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VARIATIONS IN SOIL PROPERTIES AS INFLUENCED BY LAND USE AND SOIL DEPTH IN A DERIVED SAVANNAH ECOLOGY OF SOUTH-WESTERN NIGERIA.

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ABSTRACT

Soil physical and chemical properties are strongly influenced by soil management systems and changes in land use. The study was carried out in Iseyin LGA of Oyo state which is a derived savannah zone under four different land use types' arable, grazing, fallow and tree crops. A total of twenty four soil samples were collected at two depths i.e. 0-15cm and 15-30cm, from the study area using the cluster sampling technique, profile pits were also dug on each land use type so as to classify the soil. The samples were subjected to both physical and chemical analysis to determine the fertility status of the area. Soil textural fractions varied with land use with the sand particles having the highest percentage of 76.2 % and 71.5% under arable and tree crops land use. This was followed by silt and clay fractions with values of 27.2 % and 10.64 % respectively in the grazing areas. The soils of the areas are mostly sandy loam and it also varied with depth with the top soil having higher particles than the sub soil. With respect to the soil chemical properties, the organic carbon content of the soils was generally moderate; it varied from 0.91% to 1.68 % for 0-15 cm depth while at 15-30 cm it ranged between 0.40 % - 1.24 %. The pH varied significantly with land use while the total nitrogen did not show any significant difference with all the land use types and soil depth, it ranged between 0.03 % - 0.08%. Available phosphorus and potassium contents were also not significant across all the land use types and soil depth.
Keywords: Land use, variation, soil depth, soil physical and chemical properties.

INTRODUCTION

Land use can be referred to as the use to which a piece of land is put and this centers on the human activities that relate to a particular parcel of land. Land use varies from one place to another be it a Country, State, City or Local Government Area. Land use change shows a profound impact on the soil and environment as a result of the progressive growth of population and improvement of living standards which has lead the world to the increased demand for food and water, The past management of agriculture and terrestrial ecosystems has imposed so much pressure on the soil capacity and the environmental performance in order to meet the needs of the growing human population so as to maintain the global balance of matter and energy. Land use change affects the global climate via the carbon cycle and the water cycle through changing evapo-transpiration and hydrological regimes as well as biotic diversity, soil degradation, and the ability of biological systems to support human needs (Lambin *et al.,* 2003). Although, there is a bi-modal rainfall pattern in most South West derived savannah ecology, the predictability of two planting seasons is becoming unreliable in the face of current reality in weather variability.

Majority of land use changes are related to agricultural use of the land in form of arable lands, plantations, cultivated lands including pastures and so on. Agricultural activities change the soils chemical, physical and biological properties. Such activities include tillage (mechanized or by hand), weeding, terracing, sub-soiling, deep ploughing, manure application, composting and fertilizer applications, liming, draining and irrigation (Bridges and de Bakker, 1997). All these activities have a positive or negative effect on soil fertility which is commonly defined as the inherent capacity of a soil to supply plant nutrients in adequate amounts, forms, and in suitable proportions required for maximum plant growth through sustainable management practices. (Von Uexkuell, 1988).

Management practices have a great effect on the direction and degree of changes in soil properties while soil management systems play an important role in sustainable agriculture and environmental quality. According to Hulugalle *et al.* (1997) soil physical and chemical properties are strongly influenced by soil management systems and changes in land use. Thus, land use practices affect the distribution and supply of soil nutrients by directly altering soil properties and by influencing biological transformations in the rooting zone. For instance, cultivation of forests diminishes the soil carbon (C) within a few years of initial conversion and substantially lowers mineralization of Nitrogen (N), and these factors are critical for soil health (Murty *et al.,* 2002).

The variation of soil properties should be monitored and quantified so as to understand the effects of land use and management systems on soils. The main consequences of inappropriate land use changes are land degradation and soil quality deterioration through loss of vegetative cover, reduced infiltration capacity, low soil organic matter content, low fertility status and so on. Variability of soil properties has been studied extensively based on remotely sensed and field measured data (Famiglietti *et al.,* 1998; Hu *et al.*, 2008; She and Shao, 2009).

Land use affects soil fertility and productivity and this manifests as changes in soil properties such as nutrient content (N, P, K, Ca, Mg, S etc), pH, organic matter, CEC, structure etc (Aluko and Fagbenro 2000, Akinrinde and Obigbesan 2000, Akamigbo and Asadu 2001). Therefore, knowledge of soil properties is important in determining the use to which a soil can be put (Amusan *et al.* 2006). Soil physical properties deteriorate with change in land use especially from forest to arable. Cropping may lead to erosion and leaching of soil nutrients (Chisci and Zanchi, 1981) which in turn adversely affect the soil physio-chemical properties.

These changes in the soil properties are usually influenced by the type of land use as the use to which a land is put will either increase its fertility status or reduce it and also the further you go down the depth the more changes are observed in the soil properties.

The objective of this study therefore, was to assess the soil properties under four different land use types' i.e. arable areas, grazing areas, fallow and tree crops areas in Iseyin Local Government Area of Oyo state with the aim of quantifying and comparing the changes in the soil properties and evaluating its effects on the different land use with respect to soil depth.

MATERIALS AND METHODS

Description of study site

The site, Iseyin Local Government Area (LGA), is located between latitudes 7^0 58^1 N and 8°00^1 N, and longitudes 3^0 15^1 E and 3° 45'E, 00 km north of Ibadan (Fig. 1). It covers about 992 km^2 and it falls within the derived savannah vegetation. It is predominantly an agrarian area in which the major occupation is farming. According to 2006 population census, it had a population of 236,000. Crops cultivated include food crops such as maize, cassava, tomatoes, pepper, banana, garden egg, potatoes, and leafy vegetables while some trees crops such as cocoa, oil palm and cashew are also cultivated by some farmers in the area.

Climate, Geology and Soil

The annual rainfall in Iseyin LGA is 1098.6±62mm. Humidity ranged between 49 .- 82%, the minimum and maximum temperature range between 19.0 — 23.2°C and 28.8 — 35.9°C respectively. Evapotranpiration (ETo) ranged from 3.52 — 6.14 mm/day with an average reference ETo is 4.56 mm/day. This high ETo is responsible for very dry environment beyond the raining season in the area. Farmers therefore find it difficult to cultivate beyond the rainy season when average daily rainfall exceeds ETo

Land use types

Land use in this area is characterized by continuous cropping under high cropping intensity. Most of the farmers in the study area are into arable farming because they farm mostly at the subsistence level. The identified land use in the area includes arable crop, grazing, tree, and fallow lands. Farmers cultivated arable crops such as maize, cowpea, sorghum etc. and other food crops. Tree crops such as cashew, mango and cocoa are also cultivated the farmers in the area. The grazing land is predominantly grass and is open to grazing by animals mostly cows, sheep and goats. Grasses found in the area include but not limited to Spear grass (*Imperata cylindrica*), Tridax, Siam weed etc. The fallow lands are made up of the areas that have once been cultivated but now left to fallow for some years due to the prevalence of shifting cultivation in the area.

Field Soil sampling:

Due to the large area to be covered in the survey, cluster sampling method was adopted so as to be able to get a fairly representative sample of the whole area. Four (4) clusters were located within the area each cluster having a profile pit dug for the representation of the mapping unit. The pits were demarcated into different horizons and soil samples were collected from each horizon layer. A total of 24 soil samples were also collected at 0-15cm and 15-30 em depths (i.e. 12 for each depth), and analysed for soil fertility evaluation.

Laboratory analysis:

The soil samples were air-dried, crushed and passed through a 2 mm sieve. Soil samples were analyzed for soil pH in both water and 0.01 M potassium chloride solution (1:1) using glass electrode pH meter (Mclean, 1982). Total nitrogen was determined by the Macro-Kjeldahl digestion method of Jackson (1962), available phosphorous (Av.P) was determined using Olsen's extraction method (UV/visible Spectrometer, Lambda EZ 201) (Olsen, 1965). Available K is part of the exchangeable bases the exchangeable bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+) were measured by atomic absorption spectrophotometry

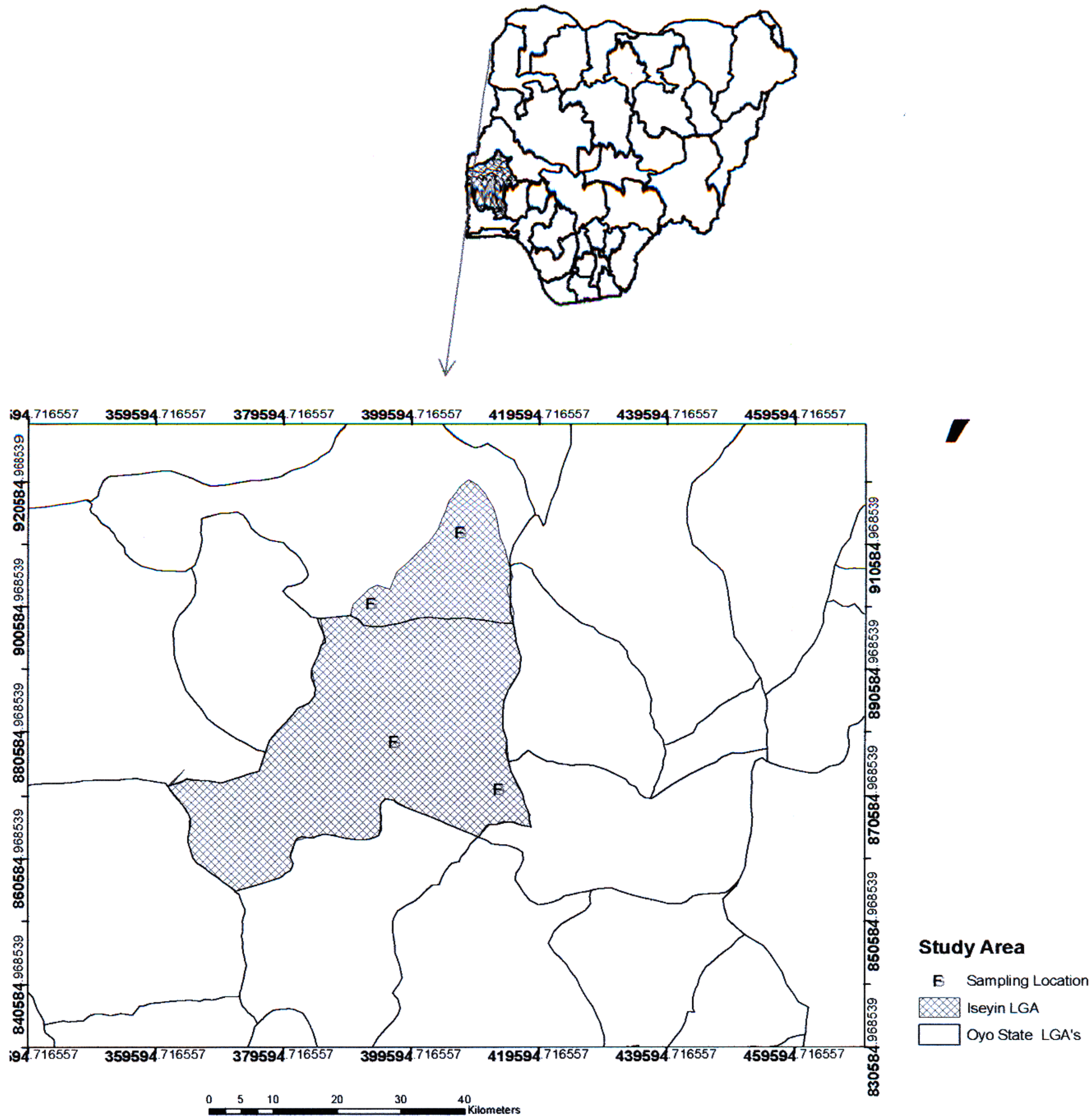

Figure 1: Map of Oyo State showing the study area.

after extraction with ammonium acetate at pH 7 (Black *et al.,* 1965).The cation exchange capacity (CEC) was determined by extraction with ammonium acetate (Chapman, 1965); Percent base saturation (PBS) was calculated by dividing the sum of the charge equivalents of the base cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) by the CEC of the soil and multiplying by 100.

Statistical Analysis

Land use types and soil depth were used as independent variables (factors) and the soil parameters as dependent variables. The significance differences among the soil quality indicators with land use types and soil depth were tested using the GenStat software and the means were separated using LSD at 5% significance. A one way analysis of variance (ANOVA) was also done to test the significance of each of the parameters.

RESULTS AND DISCUSSION

Soil classification

The soils in each of the land use types were classified locally to series level according to Smyth and Montgomery (1962) and Moss (1957) table 1. The soils in the grazing area were found to be dark brown loamy sand at the surface with an overlay of yellowish red loamy sand. Arable land also had dark brown loamy sand at the surface with an overlay of yellowish red sandy clay sand. The soils within the tree crops plantation had dark brown loamy sand also at the surface but with yellowish brown clay sand at the subsurface while the fallow area had dark yellowish brown loamy sand at the surface and yellowish red sand clay at the lower depth.

Soil physical properties:

Soil texture: The particle size distribution presented in table 1 shows that the sand and silt size fractions varied significantly with land use while the clay particles was not significant ($P < 0.05$). However, the distribution of soil particles varied with depths. The sand fractions were higher in the arable land under cultivation and tree crops by 76.2% and 71.5%, (Table 2) than the other land use while silt and clay particles were higher in the grazing area by 27.2% and 10.64 %, respectively. In the soils studied, clay fractions had the lowest values in all the land use types and depth, it ranged between 9.97-10.64 %.

The increase in clay fraction with increasing depth and the lowest overall mean proportion of clay fraction compared to the sand and silt fractions concurs with the results of other studies (Yimer *et al*. 2006, Sintayehu, 2006). Although texture is an inherent property, the textural observation might be attributed to accelerated weathering as a result of continuous disturbance during farm management practices. This suggests that the different land use types did not have effect on the soil texture of the study area, since texture is an inherent soil property that is not influenced in short period of time.

The textural class however across all the land use types is sandy loam, indicating the homogeneity of soil forming processes and similarity of parent materials (Foth, 1990).

Soil Chemical Properties

Organic Carbon (*OC, %*): The organic carbon content of the soils was generally moderate, it varied from 0.91% to 1.68 % for 0 - 15 cm depth while at 15 - 30 cm depth, it ranged from 0.40 to 1.24 % (Table 3). Significant differences (p 0.05) in OC content of soils were observed among the different land use systems and within depth. The organic carbon content showed significant variation with land use types and their interaction effects. The organic carbon was highest in the grazing area followed by fallow and arable land with values 1.68 %, 0.91 % and 0.82 % respectively. This could be due to the absence of active cultivation and farming activities in these areas making most of the organic carbon to be retained; also the presence of grazing animals in the grazing area could be responsible for its high organic carbon due to fecal deposits by the animals. With respect to depth, in the top soil, OC was significantly different in all the land use (table 3) and higher than in the sub soil. The OC content in the tree crops was lowest followed by arable land this could be due to the reduced amount of organic material being returned to the soil system and high rate of oxidation of soil organic matter as a result of continuous cultivation for long period of time without fallowing, loss of organic matter by water erosion, and

Table 1: Soil classes in the area as classified locally in series level and higher category.

S/N	Land use	Coordinates	Soil Name	Soil Taxonomy	FAO/UNESCO
1.	**Grazing Area**	Lat. 7.87188037 Long. 3.56633652	Shante series	OxicHaplustept	Ferric Cambisol
2	**Arable land**	Lat. 7.8067788 Long. 3.71310557	Iwo series	ArenicKandiustalf	HumicLixisol
3	**Tree crops**	Lat. 8.06837758 Long. 3.53367669	Iwo Series	TypicKanhaplustalf	Ferric Lixisol
4	**Fallow**	Lat.8.17035022 Long. 3.65887667	Iwo Series	Typic Kandiustalf	Ferric Lixisol

The higher clay fraction in subsurface layer than in the top surface soil may indicate possible clay translocation from the top layer to the layer below (Chesworth 2008, Khresat et. al. 2008).

Table 2. pH, H, Sand, Silt and Clay properties of the soil at 0 - 15 and 15 - 30 cm depth under different land use systems.

Land Use	pH (H2O)	pH (KCl)	H	% sand	% silt	% clay	Texture
Grazing (0 – 15 cm)	6.53 b	5.95 b	0.083 a	62.2 c	27.2 a	10.64 a	SandyLoam
Arable	7.47 a	6.98 a	0.037 b	71.5 abc	17.8 bcd	10.64 a	SandyLoam
Tree	6.88 b	6.05 b	0.066 a	76.2a	13.8 cd	9.97 a	SandyLoam
Fallow	7.85 a	7.30 a	0.018 b	65.5 bc	24.5 ab	9.97 a	SandyLoam
Grazing (15 – 30 cm)	6.67 b	5.68 b	0.076 a	64.2 bc	22.5 ab	13.31 a	SandyLoam
Arable	7.56 a	6.87 a	0.032 b	73.5 ab	16.5 bcd	9.97 a	SandyLoam
Tree	6.82 b	5.95 b	0.069 a	76.9 a	13.2 d	9.97 a	SandyLoam
Fallow	7.68 a	7.02 a	0.026 b	67.5 abc	21.8 abc	10.64 a	SandyLoam

Means value within a column followed by the same letter(s) are not significantly different at $p < 0.05$

removal of green materials (Yimer *et., al.,* 2006, Girmay *et al.,* 2008), Cultivation promotes OC loss due to exposure of micro-aggregate organic carbon to microbial decomposition by changing the moisture and temperature regimes (Reicosky and Forcella 1998). Hence, cultivated soils have low organic matter content compared to native ecosystems since cultivation increases aeration of soil, which enhances decomposition of soil organic matter. In addition, most of the soil organic matters produced in cultivated lands are always removed.

Total Nitrogen: In the area studied, total N did not show any significant difference across all land use types and soil depth. However, the distribution of total nitrogen content followed a similar pattern to organic carbon distribution since organic nitrogen constitutes the bulk of total N for tropical soils (Noma *et a1.,* 2005). It has been reported that fertility of tropical soils depends on their organic matter content (Enwezor *et al.,* 1990). The total nitrogen was relatively higher in grazing area followed by tree crops while arable land and fallow had lower values. Arable land and fallow were both low in total nitrogen fractions which could be as a result of the farming activities in both areas. Such result is expected since most soil nitrogen is bound in organic carbon. However, studies have shown that total nitrogen is not significantly varied with land uses (Moges and Holden, 2008). Though not statistically significant, the relatively higher TN in the grazing and tree crops than in the arable land and fallow area could be associated with the relatively higher organic carbon which in turn resulted from plant and root biomass as well as residues being returned to the soil system. It has been observed that the main cause of N deficiency in tropical soils is intense leaching and erosion due to the high tropical rainfall (White and Reddy 1999, Isirimah *et al.,* 2003). The low nutrient recorded under these land use

Table 3. Chemical properties of the soil at 0 to15 and 15 to 30 cm depth under different land use systems.

Land Use	%TN	%OC	%OM	AV.P mg/kg	Mn mg/kg	Zn mg/kg
Grazing (0 – 15 cm)	0.04 ab	1.68 a	2.90 a	6.10 a	5.90 ab	2.27 a
Arable	0.05 ab	0.82 bc	1.42 bc	4.66 a	2.20 b	2.13 ab
Tree	0.07 ab	0.83 bc	1.45 bc	4.12 a	1.73 b	0.70 bc
Fallow	0.04 ab	0.91 bc	1.57 bc	7.13 a	2.70 ab	1.03 abc
Grazing (15 - 30 cm)	0.08 a	1.24 ab	2.14 ab	4.37 a	6.97 a	1.53 abc
Arable	0.04 ab	0.60 c	1.02 c	4.79 a	1.83 b	1.77 abc
Tree	0.05 ab	0.40 c	0.69 c	5.08 a	2.07 b	0.40 c
Fallow	0.03 b	0.76 bc	1.31 bc	4.67 a	3.03 ab	0.67 bc

Means value within a column followed by the same letter(s) are not significantly different at $p < 0.05$

types depicts serious nutrient loss under these land uses and this reflects the extent of soil degradation which has occurred under these land uses. Generally, the soils in the study area can be rated as low to very low in nitrogen content (Federal Fertilizer Department, 2012).

Soil pH (H20): The soil pH was highly significant across all the land use types at p< 0.05 and LSD value of 0.34 while there was no significant variation between the two soil depths. The pH was higher in the fallow area with a value of 7.85 and lowest at the grazing areas with a value of 6.53 (table 2). The soil pH within the land use types and depths could be categorized as slightly acidic to moderately alkaline following the classification described by Brady and Weil (2002).

Available P (Av P): The overall available P did not show any significant difference across all the land use types and soil depth at p> 0.05 and LSD value of 2.09, however the mean available phosphorus was higher in the top soil than in the sub soil. The fallow area had the highest value of 7.13 $mgKg^{-1}$ followed by grazing area 6.10 $mgKg^{-1}$ (table 3) with the least values being in arable and tree crops (4.66 $mgKg^{-1}$ and 4.12 $mgKg^{-1}$). The higher available P content under the fallow could be associated with increase in microbial activity under this land use system. Relatively, higher content of available P found under grazing land than that of tree and arable land soils could be due to the continuous application of grazing animal manure. The lower values of available phosphorus content in the arable land and tree crops may not be unconnected to phosphorus fixation in the soils. According to (Federal Fertilizer Department, 2012) rating, available Phosphorus across all the land use types was low; several studies (Busari *et al.,* 2005, Uzoho and Oti 2005, Jubrin *et al.,* 2000, Bubba *et al.,* 2003, Aluko *et al.,* 2000) have reported high P deficiency for tropical soils. The phosphorus deficiency in the soils of the study area may be due to the inherent low-P status of the parent material, high weather ability of the soils, presence of kaolinite clay as the dominant mineral, and soil loss due to erosion.

Exchangeable Potassium: The overall Exch. K did not show any significant difference with land use and soil depth at p>O.05 and LSD value of 0.16, or their interaction (table 3). Although not significant, the mean available potassium was higher under the fallow area (0.45) than in the other land use types. Arable land had the lowest value at 0.34 followed by grazing land and tree crops with values 0.43 and 0.40 respectively. In terms of soil depth, mean Av. K did not show any significant difference also but decreased with soil depth. Low exchangeable K in 0 - 15 cm under arable land use is likely the result of the effect of continuous cultivation and crop removal, whereas the high exchangeable K concentration in fallow could be due to accumulation of exchangeable K over time. This result indicates that intensity of weathering, cultivation and use of acid forming inorganic fertilizers affect the distribution of K in the soil system and enhance its depletion. According to (Federal Fertilizer Department, 2012) rating the potassium concentration in all the land use types is moderate.

Exchangeable Calcium (Ca) and Magnesium (Mg): The concentration of exchangeable calcium varied significantly with land use types and soil depth at p<O.O5 and LSD value of 0.03 (table 4), however the mean Ex. Ca was higher in the top soil than in the sub soil. The grazing and fallow area had the highest Ex. Ca^{2+} value of 0.123 cmol/kg and 0.136 cmol/kg followed by Arable land at 0.089 cmol/kg (table 3) with

Table 4. Chemical properties of the soil at 0 to15 and 15 to 30 cm depth under different land use systems.

Land Use	Exchangeable Cation (cmol/kg)				CEC	SAR	ESP (%)	PBS
	Na	K	Ca	Mg				
Grazing (0 – 15 cm)	0.82 a	0.43 a	0.136 a	2.272 a	3.73 a	0.17 a	21.77 a	97.77 b
Arable	0.52 b	0.34 a	0.089 bcd	2.184 ab	3.17 b	0.12 b	16.55 b	98.85 a
Tree	0.52 b	0.40 a	0.069 cd	2.192 ab	3.25 b	0.12 b	16.13 b	97.97 b
Fallow	0.55 b	0.45 a	0.123 ab	2.228 ab	3.37 b	0.12 b	16.20 b	99.45 a
Grazing (15 – 30 cm)	0.80 a	0.33 a	0.113 ab	2.189 ab	3.51 ab	0.18 a	22.86 a	97.83 b
Arable	0.54 b	0.38 a	0.083 bcd	2.200 ab	3.23 b	0.12 b	16.57 b	99.00 a
Tree	0.50 b	0.38 a	0.066 d	2.148 b	3.17 b	0.12 b	15.86 b	97.82 b
Fallow	0.54 b	0.43 a	0.109 abc	2.162 b	3.26 b	0.12 b	16.41 b	99.18 a

Means value within a column followed by the same letter(s) are not significantly different at $p < 0.05$

the least values in the tree crops (0.069 cmol/kg). The exchangeable calcium in all the land use types falls below the critical limit expected in soils as described by (Agboola and Ayodele 1985, FMANR, 1990), it can be rated as low and this can be attributed to the removal of vegetation cover as a result of human and animal interference.

Low values of Ca, Mg and K, have however been reported for most Nigerian soils (Akinirinde and Obigbesan, 2000) and could be attributed to leaching losses by the high tropical rain fall as well as low content in the parent rock.

Magnesium on the other hand was not significant across all the land use type and depth but was higher in the top soil than in the sub soil. Though not significant the grazing area had the highest magnesium concentration with a value of 2.272 cmol/kg (table 3) while the other land use types ranged from 2.228-2.184 cmol/kg. Generally, the concentration of exchangeable Mg^{2+} was higher (sufficient) than the critical level of 0.28 cmol/cg soil as suggested by (Agboola and Ayodele 1985, FMANR, 1990).

Exchangeable Sodium (Na): The concentration of exchangeable sodium in the study area was not significant at p>O.05 and LSD value of 0.10 across the land use type and soil depth. The highest exchangeable Na value was recorded in the grazing area (0.82 cmol/kg) while the least was in tree crops (0.52 cmol/kg). The Ex. Na content was higher at the top soil than at the sub soil and also significant. Although there were differences in available Na concentration of the soils of the different land use systems, their ESP values were above the critical level (15%).

Cation Exchange Capacity (CEC) and Base Saturation (PBS): CEC did not show any significant variation across all the land use types at p>O.05 and LSD value of 0.22 it was not also significant between the depths (table 4). However at depth of 0-15 cm the grazing area had the highest CEC value at 3.73 cmol/kg followed by the fallow area while tree crops and arabic land were lower with values 3.37 cmol/kg and 3.25 cmol/kg respectively. In accordance with the organic carbon content, CEC values of the soil decreased consistently from grazing land to fallow, tree and arable (table 3). This was also evident from the positive correlation (r0.89) of CEC with organic carbon. The depletion of organic carbon as a result of intensive cultivation had, therefore, reduced the CEC of the soils under arable land use.

With respect to depth, the CEC content was higher in the top soil than in the sub soil.

The percentage of base saturation (PBS) of soils under different land use systems showed significant differences. In 0 - 15 cm depth, the highest PBS was recorded under fallow land (99.45 %) followed by arable land (98.85%), while tree (97.97 %) and grazing (97.77%) followed respectively. Whereas in 15 - 30 cm depth, the highest value was found under fallow (99.16 %) followed by that of arable (99.00 %) while grazing (97.83 %) and tree (97.82 %) followed (Table 4). The highest PBS found under fallow land at both depths indicates that the fertility status of fallow land is higher as compared to that of the other land use systems. According to Urioste *et al.* (2006), addition of organic matter increases the amount of exchangeable bases.

CONCLUSION

Variations in soil physical and chemical properties with respect to land use and soil depth were investigated in Iseyin Local Government Area which is a derived Savanna zone in South West Nigeria. Soil textural fractions varied with land use with the sand particles having the highest percentage followed by silt then clay, the soils of the areas are mostly sandy clay loam and it also varied with depth with the top soil having higher particles than the sub soil. With respect to the soil chemical properties, organic carbon and pH varied significantly with land use while the total nitrogen, available phosphorus and potassium contents were not significant. This could be as a result of human management such as lack of sustainable farm practices, erosion problems, overgrazing, inadequate fallow periods and so on. Therefore, in order to improve soil quality, reverse deterioration, and maintain long-term productivity of the arable land the following practices are suggested: (I) integrating existing cultural management practices with appropriate technologies such as controlling soil erosion in the area; (2) strengthening and expanding existing fertility management practices such as usage of organic fertilizer (household wastes, manure, composts) to sustain agricultural production; (3) provision of technical support and assistance to the concerned farmers.

REFERENCES

Agboola, A. A. and Ayodele, 0. J. (1985). Prospects and problem of using soil testing for adoption of fertilizer use in Ekiti Akoko. Agricultural Development Project area. In: Ohun, H.W., Nagy, J.G. (eds) *Proceedings of workshop on appropriate technologies for farmers in semi-arid West Africa*. Purdue University Press West Lafayette Indiana 123-136.

Akamigbo, F.O.R. and C.L.A. Asadu (2001). The Influence of Parent materials on the soils of Southeastern Nigeria. *East Afr. Agric & Forest, Jour.*48: 81-91.

Akinrinde, E.A. and Obighesan, G.O. (2000). Evaluation of fertility status of selected soils for the crop production in five ecological areas of Nigeria. *Proc. 26 Annual Conf. Soil Science Society Nigeria* Ibadan, Oyo State. pp 279 — 288.

Aluko, A.P. and J.A. Fagbenro (2000). The role of tree species and land use systems in organic matter and nutrient availability in degraded Ultisol of Onne, Southeastern Nigeria. *Proc. Annual Conf, Soil Sci Soc Nig. Ibadan*, Oyo State. Pp 89-292.

Black, C. A., Evans, D. D., White, J.L., Ensminger, L.E., and Clark, F. E (1965). *Methods of Soil Analysis—Part 1. Physical and Mineralogical Properties* Including Statistics o/Measurement and Sampling, American Society of Agronomy, Madison,Wis, USA.

Brady, N. and Weil, R. (2002): *The Nature and Properties of Soils* 12th edition. Macmillian Ltd. New York.

Bridges, E. M. and de Bakker, H. (1997). Soils as an artefact: human impacts on the soil resource. *The Land* 1, 197-215.

Bubba, M.O, C.A. Arias and H. Briax. (2003). Phosphorus adsorption maximum of sands for use as media in sub-surface flow cultivated reed beds as measured by Langmuir isotherm. *Water Research* 37:3390 — 3400.

Buol, S. W., F. D. Hole, R. J. McCracken and R. 1. Southard (1997). *Soil Genesis and Classification.* Iowa State University Press, Ames, Fourth Edition, 527 pp.

Busari, M.A, F.K. Salako, R.A. Sobulo, M.A Adetunji and N.J. Bello (2005). Variation in Soil pH and Maize Yield as affected by the application of Poultry Manure and Lime. In: *Managing Soil Resources for Food and Sustainable Environment. Proc. of 29th Annual Conf. Soil Sci. Soc. Nig*. Pp 139 — 142.

Cambardella, C. A. and D. L. Karlen (1999). Spatial analysis of soil fertility parameters. *Precision Agriculture*, 1: 5-14.

Chapman, H.D. (1965). Cation-exchange capacity. In: C.A. Black (ed.). *Methods of Soil Analysis - Chemical and Microbiological Properties. Agronomy* 9:891-901.

Chesworth, W. (2008). *Encyclopedia of Soil Science, Springer, Dordre*cht, the Netherlands.

Enwezor, W.0., A.C.Ohiri, E.E. Opowaribo and E.J. Udo (1990). A Review of soil fertilizer use in crops in Southeastern zone of Nigeria (in five volumes). Produced by the Fed. Mm. Agric and Nat. Re. Lagos.

F. Yimer, S. Ledin, and A. Abdulkadir (2007. Changes in Soil organic carbon and total nitrogen contents in three adjacent land use types in the Bale Mountains, South-eastern highlands of Ethiopia," *Forest Ecology and Management,* vol. 242, no. 2-3, pp. 337—342.

Famiglietti, S. S., Rudnicki, J. W. and Rodell, M. (1998). Variability in surface moisture content along a hillslope transect: Rattlesnake Hill, Texas. I. *Hydrol*., 210: 259—281.

Federal Fertilizer Department. Federal Ministry of Agriculture and Rural development (2012). *Fertilizer Use and Management Practices for crops in Nigeria*. 4th Edition Pp. 40-41.

FMANR (Federal Ministry of Agriculture and Natural Resources) (1990). Literature Review on Soil Fertility Investigation in Nigeria. FMANR Lagos 2Slp.

Foth, H. D. (1990). *Fundamentals of Soil Science /* Henry D. Foth.-8th ed.

Girmay, G., Singh, B. R., Mitiku, F.L., Borresen, T. and Lal, R. (2008). "Carbon stocks in Ethiopian soils in relation to land use and soil management," *Land Degradation and Development,* vol. 19, no. 4, pp. 35 1—367.

Hu, W., Shao, M. A., Wang, Q. I. and Reichardt, K (2008). Soil water content temporal-spatial variability of the surface layer of a Loess Plateau hillside in China. *Sci. Agri.,* 65: 277-289.

Hulugalle, N. R., L. A. Lobry de Bruyn and P. Entwistle (1997). Residual effects of tillage and crop rotation on soil properties, soil invertebrate numbers and nutrient uptake in an irrigated Vertisol sown to cotton. *Applied Soil Ecology,* 7: 11-30.

Isirimah, N.O., A.A. Dickson, and C. Igwe, (2003). *Introductory Soil Chemistry and Biology for Agriculture and Biotechnology* Osia Int'l publishers.

Jackson, M.L. (1962). *Soil Chemical Analysis.* Prentice Hall, New York.

Jones, B.S.S. (2001). *Laboratory Guide for Conducting Soil Tests and Plant Analysis*, CRC press, LLC.

Jubrin, J.M, Chude, V.0., Horst, W.J. and Amapu, L.Y. (2000). The response of ten leguminous cover crops and maize to native and applied phosphate. *Proc. 26 th Annual Conf. Soil Sci. Soc. Nig. Ibadan*, Oyo, state.pp 294 — 300.

Khresat, S., Al-Bakri, J. and Al-Tahnan, R. (2008) "Impacts of land use/cover change on soil properties in the Mediterranean region of Northwestern Jordan," Land Degradalion and Development, vol. 19, no. 4, pp. 397-407, 2008.

Lambin, E. F., Geist, H. J. and Lepers, E. (2003). Dynamics of land-use and landcover change in the tropical regions. *Ann. Rev. Environ.* Resources, 28: 205-241.

Maclean, E.0 (1982). Soil pH and lime requirements. Pp 595 — 624. In: Page, A. L. *et al* (eds). *Methods of Soil Analysis*, Part 2, 2' edition. Amer. Soc Agron & Soil Sci Soc. Amer. Madison, WI.

Moges and N. M. Holden (2008). "Soil fertility in relation to slope position and agricultural land use: a case study of umbulo catchment in Southern Ethiopia," *Environmental Management,* vol. 42, no. 5, pp. 753—763.

Moss, R. P. (1957). Classification of Soils found over Sedimentary Rocks in Western Nigeria. *Soil Survey Report* No. 67. Ibadan, Nigeria,: Ministry of Agriculture and Natural Resources.

Murty, D., M. U. F. Kirschbaum, R. E. Mcmurtrie, and H. Mcgilvray (2002) "Does conversion of forest to agricultural land change soil carbon and nitrogen? A review of the literature," *Global Change Biology*, vol. 8, no. 2, pp. 105—123.

Noma, S.S., A.G. Ojanuga, S.A. Ibrahim and M.A. Iliya (2005). Detailed Soil Survey of Sokoto — Rima Floodplain at Sokoto. In: *Managing oil resources for food security and sustainable environment Proc. 29th Annual Conf Soil Sci. Soc. Nig.*

Olsen, S.R. and L. A. Dean (1965). "Phosphorous," In: *Methods of Soil Analysis—Part 2:Chemical and Microbiological Properties*, C. A. Black, Ed., vol. 9, pp. 103 5—1049, American Society of Agronomy, Madison, Wisconsin, USA.

Reicosky, D. C. and F. Forcella F. (1998) "Cover crop and soil quality interactions in agroecosystems," J*ournal of Soil and Water Conservation*, vol. 53, no. 3, pp. 224—229.

She, D. L., Shao, M. A., Timm, L.C. and Reichardt, K. (2009). Temporal changes of an alfalfa succession and related soil physical properties on the Loess Plateau, China. Pesq. Agropee. Bras., 44: 189-196.

Sintayehu, M. (2006). Land Use Dynamics and its Impact on Selected Physicochemical Properties of Soils in Yabello Woreda of Borana Lowlands, Southern Ethiopia [M.Sc. thesis], Haromaya University, Haromaya, Ethiopia.

Smyth, A. J. & Montgomery, R. F. (1962). Soils and land use in Central western Nigeria. Nigeria, Ibadan: Government Printer.

Urioste, A.M., Bono, A.A., D.E. Buschiazzo, G.G. Hevia & E.N. Hepper. (1996). Fractions of phosphorus in agricultural soils and pastoral the semi-arid Pampa Central (Argentina). *Scien- Region Soil* cia 14 (2): 92-95

Uzoho, B.U. and N.N. Oti (2005). Phosphorus adsorption characteristics of selected South-eastern Nigerian soils.

Von Uexkuell, H.R. (1988). Nutrient cycling in soil management and smallholder development in the Pacific Islands. In: *IBSRAM (International Board for Soil Research and Management) Proceedings*. Bangkok, p. 21.

White, J. R. and Reddy, K. R. (1999). Influence of nitrate and phosphorus loading on dentrification enzyme activity in Everglades wetland soils. *Soil Sci. Soc. Am.* J. 63 1945-1954.

Yimer, F., Ledin, S. and Abdelkadir, A. (2006). "Soil property variations in relation to topographic aspect and vegetation community in the south-eastern highlands of Ethiopia," Forest Ecology and Management, vol. 232, no. 1—3, pp. 90—99.