mean soil P of 7.70 mg/kg (±3.14) (Figure 3a). Available P ranged from 3.66-182 mg/kg (Table 1) and fluctuated moderately. Mean concentrations differed (LSD 0.05) and better in WGS and CP compared to TCP and FOR probably due to increased litter accumulation. In general, values of the various land uses were low compared to critical levels for soils of southwestern Nigeria probably due to high sorption reaction (Uzoho, 2005). Low values for the soils suggest the need for P fertilization to sustain crop yields.

3.4 Soil organic matter (SOM)

Soil organic matter ranged from 0.76 - 5.38% (±0.97-1.10) for all the land uses considered. Mean concentrations of SOM differed significantly among the various land uses. Mean SOM decreased in the order FOR (4.00%) > TCP (2.37%) > WGS (2.26%) > CP (2.01%) (Figure 3b) with FOR having the highest compared to the other land uses. Higher SOM concentration recorded in the forest soils could be due to high litter accumulation from leaf drops. Low organic carbon content of CP compared to others could be due to rapid decomposition and depletion of plant materials (Uzoho *et al.*, 2007). The general low levels recorded in the CP could be as a result of management practices involving high burning and intensive land use as well as the reduction in fallow period (Akinrinde and Obigbesan, 2000 ; Anikwe 2010). Reduction in soil organic matter due to conversion of forests into more intensive land uses have been reported (Anikwe, 2003; Uzoho, 2005; Senjobi, 2007; Uzoho *et al.*, 2007; Onweremadu *et al.*, 2008; Ndukwu *et al.*, 2009; Anikwe, 2010). Values of soil organic carbon of the various land uses are within the range of critical levels of 1.5–2.0% for tropical soils and 2.5, 3.0 and 3.5% for soils of Western, Northern and Eastern Nigeria respectively (Akinrinde and Obigbesan, 2000; Enwezor, *et al.*, 1990).

3.5 Exchangeable Cations and Cations Properties

Land use types has significant effect on the soil CEC ($p<0.05$). However, FOR has the highest soil CEC of 5.07 (±2.269) cmol/kg while WGS has the least mean soil CEC of 2.98 (±0.913) cmolkg (Figure 4a). Cation Exchange Capacity (CEC) of the soils ranged from 2.01-10.43 cmolkg and varied minimally (CV=0.804-2.82%). Mean values varied as 5.066 cmol/kg and 3.58 cmol/kg (FOR and CP), 3.56 cmol/kg and 2.98 cmol/kg (TCP and WGS) land use types. Soil CEC has been classified into low, medium and high with values as < 6, 6-12 and > 12 cmol/kg respectively (Adepetu et al., 1979). This shows that for the soils studied, CEC is low attributable to their high weatherability (Noma et al., 2005). It has been indicated that the low CEC of tropical soils is due to the dominance of kaolinitic clay in their fine earth fraction (Eshett 1995; Uzoho *et al*., 2007).



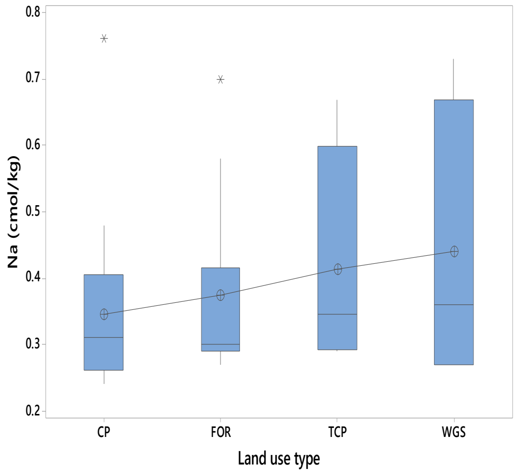
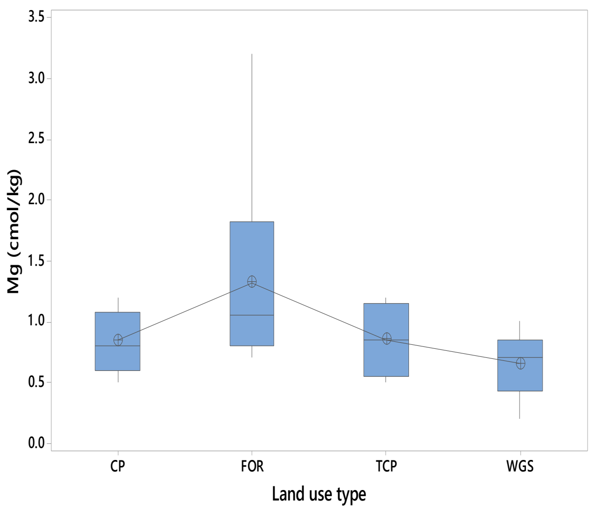


Figure 4: Mean difference of (a) CEC and (b) Na for different land uses

3.5.1 Exchangeable cation

Ca/Mg ratio ranged from 0.24 – 6.5 for all the land uses and varied moderately. Mean values varied as 2.34 for land use CP, 2.22 for land use FOR, 2.21 for land use TCP and 2.28 for land use WGS (Figure 5). According to Ca/Mg values less than 12.0 indicate low fertility (Landon, 1991). This shows that soils under the land uses are of low fertility probably due to intense land use practice and excessive loss of Ca through leaching by the high tropical rainfall (Landon 1991, Onweremadu 2007). Addition of lime and organic manure can be used to supply Ca and improve soil fertility under the land use types (Uzoho *et al*., 2007).



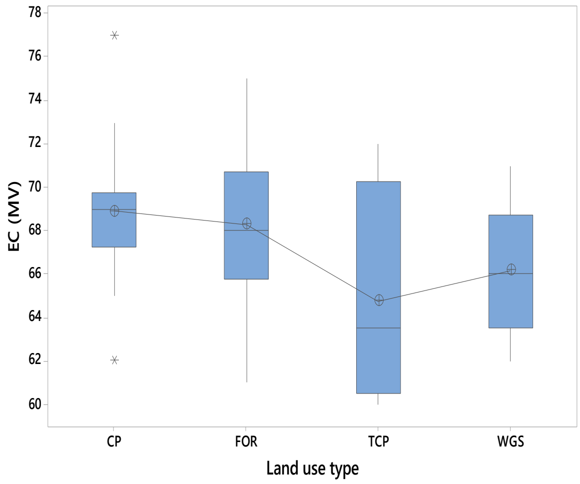


Figure 5: Mean difference of (a) Mg and (b) EC for different land use

Exchangeable Ca ranged from 0.25-10.3 cmol/kg with moderate (CV = 5.45–21.72%) and a concentration of exchangeable Ca were low, Mg ranged from 0.2-1.1 cmol/kg, Na ranged from 0.24-0.76cmol/kg and K from 0.25- 0.72cmol/kg. Mean exchangeable base distributions varied as 2.27 and 2.26 cmol/kg. Percentage base saturation ranged from 60-77% with minimal variation. Mean values for the various land uses were 68.90%, 68.30%, 66.17% and 64.75% for CP, FOR, WGS and TCP respectively. Percent base saturation was generally attributable to poor base concentration due to intense leaching by the high tropical rainfall (Anikwe, 2003; Ndukwu *et al*., 2009; Senjobi and Ogunkunle, 2011).

4. CONCLUSION

Soils of different land use types: Forest, Tree crop plantation, Woodland, grassland and shrubs were studied. The principal objective was to determine the effect of different land use types on chemical properties of soils in the sixteen (16) local government areas of Ekiti state. The study also determined the relationship among soil properties in different land use types. It is obvious from this research that chemical properties of the soils of the study sites vary with different land use types. The pH was acidic. Total nitrogen was generally low in all the soils of different land uses. Exchangeable cations and Cation Exchange Capacity (CEC) varied with irregular pattern of decrease.

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