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VARIABILITY IN SOME PHYSICAL AND CHEMICAL PROPERTIES OF SOIL ALONG A TOPOSEQUENCE IN ALVAN IKOKU FEDERAL COLLEGE OF EDUCATION, OWERRI, IMO STATE, NIGERIA

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ABSTRACT

The research was embarked upon to assess the variability in some physico-chemical properties of soil along a toposequence in Alvan Ikoku Federal College of Education, Owerri, Imo State. Soil samples were collected from two different depths, 0-15 cm and 15-30 cm, at each topographic unit, namely, upper slope, mid slope and bottom slope. A total of 12 samples were used for the study. The, samples collected were air-dried, crushed and sieved in a 2 mm sieve preparatory to laboratory analysis. Means and coefficient of variation were used as the statistical tools. The results show that the physico-chemical properties of soil along the toposequence varied from low to high variation with the coefficient variation ranging from 1.05 % to 77.5 %. Sand fractions increases with depth, silt contents increases with decrease in slope and clay content increases down the slope and depth. The silt/clay ratio was low in all pedons. Soil pH was acidic in all the pedons. Percent organic carbon decreased with depth and increased from upper to bottom slopes. The results of this work have showed that there are changes in some physico-chemical properties of soil along a toposequence in A. I. F. C. E, Owerri.

KEYWORDS: Soil, Physical and Chemical Properties, Toposequence

INTRODUCTION

It is a well known fact that the physico-chemical properties of soil vary along a landscape due to soil forming factors, soil frequently occurs in a well defined and fairly regular sequence (Smith and Montgomery, 1990). These sequences have been referred to as toposequence, Moorman, (1999).

Thus, soil properties as the potentials for crop production often vary from crest to the valley bottom due to differences in soil types. Odenerhol, (2000) opined that the distribution of individual soil series on a toposequence has considerable influence on the land use pattern of an area. Toposequence can be classified into three classes according to slope gradient as upper slope, mid slope and bottom slope.

Soil is defined as a collection of natural bodies occupying parts of the earth's surface that is capable of supporting plant growth and living organism acting upon parent material as conditioned by topography over a period of time (Brady and Weil, 2007).

Topography gives rise to toposequence of related soils from the same parent materials, about the same age and occupying under similar climatic conditions but have differences in their characteristics due to change in slope (Brady and Weil, 2007). Farmers often cultivate the entire toposequence, while some however restrict the cultivation to

only a section of it (Eshett, 2003).

Topography therefore is an important factor affecting the nature and distributions of soil. *Buol et al.,* (1999), observed that along a toposequence, soil patterns could be differentiated on the basis of various characteristics.

In spite of the reported changes in soil properties and crop yield along the toposequence, recommendation for agronomic practices are often made to farmers without due consideration for specific topographic locations that may influence the management options such as fertilizer rates and types (Stoop, 2000).

Effective land use management for crop production on a toposequence therefore requires knowledge of both the physical and chemical properties of the soil at different slope positions.

Therefore, the objective of this paper is to assess the variability in some physical and chemical properties of soil along the toposequence in Alvan Ikoku Federal College of Education, Owerri, with the view of providing information to the farmers on the best management practices that should be adopted on a topographic location.

MATERIALS AND METHODS

Area of the Study

The study was conducted in Alvan Ikoku Federal College of Education, Owerri, Imo State. It lies between latitude 5° 35^{1}N and Longitude 5^{0} 04^{1}. It is about 1km from Owerri capital city of Imo state. The area has a humid tropical climate with annual rainfall greater than 2500 mm, the mean relative humidity of 70-80 % during rainy season and 50-60 % during the dry season the area has a temperature ranging 27 °C to 33 °C.

It is a rain forest area characterized by multiple plant species such as banana (*Musa sapientium*), India bamboo (*Bam busatulda*) etc.

Field Work

A field work followed reconnaissance visit. The toposequence was delineated into three topographical units (upper slope, mid slope, and bottom slope) and a transverse was cut to link them. Each of the topographical position was geo-referenced with a hand held global positioning system (GPS) receiver which also gave the altitude of patch point and the distance from one another.

Table 1: Location of the Toposequence Taken with GPS, Pedons Elevation (Above Sea Level) Coordination

A. (Upper slope)	66m	Lat. 5^{0} 2^{1} 55^{1} N	Long. 7^{0} 49^{1}10.8^{1}E
B. (Mid slope)	50m	Lat. 6° 2^{1} 46^{1} N	Long. 6° 49^{1} 6.8^{1} E
C. (Bottom slope)	35m	Lat. 6° 2 43^{1} N	Long 6° 49^{1} 5. 01 E

Soil Sample Collection

The soil sample were collected using soil auger to obtain both composite and core sample from two depths along the topósequence (0-15 cm and 15-30 cm) at the upper slope, mid slope and bottom slope, giving a total of 12 samples.

Soil Sample Preparation

The soil samples were air-dried at room temperature 26° C, after a careful removal of plant and other unwanted materials, the soil samples were crushed with a wooden roller, sieved with 2 mm sieve according to Ano *et al.,* (2009).

Laboratory Analysis

Standard laboratory soil analysis was carried out, they include; particle size distribution determined using hydrometer method (Gee and Or, 2002), Bulk density was determined using the core method, moisture content was determined using the gravimetric method (Nelson, 1990). Hydraulic conductivity determined using the constant Lead Method by Blake, (1995). pH was determined using the glass electrode method as outlined by Ano, (2009). Organic carbon was determined using oxidation method as modified by Nelson and Summers (1990) while organic matter was obtained by multiplying the organic carbon by 1.724. Total nitrogen determined using microkjeldahl method (Bremmer and Mulvancy, 1990). Available phosphorus determined using Bray II method by Bray and Kurtz, (1998). Exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) were determined using in NH_4OAC (Jackson, 1990). Base saturation was obtained using the formula:

$$BS\ (\%) = \frac{\text{Sum of exchangeable bases}}{\text{Cation exchange capacity}} \times \frac{100}{1}$$

Exchangeable acidity determined using IN KCl extraction method, Mclean, (1998).

Statistical Analysis

The statistical tools used were mean and coefficient of variation (CV),

It is given as $C.V = \frac{SD}{X} \times \frac{100}{1}$

Where SD = Standard Deviation

X= Mean

CV = coefficient of variation

Coefficients of Variation were ranked according to Aweto, (1990) as follows;

CV < 20% Low variation

CV = 20-50% Moderate variation

CV = 50% and above high variation.

RESULTS AND DISCUSSIONS

Physical Properties of soil Table 2. showed that sand fraction were decreasing with increase in depth down the toposequence, the mean sand values were 78.15 %, 73.20 % and 69.10 % for upper, mid and bottom slopes respectively. The silt content increased with increase in slope, ranging from upper (3.60%) to bottom (11.20%) slope, thus the bottom slope has the highest silt content with the mean of 7.70%. The clay content of the pedons increase down the slope and depth. The mean values for the upper, mid and bottom slopes were 18.45 %, 21.80 % and 25.20 % respectively. The may be due to down-ward accumulation of clay in the subsoil (Brady and Weil, 2007).

The soils of the upper slope had the sandy loam texture and changes to sandy clay loam from the mid slope (15-30 cm depth) to the bottom slope. The moisture content was higher in the bottom slope with depth than in other topographic units.

Table 2: Results of the Physical Properties of Soils in the Study Area

Soil Depth (cm)	B.D (g/cm3)	M.C (%)	Porosity (%)	Ksat (cm/hr)	Sand (%)	Silt (%)	Clay (%)	Silt/Clay Ratio	Textural Class
Upper Slope									
0-15	1.06	48.28	60.00	22.34	80.00	3.60	16.40	0.22	Sandy Loam
15-30	1.23	50.00	53.58	28.80	76.15	3.60	20.10	0.18	Sandy Loam
Mean	**1.15**	**49.14**	**56.79**	**25.57**	**78.15**	**3.60**	**18.25**	**0.20**	
Mid Slope									
0-15	1.02	51.09	61.51	22.88	78.20	4.00	17.80	0.23	Sandy Loam
15-30	1.22	53.98	53.96	28.40	68.20	6.00	25.80	0.23	Sandy Clay Loam
Mean	**1.12**	**52.54**	**25.74**	**25.64**	**73.20**	**5.00**	**21.8**	**0.23**	
Bottom slope									
0-15	1.01	61.9	61.89	23.06	67.60	11.20	21.20	0.53	Sandy Clay Loam
15-30	1.21	61.90	61.89	23.06	67.60	11.20	21 20	0.53	Sandy Clay Loam
Mean	**1.11**	**65.49**	**58. 12**	**26.28**	**67.10**	**7.70**	**25.20**	**0.31**	

Where; B.D=Bulk Density (g/cm^3)
M.C=Moisture Content (%)
K_{sat}=Hydraulic Conductivity (cm/hr)

Chemical Properties of the Soils pH

There was an irregular distribution of pH values in the pedons at various depths (0-15 cm and 15-30 cm). The pH mean values obtained were 4.8, 5.4 and 5.1 for upper, mid and bottom slope respectively. This indicates acidity rated as very strongly acidic to strongly acidic (Landon, 1991). This is due to the constant leaching by rainfall which leaves the soil saturated with more AI^{3+} and H^{+}.

Available Phosphorus

The available phosphorus decreased down the slope, but was moderate to high (14.80-38.60 mg/kg) from bottom to upper slope. This suggests that the soil reaction was probably favorable for phosphorus availability in the study area.

Organic Carbon

There was a decrease in percentage organic carbon with depth in all the pedons, while the high values occurred at the depth of 0-15 cm, with the highest value (1.83 %) occurring at the bottom slope (Table 3). This could be as a result of the transportation and deposition of organic materials from the upper slope to the bottom slope by the erosive agent of water (Brady and Weil, 2007).

Total Nitrogen

All the soil samples in all the pedons showed a decrease in nitrogen content with depth. The mean values of total nitrogen were 0.105%, 0.098 and 0.098% and 0.098% for upper, mid and bottom slopes respectively. This agrees with the work of Miller *et at.,* (2000) who observed low organic matter and nitrogen with slope position along a toposequence. Hence the total nitrogen was generally low in all the pedons ranging from 0.098-0.105 % (Table 3).

The Effective Cation Exchange Capacity (ECEC) was low in all the pedons except in 0-15 cm depth of the upper slope, having 17.30 Cmol/kg with the mean value of 10.9 Cmolkg. The soils are kaolinitic in nature with ECEC values ranging from 4.50 to 17.30 Cmol/kg.

Table 3: Results of the Chemical Properties of Soils in the Study Area

Soil Depth (cm)	pH Water	P Mg/kg	N (%)	O.C (%)	O.M (%)	Exchangeable Base				TEB	EA	ECEC	BS
						Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}				
Upper Slope													
0-15	4.60	38.60	0.14	1.29	2.22	9.60	5.60	0.06	0.13	15.38	1.92	17.30	88.91
15-30	4.90	19.60	10.69	0.07	1.19	2.05	2.00	1.20	0.05	3.30	1.20	4.50	7.22
Mean	4.80	29.10	0.11	1.71	2.14	5.80	3.40	0.05	0.09	9.34	1.56	10.90	81.07
Mid Slope													
0-15	5.10	31.30	0.10	1.15	1.98	3.60	2.00	0.10	0.75	6.45	1.52	7.97	80.93
15-30	5.70	24.00	0.10	1.14	1.97	7.20	3.20	0.09	0.02	10.51	2.08	12.59	83.48
Mean	**5.40**	**27.65**	**0.10**	**1.31**	**1.98**	**5.40**	**2.60**	**0.09**	**0.05**	**8.48**	**1.80**	**10.28**	**82.21**
Bottom Slope													
0-15	4.90	27.50	0.14	1.83	3.15	4.00	2.40	0.06	0.08	6.54	2.08	8.62	75.82
15-30	5.30	14.80	0.06	1.73	2.98	2.80	1.60	0.04	0.08	4.52	1.68	6.20	72.90
Mean	**5.10**	**21.15**	**0.10**	**1.78**	**3.07**	**3.40**	**2.00**	**0.05**	**0.08**	**5.53**	**1.88**	**7.41**	**74.36**

Where: P=Phosphorus (Mg/kg), N-Nitrogen (%), 0.C=Organic Carbon (%), 0.M=Organic Matter (%) Ca^{2+}= Calcium ($Cmolkg^{-1}$), Mg^{2+}=Magnesium ($Cmolkg^{-1}$), K^{+}=Potassium ($Cmolkg^{-1}$), Na^{+}=Sodium ($Cmolkg^{-1}$) TEB=Total Exchangeable Bases ($Cmolkg^{-1}$), EA-Exchangeable Acidity ($Cmolkg^{-1}$) BS= Base Saturation (%), ECEC= Effective Cation Exchange Capacity ($Cmolkg^{-1}$)

Variability of Soil Properties along Toposequence

It was observed that the overall physico-chemical properties of soil varied form low to high variations with coefficient of variation arranging from 1.05 to 77.9% respectively in shown in Table 4. At upper slope, clay, sand, pH, Bulk density and base saturation showed low variation, exchangeable acidity showed moderate variation while total nitrogen, organic carbon, available phosphorus and total exchangeable bases showed high variation.

At mid slope, pH, base saturation, clay, sand and bulk density showed low variation, organic carbon, exchangeable acidity, phosphorus and silt showed moderate variation while effective cation exchange capacity and total exchangeable bases showed high variation.

At bottom slope pH, sand, silt, clay, bulk density etc showed low variation, exchangeable acidity total nitrogen showed moderate variation while available phosphorus, organic carbon, total exchangeable bases, effective cation exchange capacity etc showed very high variation. The results were in line with the work done by Brubakar, (1993) who observed that landscape position creates variability in soil formation and properties along a toposequence.

Table 4: Variability Grouping of Selected Soil Properties along the Toposquence

Rating	CV%	Soil Properties
Upper Slope		
Low variation	<20	pH, B.S, clay, sand silt and bulk density
Moderate variation	20-50	E.A
Highly variation	50 and above	TN, OC, ECEC, P, TEB,
Mid Slope		
Low variation	<20	pH, BS, Clay, silt Sand, Bulk density, porosity
Moderate variation	20-50	OC, EA, P, TN,
Highly variation	50 and above	ECEC, TEB,
Bottom Slope		
Low variation	<20	pH, Sand, silt, porosity and clay
Moderate variation	20-50	TN, EA,
Highly variation	50 and above	AP, OC, TEB, ECEC,

Where BS = Base Saturation, TEB=Total exchangeable Bases T N=Total nitrogen, OC = organic carbon, P - Phosphorus EA = Exchangeable Acidity

CONCLUSIONS AND RECOMMENDATIONS

The results of the study showed that topography affects and changes the overall soil properties of a given landscape. In the study area, some physico-chemical properties of the soils, in the three topograghic units varied from the upper slope to the bottom slope. Such properties like sand fraction decreased with increase in depth down the toposequence with the highest sand fraction occurring at the upper slope. Silt and clay contents increased with decrease in slopes with the bottom slope having the highest values of silt and clay contents.

Soil pH was acidic in all the pedons, the available phosphorus was moderate to high from bottom slope to upper slope. The results also showed that percentage organic carbon decreased with depth and increased from upper to bottom slopes.

The results of the coefficient of variation also showed that the overall physico-chemical properties along the toposequence varied from low to high.

RECOMMENDATIONS

Since toposequence is controlled by the forces of degradation, there is need to adopt the appropriate agronomic measures for a sustainable agricultural production, such as,

- Strip cropping to control flow of water across a toposequence.
- Contour tillage should be practiced which involved the cultivation of a sloppy land with ridges made across the toposequenc
- Use of vegetative barriers to create natural terraces against runoff.
- Use of alley cropping for fertility maintenance.
- Mulching should be adopted to protect the soil surface against raindrops.
- Use of organic and green manures will help maintain the organic matter content of the toposequence.
- Agro-forestry should be adopted as an alternative measure to slash and burn on a toposequence.

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