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Assessment of Soil Quality Status under Different Land-Use in Akpabuyo Local Government Area of Cross River State-Nigeria

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Abstract – **The conversion of natural forest into other forms like pasture or croplands is of considerable concern worldwide in the context of environmental degradation and global climate change. This study is aimed at examining variations in soil properties in continuously cropping and forested plots in parts of southern Cross River State – Nigeria. To achieve this, four transects were established in the cardinal directions due to break in slope of the land terrain and nine soil profiles comprising two in each direction and the starting point were selected along the transects. Soil samples were taken from the different horizons. The samples were stored in polyethylene bags and taken to the laboratory. In the laboratory, the samples were air-dried, crushed and allowed to pass through a 2mm sieve and analysed using standard methods. The method of statistical analysis employed was the pair-wise t-test, otherwise known as the paired comparison as described by Snedecor and Cochram to determine the significant differences that existed between the landuse types on the measured soil properties in the study area. The index of deterioration (DI) was also calculated for the soil properties to determine the rate of deterioration. The result of the analysis of chemical properties shows that organic matter in the soil under continuous cropping had mean values and SE of 3.8±0.6 and 2.0±0.4 whereas soils under forest plot had mean values and SE of 13.0±1.9 and 2.9±5.0 for topsoil and subsoils respectively. There was a significant difference in the soil pH between the two land use types. The forest plot had a mean and SE value of 5.3±0.08 and 5.2±0.06 while the continuous cropping plot had higher pH values of 3.5±1.2 and 3.1±1.0 for both the topsoil and subsoil respectively. EC, moisture content, total nitrogen, exchangeable calcium, exchangeable magnesium and available phosphorus were higher in soils under forest plot than the soils under continuous cropping while exchangeable sodium was higher in soil under continuous cropping of arable crops. The results show that silt, clay, organic matter, electrical conductivity, total nitrogen, available phosphorus, exchangeable calcium and magnesium shows deterioration indices above 50%. The result further revealed that the soils under investigation have not only deteriorated but degraded as some of the elements have negative (DI). Therefore, there is the need for appropriate soil management strategy to be put in place in order to sustain food production in the study area.**

Keywords – **Soil Quality Status, Assessment, Landuse, Akpabuyo L.G.A., Soil Properties.**

I. Introduction

Soil is an essential part of the terrestrial ecosystem. It is defined as the product of interactions between parent materials, biotas, topography and climate through time (Aderonke and Gbadegesin, 2013). Soil properties deteriorate with change in land-use especially from forest to arable land (Oguike and Mbagwu, 2009). The cropping system may lead to erosion and leaching of soil nutrients which in turn adversely affect the physico-chemical properties of the soil (Awotoye et al., 2011).

Gol and Dengiz (2008) observed that variation of landuse and management practices implemented locally, such as long term cultivation, deforestation, overgrazing and mineral fertilization can cause significant modification in soil characteristics. The conversion of natural forest into other forms like pasture or crop lands are of considerable concern worldwide in the context of environmental degradation and global climate change (Mahtab and Karim, 1992; Wail *et al.,* 1999; Celik, 2005). Additionally, landuse changes such as conversion of the natural forest to arable agricultural lands are known to result in loss of organic matter associated with organic carbon and nitrogen content (Houghton *et al.,* 2004; Henrot and Robertson, 1994). Jiang *et al.* (2006) reported in their study that soil organic matter content decreased from 38.02 to 25.76gkg^{-1} in the past 20 years (1982 – 2003) after transformation of forestland into cultivated land. These changes in organic matter content following land transformation can connect distribution and stability of soil aggregates (Paustian *et al.,* 2002; Elliot, 1986) and provoke soil erosion (Williams, 1993).

As a result of human activities, the soil is also one of the most affected parts of the ecosystem (Flechsig *et al.,* 1995; Rapaport *et al.,* 1995; Schlesinger, 1991). Human activities have however resulted in soil degradation and reduction in soil functions. For sustainable crop production, reliable soil data are the most important prerequisite for the design of appropriate land-use systems and soil management practices as well as for a better understanding of the environment. It is therefore important to note that during cropping, there is lowering of soil fertility and this can be highly observed in continuous cropping because the soil is exposed for long and unprotected from damaging climatic influences. Considering various effects caused by crops on soil properties, it is also important and advisable to assess the soil quality under different landuse system of peasant farming so as to promptly step up the restoration measures if the soil is degraded.

The objective of this study was to examine variation of soil properties of a continuously cropping (cultivated) and forested plot in parts of southern Cross River State – Nigeria.

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II. Materials and Methods

Study Area

The study site is Akpabuyo Local Government Area of Cross River State located between longitudes $8^0$20'E and $8^0$40'E of Greenwich Meridian and latitudes $4^0$45'N and $5^0$10'N of the Equator. Akpabuyo Local Government Area extends from the Great Kwa River along Atimbo bridge head characterized by tertiary coastal plain sand. The soils of Akpabuyo are derived from the tertiary coastal plain sands of Pleistocene era. The area is characterized by a tropical climate marked with wet and dry seasons. Annual temperature ranges from 21 to 31^0c.

The land-use systems studied include: A forested plot of land occupying 12 hectares and a continuously cropping land measuring 4 hectares. The crops combination cultivated manually include yam, cassava, maize, okoro and pumpkin as cultivation has been going on for the past six years.

Fieldwork: Four transects were established in the eastern, western, southern and northern directions due to break in slope of the land terrain. Nine representative profiles comprising two in each direction and the starting point were selected along the transects. The profiles were dug and soil samples taken from the different horizons. The samples were stored in polyethylene bags and transported to the laboratory for analysis.

Laboratory Analysis:

The samples will be air-dried, crushed and allowed to pass through a 2mm sieve. The gravel content (materials >2mm) was determined and expressed as a percentage of the total weight of the soil. Soil samples will be analysed for soil pH in both water and 0.01M potassium chloride solution (1:1) using glass electrode pH meter (McLean, 1965). Total nitrogen will be was determined by the macro-kjeldahl digestion method as described by Jackson (1962). Bray-1 P was determined by molybdenum blue colorimetry (Bray and Kurtz, 1945) while exchangeable cations will be extracted with 1M NH4OAC (pH 7.0) to determine K and Na using flame photometer and exchangeable Mg and Ca by atomic absorption spectrophotometer (Sparks, 1996). Exchangeable acidity will be determined by the KCl extraction method (Mclean, 1965) and organic carbon was after dichromate wet oxidation method (Walkey and Black, 1934). Conversions between values of organic carbon and organic matter will be made using Van Bemmelen factor of 1.724 on the assumption that, on average, SOM contains 58% of organic C. Cation Exchange Capacity (CEC) will be calculated from the sum of all exchangeable cations. Particle size distribution will be determined using hydrometer method (Day, 1965).

Data Analysis:

The method of statistical analysis adopted was pair-wise t-test, otherwise known as the paired comparison as described by Snedecor and Cochram (1967). It was used to determine the significant differences that exist in the soil properties between continuous cropping and forest plots. The means of the soil properties or parameters examined for each of the plots were calculated. Index of deterioration (DI) was applied according to Ekanade (1991b) to computer the rate of deterioration of the soil properties in the study area. The index of deterioration is given as thus:

$$DI = \frac{\bar{x} - \bar{x}_1}{\bar{x}}$$

Where

$\bar{x}$ = mean value of soil parameters in forested plot (reference site),

$\bar{x}_1$ = mean value of soil parameters in compared site.

III. Result

Table I shows the mean value of the topsoil and subsoil properties in forest and continuous cropping plots. There is a significant difference in the mean values of the soil properties (top and subsoils) across the soil levels. The results of the analysis reveals that sand particles in soil under continuous cropping was higher 885.6±3.8gm-kg and 819.8±5.0gm-kg while forest plot was 773.6±6.8 and 707.0±7.0gm-kg top and subsoils respectively. The mean value of silt for continuous cropping was 4.6±2.0 and 6.4±2.0gm-kg while forest plot values were 28.2±7.0 and 32.9±4.4gm-kg topsoil and subsoil respectively. The mean value of clay particles was higher in forest plot than continuous cropping (Table I). Nonetheless, the mean value of pore space of soil under forest plot was 17.8±9.7 and 17.6±9.7 both top and subsoils respectively while soul of continuous cropping of arable crops were 11.8±0.4 and 4.2±6.3 respectively for both subsoil and subsurface soils. The result of the analysis of chemical properties shows that organic matter in the soil under continuous cropping had mean values and SE of 3.8±0.6 and 2.0±0.4 whereas soils under forest plot had mean values and SE of 13.0±1.9 and 2.9±5.0 for topsoil and subsoils respectively. There was a significant difference in the soil pH between the two land use types. The forest plot had a mean and SE value of 5.3±0.08 and 5.2±0.06 while the continuous cropping plot had higher pH values of 3.5±1.2 and 3.1±1.0 for both the topsoil and subsoil respectively. EC, moisture content, total nitrogen, exchangeable calcium, exchangeable magnesium and available phosphorus were higher in soils under forest plot than the soils under continuous cropping while exchangeable sodium was higher in soil under continuous cropping of arable crops. Exchangeable potassium was higher in forest plot for topsoil than the continuous cropping plot and had the same values for both plots in the (top and subsoils) table I. Electrical conductivity (EC) was higher in the forest plot (2.1±1.3dSm^{-1} and 2.3±1.5dSm^{-1}) than in the continuous cropping (0.045±0.02dSm^{-1} and 0,023±0.02dSm^{-1}) for topsoil and subsoil respectively.

Table I: Mean values of soil properties (topsoil and subsoil) in forest plot and continuous cropping

Parameter	Forest plot Mean ± SE	Continuous cropping Mean ± SE
Sand	T 886 ± 3.8 SS 819 ± 5.0	774 ± 6.8 707 ± 7.0

Silt	T 28.2 ± 7.0 SS 32.9 ± 4.4	4.6 ± 2.0 6.4 ± 2.0
Clay	T 38.08 ± 14.8 SS 38.05 ± 12.6	7.54 ± 4.6 11.7 ± 3.6
pH	T 3.5 ± 1.2 SS 3.1 ± 1.0	5.3 ± 0.08 5.2 ± 0.06
Organic matter	T 13$^{\pm}$ ± 1.9 SS 3.1 ± 5.0	3.8 ± 0.6 5.2 ± 0.4
Electrical conductivity (EC)	T 2.1 ± 1.3dSm^{-1} SS 2.3 ± 1.5dSm^{-1}	0.045 ± 0.02dSm^{-1} 0.023 ± 0.02dSm^{-1}
Moisture content	T 36.3 ± 36.3 SS 33.52 ± 36.9	55.51 ± 4 46.52 ± 23.8
Pore space	T 17.8 ± 9.7 SS 11.8 ± 3.7	17.6 ± 9.7 14.2 ± 6.3
Total nitrogen	T 7.2 ± 0.6 SS 7.3 ± 0.4	0.5 ± 0.06 0.5 ± 0.05
Available phosphorus	T 28$^{\pm}$ ± 6.0 SS 41$^{\pm}$ ± 6.0	5.0 ± 0.9 6.0 ± 0.4
Exchangeable calcium	T 9.54 ± 1.1 SS 9.99 ± 1.2	2.44 ± 0.24 2.33 ± 0.3
Exchangeable magnesium	T 15.3 ± 1.2 SS 16.47 ± 1.9	1.15 ± 0.14 1.08 ± 0.11
Exchangeable sodium	T 0.06 ± 0.04 SS 0.05 ± 0.3	0.09 ± 0.05 0.07 ± 0.04
Exchangeable potassium	T 0.02 ± 0.02 SS 0.10 ± 0.01	0.10 ± 0.3 0.10 ± 0.02

IV. DISCUSSION

The relatively high organic matter content in the forest plot maintained through accumulation of litter assisted in lowering the bulk density and improving the soil total nitrogen (Awotoye *et al.*, 2011; Eludoyin *et al.,* 2011 and Gbadegesin *et al.,* 2011). The low available phosphorus content in both the topsoils in the forest and continuous cropping plots could be attributed to the uptake of nutrients by cassava, yam and maize among others at that layer in an immobilized form (Ekanade, *et al.,* 1991). The amount of organic matter stored in the soil results from net balance between the rate of soil organic matter inputs and rate of mineralization (Schlesinger, 1990). The decrease in organic matter with depth may be due to decrease in abundance of fine roots (Post and Kwon, 2000). Oriowo (1989) reported abundance of fine roots in 0 to 20cm depth in a regrowth forest and this possibly enhances organic matter content in the topsoil.

The result shows that the distribution of particle size composition reveals that the two plots were predominantly sandy but texturally homogeneous, characterized by tertiary coastal plain sand derived from Pleistocene era as both soils are of the same geological material of sedimentary origin (Abua, 2012). The higher sand particles observed in the continuous cropping land use type may be presumably due to erosion caused by the long period of intensive cultivation while the low proportion of silt particles under the continuous cropping plots suggest that cultivation of crops reduces silt particles in the soil. This may be traceable to erosion, which removes fine particles of soil due to less vegetation cover that could reduce the impact of raindrops on soil in the cultivated plots. The clay particle, which shows variation between the two land use types, suggest that the soils are similar with respect to textural composition as the soils are derived from the same parent materials.

Calcium and Magnesium concentration were revealed from the analysis to be higher among other exchangeable bases (sodium and potassium) in the study area; thus, this conforms with (Aweto *et al.,* 1992) observation that calcium and magnesium were the highest of other exchangeable bases on a forest alfisol in southwestern Nigeria. This may also be attributed to organic matter dimunition and more so, more magnesium would be undoubtedly utilized by cultivated crops and some may be washed off by surface erosion following the exposure of land through continuous cultivation. The electrical conductivity values in the surface and subsurface soils for both landuse types investigated were within the critical value of 2dSm^{-1} for sensitive crop species (FAO, 1974) and 4dSm^{-1} for identifying the soils as saline soils (Donuahue, et al., 1990). These results suggest that the soils do not have salinity problem. The relatively higher values with depth could be ascribed to the influence of soil texture.

Table II: Deterioration Indices (DI) of soil properties for topsoil and subsoil

Parameter	Topsoil DI (%)	Subsoil DI (%)
Sand	12.64	13.68
Silt	83.68	80.55
Clay	80.20	69.25
pH	-51.42	-67.74
Organic matter	70.77	31.03
Electrical conductivity (EC)	97.86	99
Moisture content	-51.70	-38.78
Pore space	33.71	19.32
Total nitrogen	88.89	93.15
Available phosphorus	82.14	85.37
Exchangeable calcium	74.42	76.68
Exchangeable magnesium	92.48	93.44
Exchangeable sodium	-50	-40
Exchangeable potassium	50	-

DI = deterioration index in percentage. Values above 50% represent high deterioration and negative indices show degradation

The analysis in table 2 revealed that sand content, pore space, exchangeable potassium and organic matter (subsoil) of the soils in the study area, shows low level (percentages) of deterioration. The rest of the soil parameters i.e. silt, clay, organic matter (top soil), electrical conductivity, total nitrogen, available phosphorus, exchangeable calcium, exchangeable magnesium and exchangeable potassium (in top soil) shows deterioration indices (DI) above 50% representing high level of soil deterioration in the study area. This is attributed to the fact that a lot of nutrients must have been lost during harvesting. pH, moisture content and exchangeable sodium had negative indices of deterioration depicting high level of soil degradation. Exchangeable potassium was the only element (in subsoil) without any percentage of deterioration of soil in the study area.

V. Conclusion

An assessment of different land use types has been carried out using index of deterioration to examine the extent to which the soils in the study area have deteriorated. The results revealed that the soil under investigation has not only deteriorated seriously but has been degraded owing to continuously cropping of the land with arable crops. Therefore, there is the need for appropriate soil management strategy to be put in place in order to sustain food production in the study area.

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