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Morphological and Physical Characteristics of Soils Developed on a Toposequence Derived from Coarse-grained Pegmatites in a Tropical Region, Delta State, Nigeria

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Abstract

A study was conducted to evaluate the morphological and physical characteristics of a soil developed on a toposequence using fire slope positions. Modal profile pits were dug in each of the slope positions and characterized. Soil samples were collected from each of the pedogenetic horizons and analyzed routinely for particle size distribution of bulk/particle densities and total porosity. Results showed that the landscape had a relative elevation of 0-24. 25 m with a slope gradient value from the crest to valley bottom as: 1.68, 1.55, 1.46, 1.42 and 1.22%. Soil colour from the crest to the valley bottom varied significantly from dominant 5YR to 7.5 YR and 10YR respectively. Soil depth, structure, consistence and rootlets varied significantly ($P \leq 0.05$) across slope position. Bulk and particle densities value were higher in the crest and upper-slope positions with mean values of 1.20 gcm^{-3} and 2.35 gcm^{-3}. There were no significant variations ($P > 0.05$) in particle size distribution across slope position.

Keywords: Morphological, physical characteristics, toposequence, coarse-grained, pegmatites, tropical region

Introduction

Many topical soils are derived from coarse grained pegmatites whose parent materials are resistant to weathering, and the fine earth fractions usually made up of coarse sand and are rarely clayey. These soils are known to be rich in feldspars and quartz primary minerals and, they are neither stable nor resistance to human induced activities (Akinbola *et al.*, 2010). The physical, morphological, chemical and mineralogical properties which are fundamentally related to their geological background, parent materials and the intensity of the different soil forming factors and processes varied considerably.

Most African soils are characterized by rolling landscape and soil properties are different due to the factor of topography which plays a vital role in bringing about changes in soil properties as one moves from inter fluves/crest position down to the valley bottom. These changes in soil properties led to the concept of CATENA (Milne, 1935) or Toposequence (King *et al.*, 1983). In other words, where related soils differ in their characteristics due to the influence of topography, such a sequence of soils is known as a Toposequence. According to Juo and Moorman (1981), Toposequence refers to a succession of sites from crest to a valley bottom, which contains a range of soil profiles that are representative of the landscape and soils. The topographical features of a landscape are vital in understanding soil forming processes and modification of soil profile development. Consequently, understanding the roles of topography in a landscape will help in assessing productive values of soils and most importantly, in developing strategies for its conservation. The influence of

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soil morphological and physical properties on plant growth cannot be under-estimated. Since most tropical soils are on a rolling terrain, agricultural crop production activities are bound to be affected negatively thereby resulting to low productivity. It is therefore the objective of this study to evaluate the morphological and physical properties of these soils and their management implications.

Materials and methods

Description of the study area

The study was conducted in Anwai-Asaba in Delta State, Nigeria. Anwai is located between latitude 06° 14¹N and longitude 06° 99¹E of the equator and lies significantly in a tropical rainforest zone with over 1,565mm of rainfall per annum. The rainfall characteristics are bimodal in nature with peaks in July and September. The mean annual temperature ranges between 27° – 28.6°C with an annual relative humidity of about 65.7%. The geology is made up of coarse grained pegmatites derived from a basement complex that gave rise to coarse-textured soils that are more acid than base (Egbuchua, 2012). The landscape is generally undulating with pockets of rolling features scattered all over the places. Land use is typically based on rain-fed agriculture and crops commonly cultivated include roots and tuber crops, cereals, pulses and different varieties of vegetables. An isohyperthermic temperature regime and an udic soil moisture regime typify the general area.

Field work

A topographic survey of the study area was carried out using Dumpy level and soil characteristics described in accordance with the guidelines provided by Young, (1976), for topographic survey description and interpretations. Based on the guidelines, five slope positions were created. These were crest, upper-slope, middle-slope, lower-slope and valley bottom positions (Fig 1).

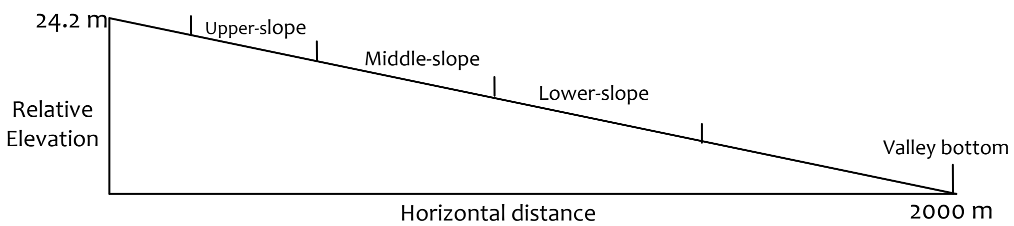

Fig 1: A cross section of the study area showing the various slope positions

In each of the slope positions, a transect was selected and two profile pits dug to the required depth where possible. The profile pits were carefully examined; delineated and described using the guidelines as contained in the soil survey manual (Soil survey staff, 2006). From each of the pedogenetic horizons, soil samples were collected, formally processed by air-drying, grinding and sieving through a 2 mm mesh and labelled properly for laboratory analysis.

Laboratory analysis

The particle size distribution of the soil samples were analysed by hydrometer method as described by Gee and Bauder, (1986), and the textures were finally determined using the USDA textural triangle. Bulk density was determined by core-method using a metal sampler as described by Blake and Hartge, (1986). Particle density was determined by the pycometer method (Blake and Hartge, 1986). Total porosity was calculated using the formular:

$$Tp = I - \left(\frac{B^d}{P^d}\right) \times 10$$

Where, Tp = Total porosity

B^d = Bulk density
P^d = Particle density

Statistical analysis
Descriptive statistics such as mean, standard deviation and coefficient of variation were used according to the procedure outlined by Steel and Torrie (1980).

Results and discussion

Topographic features
The results of the topographic survey showed a relative elevation of 0 - 24.25m (Fig 1). This is an indication that the study area was a plain of low relief (Young, 1976). Slope gradients as determined from the crest, to the valley bottom positions were 1.46, 1.68, 1.28, 1.42 and 1.55% respectively (Table 1). The slope gradient could be said emphatically to be very gentle at all positions.

Table 1: Topographic characteristics of the study area

Landscape position	Gradient (%)	Distance from absolute crest at mid position (m)	Relative elevation at mid position (m)
Crest	1.68	222.34	22.30
Upper slope	1.55	1425.47	19.47
Middle slope	1.46	1223.2	14.27
Lower slope	1.42	548.2	8.21
Valley bottom	1.22	53.46	3.17

Morphological characteristics
The morphological features **(**Table 2**)** were found to vary along toposequence. The soil colours differed from the crest, upper and middle-slope positions and are characterized by a Hue of 5YR yellowish red. The lower and valley bottom slope positions have 7.5 YR and 10 YR reddish, yellow and grayish colour sequence as evidence of water saturation at some period of the year thereby signifying poor drainage conditions. The observed change in soil colour along the toposequence was as a result of the influence of topography on micro-climate. In times of rainfall, the crest and upper slope positions receive atmospheric precipitation only, while the lower and valley bottom slopes receive both precipitation and run off from the crest and upper slope positions. This phenomenon saturates the lower and valley bottom slope positions with water for an extended period than the crest and upper slopes. The implication of this, is the reddish, yellowish and greyish colour sequence in the lower slopes depicting mottling as observed in the study.

Soil depth or thickness of solum
Soil depth increased progressively along the slope positions. The crest and upper-slopes were deep up to 140 cm. The lower and valley bottom slopes were shallow (60-80 cm depth) because of high water table. The shallow depth observed in the lower/valley bottom slope positions could be attributed to water erosion effects along the slope as some materials could be eroded from the crest and upper slopes downward thereby decreasing the thickness of the solum. The implication is that land use will therefore vary between the lower/valley bottom and upper slope positions. The available moisture in the lower/valley bottom positions will therefore, guarantee dry season farming in them. The structure was found to improve down-slope. The crest, upper-slope and middle-slope positions were weakly structured due to the impact of run-off, while the lower slope/valley bottom positions were strongly structured, firm, sticky and plastic due to increased clay and organic mattercontents.

Table 2: Morphological descriptions of the soils

Horizon design	Soil depth (cm)	Colour (moist)	Mottling	Structure	Consistence	Inclusions	Rootlets	Boundary
Pedon 1								
A	0-15	5YR 2/3	-	1, c, gr	Lo, fr	-	1	cs
Ap	15-45	5YR 4/8	-	1, c, gr	Lo, fr	-	1	cs
B	45-75	5YR 5/8	-	I, c, sbk	Lo, fr	-	1	cs
Bti	75-115	7.5YR 5/8	-	I, c, abk	Lo, fr	-	-	d
C	115-140	7.5YR 4/8	-	I, c, abk	Lo, fr	-	-	d
Pedon 2								
A	0-15	5YR 2/3	-	1, c, gr	Lo, fr	-	1	cs
Ap	15-45	5YR 2/3	-	1, c, gr	Lo, fr	-	1	cs
B	45-75	5YR 5/8	-	I, c, gr	Lo, fr	-	1	cs
Bti	75-115	5YR 5/8	-	I, c, gr	Lo, fr	-	-	d
C	115-140	7.5YR 5/8	-	I, c, gr	Lo, fr	-	-	d
(Upper Slope Position) Pedon 3								
A	0-25	5YR 2/3	-	1, c, gr	Lo, fr	-	1	gs
Ap	25-60	5YR 2/3	-	1, c, gr	Lo, fr	-	1	gs
B	60-75	2.5YR 7/6	-	I, c, gr	Lo, fr	-	1	cs
Bti	75-95	2.5YR 7/6	-	I, c, gr	Lo, fr	-	1	cs
C	95-140	2.5YR 7/6	-	I, c, gr	Lo, fr	-	-	d
Pedon 4								
A	0-25	5YR 2/3	-	1, c, gr	Lo, fr	-	1	gs
Ap	25-60	5YR 2/3	-	1, c, gr	Lo, fr	-	1	gs
B	60-75	2.5YR 7/6	-	I, c, gr	Lo, fr	-	1	cs
Bti	75-95	2.5YR 7/6	-	I, c, gr	Lo, fr	-	1	cs
C	90-140	2.5YR 7/6	-	I, c, gr	Lo, fr	-	-	d
(Middle Slope Position) Pedon 5								
A	0-25	7.5YR 4/3	-	1, c, gr	Lo, fr ns	-	2	gw
Ap	25-45	7.5YR 4/3	-	1, c, gr	Lo, fr ns	-	2	gw
B	45-65	7.5YR 6/8	-	I, c, gr	Lo, fr ns	-	2	gs
Bti	65-85	7.5YR 6/8	-	I, c, gr	Lo, fr ns	-	-	gs
C	85-120	7.5YR 5/8	-	I, c, gr	Lo, fr ns	-	-	gs
Pedon 6								

A	0-25	7.5YR 4/2	-	1, c, gr	Lo, fr ns	-	2	gw
Ap	25-45	7.5YR 4/2	-	1, c, gr	Lo, fr ns	-	2	gw
B	45-65	5YR 5/8	-	I, c, gr	Lo, fr ns	-	2	gs
Bti	65-85	5YR 5/8	-	I, c, gr	Lo, fr ns	-	-	gs
C	85-120	7.5YR 5/8	-	I, c, gr	Lo, fr ns	-	-	gs
(Lower Slope Position) Pedon 7								
A	0-15	5YR 5/8	-	1, c,	sh, sst	-	3	gw
Ap	15-35	5YR 5/8	-	1, c,	sh, sst	-	3	gw
B	35-45	7.5YR 4/8	-	2, sbk	sh, sst	Fe conc	3	ds
Bti	45-60	7.5YR 4/8	-	2, abk	sh, sst	Fe conc	F	gs
C	60-80	7.5YR 5/8	7.5YR 5/8	2, abk	sh, sst	Fe conc	F	gs
Pedon 8								
A	0-15	5YR 5/8	-	1, c	sh, sst	-	3	gw
Ap	15-35	5YR 5/8	-	1, c	sh, sst	-	3	gw
B	35-45	7.5YR 5/8	-	1, sbk	sh, sst	Fe conc	3	ds
Bti	45-60	5YR 5/4	-	2, abk	sh, sst	Fe conc	F	ds
C	60-80	5YR 5/8	7.5YR 5/8	2, abk	sh, sst	Fe conc	F	gs
(Valley Bottom Position) Pedon 9								
A	0-15	7.5YR 4/6	-	2, sbk	fm, spl	-	M	cs
Ap	15-30	7.5YR 4/6	-	2, sbk	fm, spl	-	M	cs
B	30-45	7.5YR 4/1	-	2, sbk	fm, spl	Fe Mn conc	2	gw
Bti	45-60	7.5YR 6/8	7.5YR 5/8	3, sbk	fm, spl	Fe Mn conc	2	gw
C	60-75	7.5YR 6/8	7.5YR 5/8	3, sbk	fm, spl	Fe Mn conc	2	gw
Pedon 10								
A	0-15	7.5YR 6/2	-	2, sbk	fm, spl	-	M	cs
Ap	15-30	7.5YR 6/2	-	2, sbk	fm, spl	-	M	cs
B	30-45	7.5YR 6/2	-	2, sbk	fm, spl	Fe Mn conc	2	gw
Bti	45-60	7.5YR 6/8	7.5YR 5/8	3, sbk	fm, spl	Fe Mn conc	2	gw
C	60-75	7.5YR 6/8	7.5YR 5/8	3, sbk	fm, spl	Fe Mn conc	2	gw

Symbols as interpreted in the USDA – SCS (1998) Special publications on soil profile description **Structure**: 1 = weak, 2= moderate, 3 = strong, c= coarse, gr = gravelly, sbk = sub angular block, abk = angular blocky **Consistence**: Lo= loose, fr = friable, sh=slightly hard, h=hard, pl=plastic, st = sticky, sl st = slightly sticky **Inclusions**: Fe = Iron concretion, Mn = Manganese concretion **Rootlets**: 1 = common, 2 = few, 3 = many, m = many
Boundary: cs = clear smooth, d = diffuse, gs = gradual smooth, gw = gradual wavy, ds = diffuse smooth, gv = gradual wavy

The consistence also improved down-slope. At the upper slope positions, the consistence was loose, friable, non plastic and non-sticky due to erosion influence. At the lower slope position the consistence was however more compact, plastic, firm and sticky.

Rootlets were common, with few roots at the upper-slope position, to many, fine and medium in the lower slope position. The distinctness and outline of horizons within the horizons ranged from clear smooth to diffused at the crest and upper slope positions to gradual smooth at the middle slope and dominantly gradual and wavy at the lower/valley bottom slopes.

Particle size distribution

The data for the particle size distribution is shown in (Table 3**)** while the weighted means, standard deviation and coefficient of variations for the crest/upper-slope, middle-slope and lower slope/valley bottom positions are shown in (Table 4), respectively.

In the crest, upper-slope and middle-slope positions, sand seemed to be the dominant soil fraction at the surface horizon and tend to decrease with depth. The cumulative weighted mean values for the crest/upper-slope positions were 56.84% with a coefficient of variation of 21.49%. The middle-slope position had a mean value of 67.52% and a coefficient of variation of 63.06%. The lower and valley bottom-slopes had a mean value of 38.82% sand and a coefficient of variation of 13.87% (Table 4).

The percentage clay content on the other hand, increased downward from the crest to middle slope positions while the lower and valley bottom slopes showed a contrasting trend in clay accumulation and an increasing trend in sand accumulation. The differences in clay accumulation along the toposequence could have resulted from lateral translocation of clay which were removed in suspension from the upper slopes due to surface wash and deposited in the lower slopes. The decrease and irregular accumulation of clay with depth and progressive increase as observed in some of the topographic positions could be due to differences in parent material or lithologic discontinuity. Another observed feature was the presence of gravelly concretions in the lower horizons in the crest upper-slope and middle-slope positions. According to Idoga and Malgwi (2006), these minerals are mainly iron oxide nodules or dimitritus of lateritic ironstone and quartz which have been deposited to form the parent materials of the area.

Bulk density

The mean bulk density for the crest/upper slopes, middle-slope and lower/valley bottom slopes were 1.20 gcm^{-3}, 0.79 gcm^{-3} and 0.47 gcm^{-3} and coefficient of variations of 19.30%, 11.47% and 14.65% in that order respectively (Table 4). Generally, in all the topographic positions, the bulk density was found to increase with depth of profiles. This could be attributed to decrease in organic matter accumulation with depth, less root penetration and compaction caused by the weight of the overlying layers (Brady and Weil, 2007).

Particle density

The mean values of particle density (Table 4), ranged from 2.35 gcm^{-3} with a coefficient of variation of 4.22% for the crest/upper slope position; 2.20 gcm^{-3} and a coefficient of variation of 8.49% for the middle-slope position and 1.19 gcm^{-3} and a coefficient of variation of 6.53% for the lower/valley bottom slope positions. The particle density has an inverse relationship with bulk density as it decreases with depth of profile. This could be vividly explained by the higher content of organic matter in the soil surface which weighs much less than an equal volume of mineral solids. Therefore, its presence in large quantity in the soil will lower the soil's particle density as reported by Brady and Weil (2007). The data obtained from this study was an indication that particle density of most mineral soils does not very much.

Table 3: Some physical properties of the soils

Horizon design	Soil depth (cm)	Gravel →	Sand	Silt % ←	Clay	Silt/clay ratio	Bulk density gcm^{-3}	Particle density gcm^{-3}	Total porosity %	Text class
					Crest Position Pedon 1					
A	0-15	-	52.26	28.28	19.46	1.45	0.95	2.54	63	SL
Ap	15-45	-	50.23	28.28	21.49	1.32	0.98	2.52	61	SCL
B	45-75	-	46.24	19.74	34.02	0.58	1.35	2.32	42	CL
Bti	75-115	-	34.32	18.24	47.44	0.38	1.46	2.25	35	C
C	115-140	58	40.18	15.36	44.46	0.35	1.55	2.18	29	SC
					Pedon 2					
A	0-15	-	54.27	22.14	23.59	0.94	0.98	2.52	61	SCL
Ap	15-45	-	52.25	21.37	26.38	0.81	1.03	2.49	59	CL
B	45-75	-	48.37	19.31	32.32	0.60	1.17	2.42	52	CL
Bti	75-115	-	42.75	19.31	37.94	0.51	1.35	2.36	43	SCL
C	115-140	60	43.18	20.13	36.69	0.54	1.45	2.24	35	SCL
					Upper slope position Pedon 3					
A	0-25	-	72.34	22.74	5.92	3.67	0.86	2.39	64	LS
Ap	25-60	-	69.21	20.85	9.94	2.09	0.95	2.35	60	SL
B	60-75	-	65.34	19.75	14.91	1.32	1.13	2.30	51	LS
Bti	75-95	-	62.10	19.20	18.70	1.03	1.24	2.27	45	SL
C	95-140	62	59.38	17.35	23.27	0.75	1.54	2.22	31	SCL
					Pedon 4					
A	0-20	-	75.45	13.45	11.10	1.21	0.91	2.42	62	LS
Ap	20-45	-	72.10	11.75	16.15	0.73	0.98	2.38	59	LS
B	45-75	-	69.85	10.24	19.91	0.51	1.24	2.32	47	SL
Bti	75-90	-	65.25	10.75	24.0	0.45	1.34	2.28	41	SCL
C	90-140	64	63.75	10.10	26.15	0.39	1.47	2.23	34	SCL
					Middle Slope Position Pedon 5					
A	0-25	-	72.35	17.35	10.30	1.68	0.68	2.36	71	SL
Ap	25-45	-	70.28	15.45	14.27	1.08	0.73	2.34	69	SL
B	45-65	-	67.34	12.75	19.91	0.64	0.81	2.27	64	SL
Bti	65-85	-	62.14	12.05	25.81	0.47	0.85	2.21	62	CL
C	85-120	54	62.05	11.74	26.21	0.45	0.93	1.87	50	CL

Pedon 6										
A	0-25	-	73.25	19.24	7.51	2.56	0.67	2.34	71	SL
Ap	25-45	-	71.28	16.34	12.38	1.32	0.72	2.30	69	SL
B	45-65	-	69.11	14.35	18.54	0.77	0.78	2.24	65	SL
Bti	65-85	-	65.24	14.15	20.61	0.69	0.85	2.18	61	SCL
C	85-120	60	63.14	13.28	23.58	0.56	0.90	1.85	51	SCL
Lower slope position Pedon 7										
A	0-15	-	36.15	29.15	34.70	0.84	0.43	1.35	68	CL
Ap	15-35	-	38.0	31.10	30.90	1.01	0.47	1.25	62	CL
B	35-45	-	40.45	32.60	26.95	1.21	0.53	1.20	56	CL
Bti	45-60	-	42.34	34.10	23.56	1.45	0.58	1.15	50	CL
C	60-80	-	44.17	36.10	19.73	1.83	0.61	1.12	46	CL
Pedon 8										
A	0-15	-	37.30	26.34	36.36	0.72	0.74	1.36	65	CL
Ap	15-35	-	38.12	28.25	33.63	0.84	0.49	1.27	61	CL
B	35-45	-	42.35	32.0	25.65	1.25	0.51	1.19	57	CL
Bti	45-60	-	42.95	35.24	21.81	1.62	0.53	1.15	54	CL
C	60-80	-	45.10	36.31	18.59	1.95	0.59	1.10	46	C
Valley Bottom Position Pedon 9										
A	0-15	-	28.35	31.34	40.31	0.78	0.37	1.25	70	CL
Ap	15-30	-	30.15	35.24	34.61	1.02	0.38	1.21	69	CL
B	30-45	-	35.45	32.14	32.41	0.99	0.41	1.18	65	CL
Bti	45-60	-	42.28	32.13	25.11	1.28	0.43	1.12	62	CL
C	60-75	-	45.30	38.35	16.35	2.35	0.45	1.10	59	C
Pedon 10										
A	0-15	-	31.20	34.12	34.68	0.98	0.39	1.23	68	CC
Ap	15-30	-	33.10	36.35	30.55	1.19	0.41	1.20	66	SCG
B	30-45	-	35.35	42.14	22.51	1.87	0.45	1.17	62	L
Bti	45-60	-	41.20	38.35	20.45	1.88	0.48	1.12	57	L
C	60-75	-	47.12	35.37	17.51	2.02	0.50	1.09	54	C

Table 4: Mean, standard deviation and coefficient of variation (CV %) of slope positions in the study area

Slope position	Soil properties	$\bar{X}$	Sd	CV%
Crest/upper slope	Sand	56.84	12.22	21.49
	Silt	18.36	5.23	28.41
	Clay	24.67	11.21	45.43
	Silt/clay ratio	0.83	0.45	54.25
	B^d	1.20	0.23	19.30
	P^d	2.35	1.11	4.22
	T_p	48.45	11.81	24.37
Middle slope	Sand	67.52	4.26	63.06
	Silt	14.47	2.26	15.59
	Clay	17.91	6.54	36.52
	Silt/clay ratio	10.22	0.67	65.68
	B^d	0.79	0.09	11.47
	P^d	2.20	0.19	8.49
	T_p	63.30	7.62	12.83
Lower slope/valley bottom	Sand	38.82	5.38	13.87
	Silt	32.12	3.42	10.66
	Clay	27.19	6.41	23.58
	Silt/clay ratio	1.35	0.48	35.77
	B^d	0.47	0.07	14.65
	P^d	1.19	0.08	6.53
	T_p	59.85	7.28	12.16

Keys: x = mean, sd = Standard deviation; CV% = Coefficient of variation.
Pd = Particle density, Bd = Bulk density, Tp = Total porosity

This is because quartz, feldspars and colloidal silicate clays make up the major portions of mineral soils and impart their intrinsic characteristics of stability to the soil (Brady and Weil, 2007).

Total porosity

The crest/upper slopes have lower total porosity with mean values of 48.45%, while the lower/valley bottom slopes have mean total porosity of 59.85% (Table 4). Total porosity was found to decrease with depth of profile and it is closely related to organic matter content, clay accumulation and the activities of earthworms and other macro-animals in the soil system. Total porosity has also an inverse relationship with bulk density.

Silt/clay ratios

The silt/clay ratio which is used to study the degree of pedogenetic weathering in soils Sombroek and Zonneveld (1971) showed that the crest/upper slope and lower/valley bottom slope positions had mean silt/clay ratios of 0.83 and 1.35 indicating moderate pedogenetic weathering processes. The middle-slope with a mean silt/clay ratio of 10.22 was an indication of recent pedogenetic process.

According to Sombroek and Zonneveld (1971), any value of silt/clay ratio less than 0.75 indicates old age of the surface deposits while values between 0.75 and 1.5 indicate moderate pedogenetic weathering processes. Higher values (>1.5) indicate recent pedogenetic processes. The findings in this study to some extent collaborate with earlier works on toposequence in the tropics by Juo and Moorman (1981), Essoka *et al.* (2006) and Idoga *et al.* (2006) respectively who affirmed some variations in soil properties on toposequence.

Conclusion

The study was carried out to evaluate the morphological and physical characteristics of soils on a toposequence. The results showed the landscape as a plain of low relief with very gentle slope. The morphological properties showed variations in soil colour in relation to slope positions with a dominant 5YR at the crest and 7.5YR and 10YR in the lower slope positions. Soil depth, structure, consistence, and rootlets varied across slopes. The texture especially the clay fraction was not statistically significant across slopes, while the silt/clay ratio revealed moderate pedogenetic weathering processes for the crest/upper slope and lower valley bottom positions. The middle slope position indicated recent pedogenetic processes. Bulk, particle densities and total porosity were not statistically influenced (P > 0.01) across slope positions. The general results showed the role of topography in assessing the productive value of soils and the need to develop strategies for its conservations. Because of the nature of rainfall with its attendant erosion effects, the crest, upper slope and middle slope positions should remain under vegetative cover. The establishment of vetiver grass stripes across slope positions will help to stabilize the soil and in effect, check erosion. The lower slope and valley bottom position can be cultivated with field crops under strict soil conservation practices.

References

Akinbola, G. E., Ojo U. A., & Adigun, M. O. (2010). *Variability of properties of some pedons on basement complex of south western Nigeria*, Proceedings of the 34th annual conference of the soil science society of Nigeria. March 22nd -26th, 2010 Ibadan, Nigeria.

Blake, G. R., & Hartge, K. H. (1986). *Bulk density. In: Klute (eds). Methods of soil analysis*, Part 1: Physical and mineralogical methods. SSSA Madison, W. I. pp. 377 - 382.

Brady, A. C., & Weil, R. R. (2007). *The nature and properties of soils.* (13th edition), Prentice hall, New Jersey.

Egbuchua, C. N. (2012). Pedogenetic characteristics of some alluvial complex soils in delta state, Nigeria. *Nigerian Journal of Soil and Environmental Research*. 9, 65-70.

Essoka, P. A. Jaiyeiba, I. A., & Essoka, A. N. (2006). *A Toposequence study of soils developed on Gnesis and Grandoiorite on the Cross River rainforest zone,* Proceedings of the 31st annual conference of the soil science society of Nigeria. 13th-17th November, ABU, Zaria, Nigeria.

Gee G. W., & Bauder J. W. (1986). *Particle-size Analysis. In: Klute, A. (ed) Methods of soil analysis Part 2: Chemical and mineralogical properties.* 2nd (ed.) Agronomy monograph 9 ASA and SSSA Madison, WI, USA.

Idoga, S., Ibanga, I. J., & Malgwi, W. B. (2006). *Variation in Soil Morphological and physical properties and their management implications on a toposequence in Samaru area, Nigeria*, Proceedings of the 31st annual conference of the soil science society of Nigeria 13th-17th November, 2006 ABU, Zaria, Nigeria.

Juo, A. S. R., & Moorman, F. R. (1981). Characteristics of two soil toposequences in South-eastern Nigeria and their relation to potential agricultural land use. *Nigerian Journal of Soil Science*, 1, 47 - 61.

King, G. J. Acton, D. F., & Arnaud, J. S. T. (1983). Soil Landscape analysis in relation to soil distribution and mapping. *Canadian Journal of Soil Science*, 63, 657–670.

Milne, G. (1935). Some suggested units of classification and mapping particularly for East African Soils. *Soil Research*, 4(3), 183 - 198.

Moorman, F. R. (1981). *Representative toposequene of soils in southern Ni-*

geria and their pedology, In Greenland, D. J. (ed.) Characteristics of soils in relation to their classification and management for crop production. Clarendon press Oxford pp. 10 - 29.

Soil Survey Staff (2006). *Keys to Soil Taxonomy. USDA soil conservation service* (10th edition) N.R.C.S/Washington, D.C.

Sombroek, W. G., & Zonneveld, I. S. (1971). *Ancient dune fields and fluviatile deposits,* Soil survey paper No. 5 soil survey institute Wageningen. The Netherlands. pp. 109.

Steel, R. R., & Torrie, J. H. (1980). *Principles and procedures of statistics with special reference to biological science,* McGraw Hill Book Co. Inc. New York, 481p.

Young, A. (1976). *Tropical soils and soil Survey,* Cambridge University press, Cambridge.