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Comparison of the characteristics of soils of isolated forests and adjacent grasslands in Nsukka area of Enugu state, Nigeria

C.L.A, Asadu and C. Odugu

Department of Soil Science & Land Resources Management
University of Nigeria, Nsukka

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Corresponding Author's E-mail Address:

alymosses@yahoo.com +2348164980646

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ABSTRACT

The soils of isolated forests on hilltops and the surrounding grasslands in three locations at Ashor Hill, AttabaHill, and Umuowo Hill, all in Nsukka area were comparatively characterized. Two auger samples were collected (0-20 and 20-40cm) from each vegetation type per location giving a total of 12 auger samples while two profiles pit each were dug, described and sampled. In all, 24 samples were collected processed, analyzed and results subjected to statistical analysis. The majority of soil properties showed no significant difference across the vegetation types except soil pH and CEC, which were significantly higher in grassland than in forestland in A and Bt horizons. Consequently, soils of forestland were extremely acidic while that of grassland were strongly acidic. The CEC of the soils across the two vegetation types ranged from medium to high in status and soil textures from sandy loam to sandy clay loam. The clay content was generally low but increased with soil depth or down the profile probably due to argillation. The mean values of organic matter, total nitrogen, and exchangeable bases, CEC percentage base saturation and available phosphorus in the topsoil were found to be higher in forestland than grassland possibly due to higher accumulation of leaf litters and higher nutrient cycling in forestland than grassland. As a result, forestland appeared higher in fertility status and thus agricultural potential than grassland. However, contouringand lime application are necessary to optimize the productivity of the forestland.

1.0 Introduction

Soil is a natural body of minerals and organic matter which changes or has changed in response to climate and organisms. Soil is regarded as a synthograph, i.e. a natural device that records the synthesis of much that has happened to it. It is this property of soil that makes it possible to predict the soil-forming factor that dominantly influenced its formation. Any soil is a mass of material formed and influenced by some known factors or factors that can be predicted from its characteristics. The soil exhibits the signatures of the factors and certain processes which combined to produce those specific characteristics (Asadu et al., 2012).These specific features define soils and distinguish them from other soils. As such, soils under forest conditions could differ from those under grassland. The actual characteristics of soil are influenced by the type of plants growing on it (Plaster, 1992). The C, N and P dynamics, for instance, are generally affected by vegetation (Folster et al., 2001). Chen et al. (2003) revealed that forest C, N and P dynamics, as modulated by soil microbes, are different from those observed for grassland in New Zealand, owing to differences in the quantity, quality and distribution of organic matter (OM). In forest ecosystems, OM mainly accumulates as leaf and stems matter that accumulates on the soil surface, whereas OM in grassland ecosystems is mainly supplied as roots and deposited in the deep soil (Condron and Newman 1998; Chen et al., 2008). OM deposition via different vegetation types results in differential OM accumulation and therefore, differences in N and P dynamics (Sugihara et al., 2014). As is well known, forest growth also causes soil acidification by removal of mineral nutrients (P, Na, K, Ca, Mg, etc.) and dissociation of carbonic acid and organic acids (Alfredsson et al. 1998; Wright et al. 2011).Similarly, under the same climatic conditions, where forest and grassland exist side by side and have the same parent material and slope, forest soils show higher leaching of exchangeable Ca, Mg, K and Na, and a greater eluviation of clay from A to B horizons (Forth, 1990). This suggests that soils of forest and that of the grassland may have the differential potential for crop production in the same location.In order to enhance continuous utilization and sustainable use of the soil to provide adequately for man's teeming population, one needs to have a very vast knowledge of soils. As such, there is an increasing demand for information on soils as a means to produce food (Fasina*et al.,* 2007).The coupling of soil characterization, soil classification and soil mapping provides a powerful resource for the benefit of humankind, especially in the area of food security and environmental sustainability. A soil characterization study is a significant building block for understanding the soil, classifying it and getting the best understanding of the environment (Esu, 2005). Best way to study soil accurately is through soil survey of which there are different types. Soil survey is one of the groups of activities collectively known as a natural resources survey, and natural resource surveys are studies of the environment with particular reference to its resource potential (Young, 1976). However, the potential of soil as a resource of the environment depends on its characteristics which fluctuate with different vegetation types covering the soil. Nsukka soils are put to different uses ranging from agriculture to non-agricultural use. However, a reasonable proportion of the zone is occupied by hills with pockets of forests and grasslands side by side this natural arrangement though present a beautiful scenery needs to be explained pedologically. Unfortunately, little of the hills' soils are put to appropriate use be it agricultural or otherwise. This could be due to a lack of information on the soils' potential for sustainable agriculture and the environment. This study was, therefore, designed to comparatively characterize the soils of isolated forests on hilltops and the surrounding grassland in Nsukka Area.

The specific objectives of this study were to;

i. study the physical, chemical, and morphological properties of soils of isolated forest on hilltops contiguous with grassland, and

ii. compared the identified characteristics of the two soils for purposes of estimating the magnitude of their differences and potentials.

2.0. Materials and methods

2.1.Site Description

The study was carried out in Nsukka area in Enugu State, which is within the South-East geopolitical zone of Nigeria.It is located between $6^0 52^1$and $6^0 55^1$North and $7^0 13^1$and $7^0 24^1$East. Three locations were chosen within the area to delineate two different vegetation types with similar topography, parent material, climate and age. The various locations were at Onuiyi, Edem-Nru and OwereEzeOrba, Ashor, Attaba, and Umuowo Hills respectively were selected to represent sampling units for the various location with a pocket of forest on their respective tops and grasses surrounding them.

2.1.1.Climate

The general climate of the area is sub-humid tropical, having a distinct rainy season and dry season, with rainfall bimodally distributed with peaks in July and September. The mean annual minimum rainfall is 1200 mm, while the mean annual maximum rainfall is 2000 mm spread between April and early November (Asadu, 2002). The relative humidity ranges from 70 to 80% (Oko-Ibom and Asiegbu, 2006).

2.1.2. Soils

The soils of Nsukka area are deeply weathered soils mostly derived from the residua of sedimentary materials of the cretaceous and tertiary periods. Some are derived from Upper Coal measure formations, especially on hills. These geologic formations either give rise to sandy or clayey soils, respectively (Akamigbo and Asadu, 1983). The false bedded sandstone, with some colluvial materials, is found on the low land area. They consist of weakly consolidated, coarse sandy layers with colours ranging from pale brown to yellowish red. Loose white sandy materials occur at specific depths. The body of the false bedded sandstone is thick, friable and poorly sorted. It is white; sometimes there are some iron stains which signify ferruginization. Nkpologu series is formed by the weathering and feruginization of the false bedded sandstone of Ajali formation which floors the dry valley.

On the other hand, upper coal measures occupy upper slopes and tops of residual hills in the area. Generally, residua from them are often transported by colluvial and erosion processes to the lower plains to form soils of similar characteristics with those of the upper slopes (Asadu and Bosah, 2002). Nsukka soils are naturally low in fertility since the mineral constituents are made up of quartz, iron oxides and kaolin (Floyd, 1969). This is probably as a result of rapid weathering and leaching processes, which are favoured by high temperatures and rainfall characteristics of the area, in addition to the effect of parent material (Asadu and Akamigbo, 1987). The characteristics of Nsukka soils include their sandy loam textural class, considerably high sand and moderate clay fraction formed from false-bedded sandstone (Orajaka, 1975) and acidic reaction, associated with low activity clays, highly degraded and leached profiles; which Akamigbo and Asadu (1983) described as deeply weathered soils mostly derived from the residua of sedimentary materials. The CEC of the soils are generally low (Asadu, 1990) as well as low exchangeable bases in the soils. Akamigbo and Asadu (1983) reported these intrinsic properties as dependent on the parent materials of the soils. The soils of Nsukka area have an ustic moisture regime and an isohyperthemic soil temperature regime (Asadu, 1990).

2.1.3. Elevation

Nsukka area is occupied by plateau, which slopes gently towards the west at a shallow angle ($<2^0$). Wide and flat valleys characterize the surface of the plateau. These valleys separate the residual hills. The valleys are lowlands of less than 125m above sea level. The Nsukka region has a high central zone, which is generally over 365m above sea level, with isolated peaks reaching over 545m (Ofomata, 1975). The central highland section of Nsukka area forms the watershed for some upper course tributaries of the Niger and Cross Rivers (Ofomata, 1975).

2.1.4. Vegetation

The general vegetation of Nsukka area is secondary mainly due to the influence of man through bush burning, clearing and land cultivation (Asadu and Akamigbo, 1987); and can be best described as derived savannah. However, the sampling units are covered with forests with a high diversity of trees and shrubs such as *Elaeisguinensis, Gmelin arborea, Mangifera indica, Pentacletra macrophylla, etc*. The forests are surrounded by grassland dominated by species like *Sorghastrum nutans, Panicum maximum*, *Chromolena odoratum, Andropogon gayanus, Calapogo-*

and K evaluated using flame photometer while exchangeable Ca and Mg were determined by atomic absorption spectrophotometer. Exchangeable acidity was determined by extracting the soil with 0.1N KCl solution and titrating the aliquot of the extract with 1N NaOH (McClean, 1965). The summation of the exchangeable bases and acidity gave the effective cation exchange capacity (ECEC) value. The percentage base saturation was computed by dividing the value of total exchangeable bases by the ECEC value and multiplying the quotient by100.

2.4.Statistical analysis

One-way Analysis of Variance (ANOVA) was used to test for differences between the vegetation types. This analysis was carried out using Genstat Discovery Edition 4.

3.0 Results and discussions

3.1 Morphological Characteristics of the Soil

The study of morphological properties of the soils across the two vegetation types revealed that the soils were generally shallow (<70cm deep) although the thickness of the horizons varied, with forestland having thinner A horizons than grassland (Table 2). This could be attributed to the topography of the landscape. The soil colour varied from dark reddish-brown (2.5YR, 4/5) to reddish-brown (2.5YR, ¾) across the different vegetation types.

Generally, the structures of the soils were granular in A and sub-angular blocky Bt horizons respectively. The soil consistencies were non-sticky and non-plastic in forestland but ranged from non to slightly sticky and slightly plastic in grassland.

Table 2: Comparative particle size distribution of auger and profile soil samples at 0-20cm, 20-40cm (depths), A and B$_t$ Horizons across the three locations as influenced by different vegetation types

Depth (0-20cm)							
FL	**125.3**	**107.0**	**351.0**	**416.3**	**767.0**	**557.0**	**SL**
GL	**132.0**	**207.0**	**285.0**	**368.3**	**654.0**	**759.0**	**SL**
LSD$_{0.05}$	**NS**	**NS**	**NS**	**20.33**	**NS**	**NS**	
Depth (20-40cm)							
FL	**152.0**	**147.0**	**342.0**	**365.0**	**707.0**	**771.0**	**SL**
GL	**145.3**	**167.0**	**195.0**	**441.0**	**687.0**	**823.0**	**SL**
LSD$_{0.05}$	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	
A- Horizon							
FL	**210.0**	**81.0**	**461.0**	**332.0**	**791.0**	**631.7**	**SCL**
GL	**181.0**	**141.0**	**334.0**	**300.0**	**678.0**	**617.7**	**SL**
LSD$_{0.05}$	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	
B$_t$- Horizon							
FL	**228.0**	**154.0**	**225.0**	**384.3**	**618.0**	**630.0**	**SCL**
GL	**201.0**	**147.0**	**337.0**	**398.7**	**651.0**	**630.0**	**SL**
LSD$_{0.05}$	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

Note: SL=Sandy Loam; FS=Fine Sand; CS=Coarse Sand; TS= total Sand; TC= Textural Class; NS=Non Significant at 5% Probability Level; LSD$_{0.05}$= Least Significant Difference

3.1.1 Particle size distribution

The particle size distribution of auger and profile samples at 0-20 and 20-40 cm (depths), A and Bt Horizons across the three locations as influenced by different vegetation types are summarized in Tables 3. Generally, the texture of auger soil samples was sandy loam across the two vegetation types.

The average clay fraction of the forestland and grassland at 0-20cm depth was 125.3g/kg and 132.0g/kg respectively. However, the fraction increased with depth since the value recorded rose to152.0 and 145.3g/kg in the 20-40cm depth of forestland and grassland, respectively.

The increase in clay content with depth could be attributed to argillation or clay lessivage. It could also be due to sorting of soil materials, clay migration or combination of both factors (Ojanuga, 2003).

The silt content of the soils under grassland was on the average higher than that of the forestland, although their means were not significantly different.

The percentage gravel of the soils on the average was *nium mucunoides, etc.*

2.2. Field Study

The field study started with the selection of sites. Afterwards, the auger samples were collected at 1m away from profile pit points from 0-20cm and then 20-40cm. A total of 12 samples were collected from the three locations (4 from each).

After auger sampling, six profile pits were dug; two per location with one sited in forestland and the other in surrounding grassland. The profile pits were designated thus;

ASP_1–Ashor Hill Forestland Profile pit
ASP_2–Ashor Hill Grassland Profile Pit
AEP_1–Attaba Hill Forestland Profile Pit
AEP_2–Attaba Hill Grassland Profile Pit
UMP_1–Umuowo Hill Forestland Profile Pit
UMP_2–Umuowo Hill Grassland Profile Pit

The profile pits were later described macro morphologically following the guidelines for field descriptions by FAO (2006), sampled according to genetic horizons, and 12 soil samples were collected making it a total of 24 samples with Auger samples.

2.3 Laboratory Analysis

The laboratory analyses consisted of detailed routine analyses of both the auger and profile soil samples for required parameters. The particle size analysis of the soil samples was determined by Bouyoucos hydrometer method (Gee and Bauder, 1986), using NaOH as the soil dispersing agent. Soil pH in KCl and H_20 was determined using a glass electrode pH meter. Organic carbon was determined by dichromate wet oxidation method (Nelson and Sommer, 1982).The organic matter percentage was obtained by multiplying with the factor 1.724. Total nitrogen was determined by Kjeldahl process (Bremner and Mulvaney, 1982) and available phosphorus by Bray-2 extraction method (Page *et al.*, 1982).

Exchangeable cations were determined by extracting the soil with 1N NH4OAC (Thomas, 1982); exchangeable Na

Table 1: The Morphological properties of the Soils studied.

Horizon	Depth(cm)	Colour (Munsell)	Consistence		structure	Boundary
			Moist	wet		
			ASP1			
A	0-22	DRB (2.5YR,4/5)	Fr	Ns,Np	G	Faint Gradual,
Bt	22-65	RB (2.5YR,3/4)	Fr	Ss, Sp	SBK	Clear smooth
			ASP2			
A	0-24	DRB (2.5YR,4/5)	Fr	Ns,Np	G	Faint Gradual,
Bt	24-70	RB (2.5YR,3/4)	Fr	Ns,Np	SBK	Clear smooth
			AEP1			
A	0-20	DRB (2.5YR,4/5)	Fr	Ns,Np	G	Faint Gradual,
Bt	20-60	RB (2.5YR,3/4)	Fr	Ss,Sp	SBK	Clear smooth
			AEP2			
A	0-25	DRB (2.5YR,4/5)	Fr	Ss,Sp	G	Faint Gradual,
Bt	25-55	RB (2.5YR,3/4)	Fr	Ss,Sp	SBK	Clear smooth
			UMP1			
A	0-20	DRB (2.5YR,4/5)	Fr	Ns,Np	G	Faint Gradual,
Bt	20-65	RB (2.5YR,3/4)	Fr	Ns,Np	SBK	Clear smooth
			UMP2			
A	0-22	DRB (2.5YR,4/5)	Fr	Ns,Np	G	Faint Gradual,
Bt	22-70	B (2.5YR,3/4)	Fr	Ss,Sp	SBK	Clear smooth

Note: ASP_1= Ashor Hill Forestland profile pit, ASP_2=Ashor Hill grassland pit, AEP_1=Attaba Hill forestland profile pit, AEP_2=Attaba Hill grassland profile pit, UMP_1=Umuowo Hill forestland profile pit, UMP_2=Umuowo Hill grassland profile pit, DRB=dark reddish-brown, RD= reddish-brown, Fr=friable, Ns, Np=non-sticky, non-plastic, Ss, Sp=slightly sticky, slightly plastic, G=granular, SBK=sub angular blocky,

These differences could be attributed to differences in the percentage sand, silt and clay recorded and their differential arrangement across the two vegetation types.

higher in grassland than in forestland, but generally, they increased with depth. The values recorded in 0-20cm forestland and grassland were 557.0g/kg and 759.0g/kg respectively while 771.0g/kg and 822.0g/kg were recorded in the 20-40cm depth of forestland and grassland respectively. This could have contributed more to higher leaching and movement of fine particles down the profile of grassland soils.

Similar trends were observed from the results of the analysis of profile samples, although the texture ranged from sandy loam to sandy clay loam

3.2 Chemical Properties

The chemical properties of auger soil samples at 0-20 and 20-40 cm (depths), A and B_tHorizons across the three locations as influenced by different vegetation types are summarized in Tables 4.

3.2.1 Soil Reaction (pH)

The pH values of the auger soil samples across the various vegetation types were extremely acidic (pH<4.5) across the various depths based on the classification by Landon (1991). In contrary to this, the result of the profile soil samples analyzed revealed that the pH of the grassland soils was significantly higher than that of the forestland. While the pH of the grassland was very strongly acidic, that of the forestland was extremely acidic. The pH of the soils generally increased with depth. This may be due to leaching of basic cations down the profile. The lower pH under forest vegetation may be due to higher microbial oxidation of organic matter due to high organic matter content that produces organic acids, which provides H^+ to the soil solution and thereby lowers soil pH (Mohammed, 2003). The higher pH of the grassland soils may be due to lower organic matter content and thus oxidation.

3.2.2 Exchangeable Acidity

The result of exchangeable acidity of both auger and profile samples at the various depths showed that there was no significant difference between forestland and grassland on the named soil parameter. From the result of H^+, it is evident that the mean value of exchangeable acidity decreased with depth probably due to leaching of exchangeable bases down the soil profile but was generally higher in the forestland than grassland. Nair and Chimuah (1993) reported that the concentration of the H^+ that can cause acidity is pronounced at a pH value below 4 while the excess concentration of Al^{3+} is observed at pH below 5.5. This partly agrees with the pH result of this study since that of forestland was below 4.0 (3.9 at D1) and thus had higher H^+ concentration. In comparison, Al^{3+} concentration was higher in grassland soils with higher pH (4.330) although less than 5 indicating Al^{3+} toxicity is expected in this area.

3.2.3 Organic Matter

The amount of organic carbon and thus, organic matter found in the study areas showed a general decrease with soil depth. At both depths, the mean organic matter found in forestland soils is higher than that found in grassland soils, although there was no significant difference between them. The values at 0-20cm and 20-40cm of the soils were on the average 6.66g/kg and 3.68g/kg in forestland and 4.47 g/kg and 3.28 g/kg in grassland respectively. Likewise, the values at both A and Bt horizons were 4.17g/kg and 1.57g/kg in forestland and 3.33g/kg and 1.43g/kg in grassland. Following the rating of organic matter of <1.7g/kg low, 1.7-3.4g/kg moderate, 3.4-6.9g/kg adequate and >6.9g/kg high as indicated by Landon (1991), the forestland had adequate organic matter while grassland had moderate to adequate organic matter content.

Soil organic matter (organic carbon) is the accumulation of dead plant materials partially decayed and partially synthesized plant and animal residues. The higher value of organic matter recorded in the forestland (from both auger and profile samples) may be due to possible lower rate of decomposition of leaves, and other residues of diverse varieties of plant found there, thereby increasing the organic carbon compared with the grassland which often is more exposed to sunlight.

Soil fertility is closely linked to soil organic matter, whose status depends on biomass input and management, mineralization, leaching and erosion (Roose and Bathes, 2001; Nwadwa, 2001). So, it is evident that the higher organic matter value in forestland may be attributed to the lower extent of leaching and higher biomass input inform of litters in forestland than in grassland. Also due to the dense cover of the forestland, nutrient loss from the soil under the tree through leaching is minimal (Iwara, 2008) and this agrees with the result of this work which revealed that there were higher leaching of nutrients and fine materials down the profile in grassland with lower organic matter.

3.2.4 Total Nitrogen (TN)

The mean values of TN in both 0-20 and 20-40cm depths were higher in forestland (0.377 and 0.177g/kg) than in grassland (0.187 and 0.160g/kg), but no significant difference exists between them. At A and Bt horizons of the profile pit, 0.203g/kg and 0.080g/kg were obtained in forestland while 0.180 and 0.103g/kg were obtained in grassland which also showed that it was higher in forestland.

Following the rating of TN of >1g/kg as very high, 0.5-1g/kg high, 0.2-0.5g/kg medium, 0.1-0.2g/kg low and <0.1g/kg as very low nitrogen status as indicated by Landon (1991), the forestland had medium while grassland had low nitrogen status.

It has been shown that the Total N constitutes the bulk of soil organic matter in the tropics (Akamigbo, 1999, Noma et al., 2005; Anikwe, 2010) which justify why forestland soils with higher organic matter content recorded higher Total N content. On the contrary, low N values of grassland soils may be due to the rapid mineralization of soil organic matter, intense leaching and erosion due to the high tropical rainfall (White and Reddy, 1999; Anikwe et al., 2003; Isirimar et al., 2003; Senjobi, 2007; Uzoho et al., 2007), in which they were more prone to the enlisted soil degrading processes.

3.2.5 Exchangeable Cations

The mean values of exchangeable Ca^{2+} obtained from the soils of both vegetation types ranged from low to moderate. While moderate mean value (2.133Cmol/kg) was obtained in the forestland, the low mean value was obtained in grassland (1.930Cmol/kg). Also, while the content decreased with depth (from 2.133-1.600Cmol/kg) in forestland, it increased with depth in grassland (from 1.800-1.930Cmol/kg). This higher value in forestland may be due to the attraction and retention of Ca^{2+} by negatively charged organic colloids.

The results show that the mean value of Mg^{2+} obtained in forestland (2.600Cmol/kg) was higher than that of grassland (1.930Cmol/kg) although the value increased with depth in grassland may be due to higher accumulation of clay and thus cations at the lower horizon of grassland.

Higher value in forestland may be due to higher cation retention due to high organic matter. Following Landon (1991) classification of exchangeable Mg, the exchangeable Mg was generally moderate across the two vegetation types.

In terms of K^+, the higher mean value was recorded in forestland (0.200 and 0.153Cmol/kg) than grassland (0.173 and 0.087Cmol/kg). Following the rating of exchangeable K by Landon (1991), the mean value obtained was moderate in forestland but low in grassland. This low value could be due to accumulation of acid-forming cations and high-intensity weathering, which affect its distribution and thus enhance its depletion as rightly reported by Malo et al., (2005).

Following Landon (1991) classification of Na, the mean values obtained across vegetation were generally moderate. Its mean value in forestland was higher at 0-20cm than at 20 -40cm. This may be due to differences in the rate of leaching of and retention of sodium at surface soils of the various vegetation types. It was higher in forestland at 0-20cm depth because of higher retention due to higher organic colloids but lower in grassland at 0-20cm depth because of lower retention at the surface.

Generally, although higher mean values were recorded in forestland than in grassland, there was no significant difference between the vegetation on exchangeable bases.

Similar trends were observed from the mean values of profile sample results of the various exchangeable bases.

3.2.6 Cation Exchange Capacity

The results of CEC in the forestland and grassland showed that across the profile pits at B_t horizon, the mean value recorded in grassland was significantly higher than that of forestland. This could be due to higher accumulation of inorganic colloids in the form of clay and thus higher cations adsorption surface at the Bt horizons of the grassland soils. However, across auger soil samples at both 0-20and 20-40cm depths (just as in the A horizon of profile samples), higher mean values were recorded in forestland although they were not significant. This could be attributed to higher organic matter content in forestland, which possesses higher cation adsorption surface than that of grassland with lower organic matter content at the surface.

According to Landon (1991), the soils having CEC of >25cmol/kg, 15-25cmol/kg) 5-15cmol/kg, and <5cmol/kg are classified as high, medium, low, and very low respectively. Based on the above, the soils across the different vegetation types were generally medium to high in CEC status. Although low CEC has been attributed to the soils of the tropical region due to their high weathering and low organic matter content (Noma et al., 2005) and dominance of kaolinitic clay in their fine earth fraction (Eshett (1995) and Uzoho et al., 2007), the CEC of the study area had medium to high values. This could be attributed to moderate to high organic matter which has high cations adsorption surfaces. This suggests that the soils had the medium buffering capacity and thus exhibit moderate stability.

3.2.7 Base Saturation

The result of percentage base saturation shows that at 0-20cm, 20-40cm (auger depths) and A horizon, higher mean values were obtained in forestland (74.600%, 72.600%, and 49.400%) while at Bt horizon, the higher value was obtained in grassland (50.400%), although they were not significant. This indicates that base saturation decreased down the profile in forestland,whereas in grassland, it increased and vice versa. This could be attributed to higher intense leaching at the surface soils of grassland than that of forestland. The values across the vegetation ranged from low to moderate. The low percentage of the base saturation was generally attributed to intense leaching by high tropical rainfall (Anikwe et al., 2003; Ndukwu et al., 2009; Senjobi and Ogunkunle, 2011). The higher content of base saturation obtained in forestland indicate the high fertility status of the soils under such vegetation when compared to grassland as a result of the accumulation of decayed plant leaves.

3.2.8 Available Phosphorus

The content of the available phosphorus (Table 4) was found to be higher in forestland when compared to grassland across the various depths. However, there was no significant difference between the mean values from the vegetation in that respect. Generally, the variation in available phosphorus contents in soils is related to the intensity of soil weathering or soil disturbance, the degree of P-fixation with Fe and Ca, as indicated by Paulos (1996). According to Landon (1991) rating, the available phosphorus values of the soils across the different vegetation types generally were high (>15m/kg) at 0-20cm and medium (between 5 and 15 mg/kg) at 20-40cm. However, the value obtained in the forest was higher in both cases (17.09mg/kg) and (12.75mg/kg).

Similarly, the mean values of phosphorus obtained from the profile samples were also higher in forestland than in grassland. Erosion tends to transport predominantly the clay and organic fractions of the soil, which are relatively abundant in P fractions (Brady and Weil, 2002). However, more substantial evidence of erosion was observed in grassland, and higher organic matter was observed in forestland than grassland, and this may have accounted for the higher available P in forestland than in grassland.

4.0 Conclusions and Recommendations

The results of morphological, physical and chemical properties of the soils studied revealed that there were no significant differences between the two vegetation types on the majority of the soil parameters used for characterization in the three locations chosen. It was shown that organic matter content, CEC (except in Bt Horizon of the profile pit where it was significantly higher in grassland), % BS, TN, exchangeable bases and available phosphorus were higher in forestland than in grassland although not statistically significant.

However, the pH of the grassland soils was significantly higher than that of the forestland soils. These observations were attributed to the effect of different vegetation types on the soil properties. The clay content of the soils across the vegetation types increased down the profile indicating possible clay argillation. It was concluded that the soils of forestland had higher fertility status and thus agriculture potentials than those of grassland.

However, appropriate management practices should be adopted, such as contour cultivation and mulching to check erosion since the soils are at upper slopes which are prone to erosion.

Application of lime to reduce the acidity of the soils, especially that of forestland is also recommended after lime requirement test.

Table 4: Comparative chemical properties of the auger and profile soil samples at 0-20cm, 20-40cm (depths), A and B_t Horizons across the three locations as influenced by different vegetation types

Vegetation	pH H_2O	pH KCL	EA H^+ (Cmol/kg soil)	EA AL^{3+} (Cmol/kg soil)	OM (g/kg)	TN (g/kg)	Exchangeable Bases Ca^{2+}	Exchangeable Bases Mg^{2+}	Exchangeable Bases Na^+	Exchangeable Bases K^+	CEC (Cmol/kg soil)	BS (%)	P g/kg
Depth (0-20cm)													
FL	3.900	3.433	1.467	0.200	6.660	0.377	2.133	2.600	0.040	0.200	24.700	74.600	17.090
GL	4.330	3.567	1.470	0.267	4.470	0.187	1.800	1.930	0.020	0.173	20.900	70.500	15.230
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Depth (20-40cm)													
FL	3.967	3.467	1.267	0.267	3.680	0.177	1.600	1.470	0.030	0.153	18.500	72.600	13.670
GL	4.333	3.600	1.333	0.200	3.280	0.160	1.930	2.000	0.040	0.087	16.90	69.620	12.740
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
A - Horizon													
FL	4.300	3.633	2.867	-	4.170	0.203	1.400	1.267	0.023	0.117	32.000	49.200	11.500
GL	4.800	3.800	2.733	-	3.330	0.180	1.000	1.267	0.020	0.080	25.200	46.500	9.320
$LSD_{0.05}$	0.2484	0.1434	NS	-	NS	NS	NS	NS	NS	NS	NS	NS	NS
B_t - Horizon													
FL	4.567	3.767	2.733	-	1.570	0.080	1.070	1.270	0.020	0.063	20.670	47.200	6.530
GL	4.833	3.833	2.200	-	1.363	0.103	0.870	1.130	0.023	0.173	24.400	50.400	6.220
$LSD_{0.05}$	0.248	0.1434	NS	-	NS	NS	NS	NS	NS	NS	3.194	NS	NS

Note: EA= Exchangeable Acidity; OM= organic matter; TN= Total Nitrogen; CEC = Cation Exchange Capacity; BS= Base Saturation; FL= Forestland; GL= Grassland; NS=Non Significant at 5% Probability Level; $LSD_{0.05}$= Least Significant Difference

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