CHANGES IN SOIL PH ALONG AN INLAND SLOPE IN OHAFIA, ABIA NIGERIA

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Abstract
The study investigated changes in soil pH along an inland slope in Ohafia area of Abia State Southeastern Nigeria. A transect technique was used to cut traverses along the slope for aligning soil profiles on three identified topounits of summit, midslope and footslope. Three traverses were cut on the inland slope. A total of 9 soil profiles were dug with three on each topounit. Soil samples were collected based on horizon differentiation after description using FAO procedure. Some morphological properties were observed and recorded after georeferencing of soil profiles using handheld Global Positioning System Receiver. Particle size distribution was dominated by sand-sized particles which ranged from 500 to 910 g/kg (summit), 500 to 710g/kg (Midslope) and 420 to 700g/kg (Footslope). Clay-sized fraction increased downslope as sand-sized fraction decreased. Highest value of clay (450 g/kg) was reported on Bt_2 horizon on foot slope 3. Soils were generally acidic but soil acidity decreased downslope. Soil pH ranged from 4.9 to 5.5 (Summit), 5.3 to 5.7 (Midslope) and 5.3 to 6.1 footslope water. Results suggest ameloriation of soils using lime or basic fertilizers

Keywords: Soil reaction, Topography, Agronomy, Humid environment.

Introduction

Soils vary in their reactions in space and time. Differences in soil reaction could be due to the nature of parent material (Brady and Weil, 1990) and downslope movement of water (Fisher and Binkley, 2002). Ogunkunle and Ataga (1985) reported variability of soil pH with depth along a slope. However, soil pH had least variation among other soil properties measured (Ogunkunle, 1993). Soil pH influences soil phosphorus availability (Foth, 1984), and that suggests why the essential nutrient is highly variable in some slopes (Wollenhaupt *et al*., 1997). Asadu (1990) reported high influence of topography on the distribution of exchangeable bases and exchangeable acidity. All these suggest influence of topography on soil properties, a good number of which have direct and indirect relationship with soil reaction.

Ohafia area of Southeastern Nigeria is a peri-urban community where substantial farming activities take place. Soils of the area are influenced by several hills of varying orientations. Subsistence and commercial agricultural activities mainly on arable crops are found in the area. But, most of these soils are poorly studied, and farmers have minimal scientific knowledge of their fertility status. Often times, the relatively wealthy farmers applied inorganic fertilizers without soil tests in a bid to boost yield. Appropriate soil tests will reveal the status of fertility indices such pH which dictates availability of many plant nutrients of soil origin. Knowledge of soil pH especially in a hilly terrain like Ohafia, southeastern Nigeria will guide arable crop production especially for the satisfaction the evergrowing population of the area. Based on the above, the major objective of the study was to investigate changes in soil pH in an inland slope of Ohafia. Specifically, the study estimated differences of soil pH vertically among topounites (slope units) of summit, midslope and footslope.

Materials and Method

Study Area: The study was conducted at Amaekpu Ohafia in Abia State of southeastern Nigeria, located between latitudes $5^0 25^I$ and $5^0 55^I$ North and longitudes $7^0 15^I$ and $7^0 50^I$ East. It covers an area of about 25 square kilometers. The soils of the area is derived from Lower Coal Measures (Mamu formation) (Orajaka, 1975). Ohafia is located within the humid tropical climate with bimodal rainfall pattern and with a mean annual rainfall of about 1800 to 2200mm. Generally, it rains for about 9 months with 3 months of dry spell. The annual temperature ranges from 27 to 30^0C (Onweremadu, 2007). Ohafia has a rainforest vegetation (Akamigbo, 1999). There are a variety of plant species ranging from trees, shrubs and herbs, and these are arranged in tiers. Oil plam trees (*Elaeis guineensis*), mango (*Mangifera indica*), giant star grass (*Cynodon plectostachyus*), bush mango (*Irvinigia gabonensis*), oranges (*Citrus* species) and a host of others grow in the area. It is an evergreen forest.

Agriculture is a major socio-economic activitity in the area coupled with cottage industries and trading. Arable crops include cassava (*Manihot esculenta*), Okra (*Abelmoschus esculentus*), maize (*Zea mays*) and yam (*Dioscorea* spp.)

Prefield Survey

A reconnaissance survey of the area was conducted for the purpose of familiarization and preparation for field work. Necessary field materials and equipment like handheld Global Positioning System (GPS) Receiver Transparent rule, roller taper, spade and field chart were assembled.

Brief Description of Sampling Site

The sampling site is an inland slope,which is about a kilometre long and over 400metres wide. The slope has identifiable topographic units of summit, midslope and footslope. The slope is covered with secondary forests characterized by multiple plant species. However, thickness of vegetation increased downslope. Farming activities take place on the slope using traditional practices. Multiple cropping predominates on the slope.

Table 1: Geographical coordinates of Sampling points

Location	Latitude N	Longitude E	Height M
Summit 1	$5^0 43^I 605''$	$7^0 46^I .585''$	178
Summit 2	$5^0 46^I 666''$	$7^0 46^I .508''$	176
Summit 3	$5^0 46^I 610''$	$7^0 46^I .601''$	181
Midslope 1	$5^0 44^I 570''$	$7^0 46^I .408''$	150
Midslope 2	$5^0 44^I 580''$	$7^0 47^I .103''$	155
Midslope 3	$5^0 44^I 495''$	$7^0 47^I .121''$	167
Footslope 1	$5^0 40^I 404''$	$7^0 47^I .208''$	38
Footslope 2	$5^0 40^I 309''$	$7^0 47^I .416''$	43
Footslope 3	$5^0 40^I 400''$	$7^0 47^I .390''$	33

Field Survey

Transect soil survey method was used in which three traverses were cut through the summit, midslope and footslope. On each topounit, 3 soil profiles were dug, and described according to FAO procedure (FAO, 2006). Soil samples were collected based on horizon differentiation. Soil colour was determined *in situ* using Munsell colour chart under moist conditions. Each soil profile was geo-referenced using handheld Global Positioning System (GPS) Receiver. Transparent ruler was used in measuring boundary of horizons to ascertain distinctiveness. Roller tape was used to obtain horizon thickness and depth of soil profile.

Brief Description of Sampling site

Laboratory Studies

Particle size distribution was determined by hydrometer method (Gee and Or, 2002). Soil textural triangle was used to measure textural classes of soils analyzed. Soil pH was estimated according to the procedure of Thomas (1996) in a soil: liquid ratio of 1: 2.5 using a pH meter.

Results and Discussion

Some macromorphological properties of epipedons of soils are shown on Table 2, indicating thicker epipedons towards the footslope. This would be attributed to more depositions in footslope souls and higher detachment and erosion at the summit soils. Soil colours varied from very Dark grayish brown to dark red in summit, dark brown in midslope soils and dark yellowish brown through dark brown to dark grayish brown in footslope soils. Epipedon of summit 3 soils was thinner and redder, suggesting exposure of subsurface horizons was imminent.

Table 2. Some macromorphological properties of soils (epipedons)

Property	Summit 1	Summit 2	Summit 3
Depth (cm)	0 – 11	0 – 14	0 – 5
Colour (moist)	UDGB (10YR ¾)	VD GB (10YR 4/4)	DR
Structure	Weak granular	Weak granular	weaks angular blocky
Boundary	Gs	gs	aw
	Midslope 1	Midslope 2	Midslope 3
Depth (cm)	0 – 16	0 – 15	0 – 8
Colour (moist)	DB	DB	DB
Structure	Weak granular	Weak granular	Weak granular
Boundary	Gs	gs	gs
	Footslope 1	Footslope 2	Footslope 3
Depth (cm)	0 – 18	0 – 18	0 – 20
Colour (moist)	DYB (10YR ¾)	DB (7.5YR 4/4)	DGB (10 YR 4/2)
Structure	Moderate granular	Moderate granular	Moderate granular
Boundary	Cg	cg	Cg

Colur: VDGB = Very dark grayish brown, DR = dark red, DB = dark brown, DYB = dark yellowish brown DGB = dark grayish brown

Boundary: gs = gradual smooth, dw = diffuse wavy, cg = clear gradual

Table 3 shows the particle size distribution of soils of the three topounits. Sand-sized particles dominated the particle sizes, suggesting that high rainfall nature including long rainfall duration falls (9 months in a year) interacting with the sandy nature of parent materials resulted in the dominance of sands among silt and clay. Sand- sized particles ranged from 500 to 910 g/kg (Summit 1), 590 to 900 g/kg (Summit 2), 500 to 890 g/kg (Summit 3), 570 to 760 g/kg (Midslope 1), 500 to 750 g/kg (Midslope 2), 560 to 710 (Midslope 3), 460 to 570 g/kg (Footslope 1), 500 to 700 g/kg (Footslope 2) and 420 to 760 g/kg (Footslope 3). Clay-sized fraction increased down slope with highest values reported in Foot slope 3 (450 g/kg) at Bt_2. However, the ranges differed among the footslopes as footslope 1 clay content ranged from 300 to 440 g/kg, while footslope 2 and 3 ranges were 140 to 380 g/kg and 160 to 450 g/kg, respectively. Generally, silt-sized particles increased down slope like clay with highest value recorded in footslope 2 (270 g/kg at AB horizon). High values of clay at the footslope can be explained as clay is the lightest of the particle sizes followed by silt, suggesting runoff water carries these two fractions towards the footslope. Clay-sized fractions are also transported in suspension when minimal gradient created.

Table 3: Particle size Distribution

Horizon	Depth (cm)	Sand	Silt	Clay	SCR	TC
			(gkg-1)			
A	0 – 11	910	20	70	0.28	S
AB	11 – 46	850	60	90	0.66	LS
Bt1	16 – 80	660	70	270	0.26	L
Bt2	80 – 120	500	260	240	1.08	SCL
		Summit 2				
A	0 – 14	900	20	80	0.25	S
AB	14 – 34	850	50	100	0.50	LS
Bt1	34 – 76	650	80	270	0.29	SCL
Bt2	76 – 118	590	270	140	1.93	SL
		Summit 3				
A	0 – 5	890	30	80	0.34	S
AB	5 – 38	830	80	90	0.89	LS
Bt1	38 – 96	710	30	260	0.11	SCL
Bt2	96 – 126	500	260	240	1.08	SCL
		Midslope 1				
A	0 – 16	760	80	160	0.50	SL
AB	16 – 40	650	80	260	0.31	SCL
Bt1	40 – 66	570	140	290	0.48	SCL
Bt2	66 – 116	700	160	140	1.14	SL
		Midslope 2				
A	0 – 15	700	150	150	1.00	SL
AB	15 – 42	750	90	160	0.56	SL
Bt1	42 – 105	500	250	250	1.00	SCL
		Midslope 3				
A	0 – 8	710	140	150	0.93	SL
AB	8 – 46	590	260	150	1.73	SL
Bt1	46 – 110	560	140	300	0.47	SCL
		Footslope 1				
A	0 – 18	550	140	310	0.45	SCL
AB	18 – 50	570	130	300	0.43	SCL
Bt1	50 – 130	500	60	440	0.14	SC
Bt2	130 – 150	460	100	440	0.23	C
		Footslope 2				
A	0 – 18	700	160	140	1.14	SL
AB	18 – 48	590	270	140	1.93	SL
Bt1	48 – 110	500	140	360	0.39	SC
Bt2	110 - 145	520	100	380	0.26	SC
		Footslope 3				
A	0 – 20	760	80	160	0.50	SL

AB	20 – 50	740	90	170	0.53	SL
Bt1	50 – 96	500	260	240	1.08	SCL
Bt2	96 – 125	420	130	450	0.29	SC

SCR = Silt Clay Ratio, TC = Textural Class, S = Sand, LS = Loamy Sand, SL = Sandy Loam, SCL = Sandy Clay Loamy, SC = Sandy Clay C = Clay

Soil pH distribution of soils are shown in Table 4, indicating that soils are generally moderately to slightly acidic using the FDALR (1985). The values of soil pH showed that soils were more acidic at Summit than other topounits. Among pedons of the same topounit, soil pH also differed. Generally, soil pH water ranged from 4.9 TO 5.5 (Summit), 5.3 to 5.7 (Midslope) and 5.3 to 6.1 (Footslope). These values could be lower using salt solution as liquid of determination. Acidity of soils irrespective of topographic unit could be traced to sandy parent material coupled with high rainfall and land use that interactively promote weathering and ageing of soils. Similar findings were made by Akamigbo, (1999). However, the higher movement occasioned by runoff water carries basic cations away from upslope towards the footslope, leaving in abundance acidic cations in the summit.

Table 4: Soil pH distribution

Summit 1	**Depth (cm)**	**pH water**	**Summit 2**	**Depth (cm)**	**pH water**	**Summit 3**	**Depth (cm)**	**pH water**
A	0 – 11	5.1	A	0 – 14	5.2	A	0 – 5	5.0
AB	11 – 46	4.9	AB	14 – 34	5.0	AB	5 – 38	5.1
Bt1	46 – 80	5.2	Bt1	34 – 76	5.4	Bt1	38 – 96	5.5
Bt2	80 – 120	5.2	Bt2	76 - 118	5.3	Bt2	96 - 126	5.2
Midslope 1	Depth (cm)	pH water	Midslope 2	Depth (cm)	pH water	Midslope 3	Depth (cm)	pH water
A	0 – 16	5.3	A	0 – 15	5.3	A	0 – 8	5.3
AB	16 – 40	5.4	AB	15 – 42	5.4	AB	8 – 46	5.4
Bt1	40 – 66	5.5	Bt1	42 - 105	5.6	Bt1	46 -110	5.7
Bt2	66 – 116	5.4	-	-		-		
Footslope 1	Depth (cm)	pH water	Footslope 2	Depth (cm)	pH water	Footslope 3	Depth (cm)	pH water
A	0 – 18	5.4	A	0 – 18	5.3	A	0 – 20	5.4
AB	18 – 50	5.5	AB	18 – 48	5.3	AB	20 – 50	5.5
Bt1	50 – 130	5.8	Bt1	48 – 110	5.4	Bt1	50 – 96	5.6
Bt2	130 – 150	5.8	Bt2	110 - 145	5.5	Bt2	96 - 125	6.1

References

Akamigbo, F. O. R. (1999), influence of land use on soil properties of humud tropical agroecology of Southern Nigeria. Niger Agric J.30:59-7b

Brady, N. C. and Weil, R. R, (1990). The nature and properties of soil 12th edition prentice Hall Inc. New Jersey.

FAO (Food and Agricultural Organization) (2006). World References Basic of soil. World soil Report. ISSS-AISS, FAO, Rome Italy

FAO (Food and Agricultural Organization) (2006). World References Basic of soil. World soil Report. ISSS-AISS, FAO, Rome Italy

FDALR (Federal Department of Agricultural Land Resources (1985). The reconnanisance soil survey of Imo State (1:250,000). Soil Report 111 pp.

Fisher, R. F. and Binkley, O. (2000). Ecological and management of forest soil. John Wiley and Sons, New York.512pp.

Foth, A. D. (1984). Fundamentals of soil science. 7th edition. John Wiley and sons, New York.

Gee, G. W. and or D.(2002).particle size distribution. In: Dane, J. H. and Topps, G. C. (eds.) .Methods of soil analysis, part 4-physical methods. SSSA Book series,No.5, ASA and SSSA Madison,Wl,pp.225-295.

Ogunkunle, A. O. (1993).Variation of some soil along two toposequences in quartz- Schist, and branded Gneiss in Southern Nigeria. Geoderma 60(40):397-402.

Ogunkunle, A. O. and Ataga, D.O. (1985). Further investigation into soilheterogeneity and sampling procedure under oil palm. Nigeria institutes for oil Palm Res.V I40-50

Onweremadu, E. U. (2007). Basicity of major soil in lowland states of Southeastern Nigeria. Int. J. Siol Science. 2 (3): 204-210.

Orajaka,S.O(1975). Geology. In :Nigeria in maps; Eastern states. Ofomata,G.E.K. (ed.) Ethiope Publishing House Benin City Pp. 5 – 7

Thomas, G. W. (1996) Soil pH , Soil acidity. Sparks D. L. (ed.) Methods of soil Analysis, Part 3. Chemical methods. SSSA Book series, SSSA and ASA, Madison WI. Pp 159 – 165.

Wollenhaupt, N. C.; Mulla, D. J. and Granoford, C. A. (1997). Soil sampling and interpolation techniques for mapping spatial variability of soil properties. In: Pierce, F. J. and Saddler, E. J. (eds.). The state of specific management for agriculture ASA; Madisoin, WI pp. 19 – 53.