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Differences in Selected Soil Physical Properties along Three Toposequences in Ohafia, Abia State, Nigeria.

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Abstract
Some physical properties of soils were studied along three toposequences in Ohafia area in Abia State, Southeast Nigeria. Transect technique was used to align soil profiles cutting across three major units of summit, midslope and footslope. Soil particle sizes, soil bulk density and soil total porosity were evaluated in each of the topographic units. Coefficient of variation was used to estimate differences among these soil properties along the toposequence. Results indicated low variation (less than 15 % coefficient of variation) except in silt content of midslope soils. There were differences in the thickness of horizons with increasing thickness towards footslope in all toposequences. The percentage of sand was highest at the summit and decreases towards the footslope while the values of silt, clay and total porosity were highest at the footslope and decreases towards the summit. Therefore appropriate agronomic practices are recommended for improvement of soil physical properties and at the summit.

Keywords: Toposequence, Physical properties, Ohafia, Soil

1. Introduction

In southeastern Nigeria, misuse of slope soils has resulted to varying forms of soil degradation including aggregate instability, compaction, increasing bulk density, poor infiltration, increasing erodibility, sandiness, soil loss, poor aeration, siltation and loss of nutrient-rich epipedons (Onweremadu, Opara, Nkwopara & Ibeawuchi, 2006). These lead to low yield, poor quality of crop products and soil erosion. Soils vary in morphological and physical properties due to parent materials (Maniyunda, Raji, Odunze & Malwi, 2014), management strategies (Sunday, John, James, Charles & Toshiyuki, 2011) or topography (Igwe, 2004; Sunday *et al.,* 2011). Differences in properties of soil could be as a result of varying degrees of pedogenesis (Hart & Gbarandi, 2015) as well as type of pedogenetic action dominant in the locality (Onweremadu *et al*., 2006). Varying soil type and rate of pedogenesis result in contrasting morphologies (Onweremadu, 2009) at short distances (Cassel, 1983) and may become obvious among various slope orientations and forms (Hoosebeck Amudson & Bougal, 2000).

Differences occur in soil physical properties on a toposequence in relation to land use (Wang *et al.,* 2009), boron availability (Efeturi, Wapa, Musa & Chude, 2014), total nitrogen and total phosphorus (Wang, Zhang & Huang, 2009) as well as elemental toxicity (Soltanpour, 1985). Miller & Donahue (1990) observed great influence of soil texture on soil fertility which Onwudike, Uzoho, Ihem, Ahukaemere, Nkwopara, Irokwe & Echeanyanwu (2016) and Lrvin, (1996) reported as varying along a landscape and land use types. In a study conducted by Ndukwu, Onweremadu, Ukeme, Ahukaemere & Njoku (2015), it was reported that Boron had a strong relationship with soil texture particularly clay content along the topographic units. Little information is available on the variations of soil physical properties along a toposequence at Ohafia in Abia State. The major objective of this study was therefore to evaluate some physical properties of slope soils to estimate their differences along the three topographic units.

2. Materials and Methods

The study was carried out in Ohafia area of Abia State in Southeastern Nigeria. The area lies between latitudes 5^{o}30' and 5^{o}50'N and longitudes 7^{o}10' and 7^{o}50'E in an area covering over 100 km^2. Ohafia has an elevation below 200 m. Soils of the area are formed from mamu formation (lower coal measures) (Orajaka, 1975). Ohafia has hills and plains in geographic association. Ohafia is situated within the humid tropics with annual rainfall ranging from 1800 to 2250 mm, and its pattern is bimodal. However, extreme rainfall events are common in the area due to climate change (Onwudike *et al*., 2016). Annual temperature ranges from 27 to 31^{o}C. Ohafia has rainforest vegetation with several forms of plant species arranged in storey's. Palms trees are dominant in the region especially in groves located within the countryside. Several ornamental and economic trees were found in settlement areas. Shrubs are dominant especially in secondary forests. Most natural water bodies are found in valleys. Agriculture is a major socio-economic activity. Mixed cropping is practiced both in a back yard garden and distant farms. Maize, cassava, yam, okra and other vegetables are cultivated both at commercial and subsistent levels. Land preparation is by slash and burn. Soil fertility maintenance is by natural fallows, application of organic and inorganic fertilizers.

2.1. Site Description

Three slopes of varying orientations: Northeast (NE), Northwest (NW) and Southwest (SW) were chosen for the study. The slopes varied in slope length percent at summit, midslope and footslope. The area was under secondary vegetation of 8 years of fallow. All the soils were previously cultivated with arable farming.

2.2. Field Work

Three topounits were identified in each slope orientation and they were summit, midslope and footslope. A transect was used in which a traverse was cut through the forested slope to link each summit to the footslope. A soil profile was sunk on each topounit making it 3 soil profiles per slope and 9 soil profiles for the 3 slope orientations, NE-lying, NW-lying and SW-lying slopes. Soil profiles were dug, described and sampled using FAO (1997) guidelines. Core samples were collected for bulk density determinations.

2.3. Laboratory Studies

Particle size distribution was determined by hydrometer method (Gee & Or, 2002). Bulk density was measured by core procedure (Grossman & Reinsch, 2002). Textural triangle was used to estimate textural classes while total porosity was calculated using a relationship between particle density and bulk density according to Foth (1984) as follows:

$$\text{Total porosity (TP)} = 1 - \{(BD / pd) \times 100\} \qquad 1$$

Where: TP = total porosity; BD = bulk density; PD = particle density (2.65 g/cm^{3})

2.4. Data Analysis

Data collected were subjected to coefficient of variation (CV) to identify differences in studied physical properties. Ranking of variability was done according to Wilding and Dress (1983) where CV less than 15 % = low, 15 – 35 = moderate and CV greater than 35 = high.

3. Results and Discussion

3.1. Properties of Soils in the Summits

Physical properties of soils of the three summits are shown in Table 1. In all soil profiles, clay bulge was distinct indicating argillation and illuviation. The distribution of particle sizes followed a similar trend to the work of Onweremadu & Duruigbo (2007). Bulk density values decreased towards the top horizon and had an inverse relationship with total porosity.

Table 1: Physical Properties of Soils (Summit)

Horizon	Depth	Sand	Silt	Clay	BD	TP	TC
	Cm	g/kg	g/kg	g/kg	g/cm3	%	
	Ohafia 1 (9% slope) NE 5° 40^{1} 906^{11}N 70° 47^{1} 73^{11}E						
A	0-11	870	40	90	1.29	51.3	LS
AB	11 – 30	760	40	100	1.32	50.2	SL
Bt1	30-77	740	20	240	1.41	46.8	SL
Bt2	77-109	730	20	250	1.45	45.3	LS
Bt3	109-185	750	40	210	1.48	44.1	SL
	Ohafia 2 (8% slope) NW 5° 41^{1} 113^{11}N 7° 43^{1} 230^{11}E						
A	0-9	880	20	100	1.35	49	LS
AB	0-29	790	10	200	1.41	46.8	SL
Bt1	29-65	730	20	250	1.48	44.1	SL
Bt2	65-115	720	10	270	1.49	43.7	SL
Bt3	115-190	740	20	240	1.52	42.6	SL
	Ohafia 3 (9% slope) SW 5° 39^{1} 352^{11}N 7° 48^{1} 103^{11}E						
A	0-18	760	30	110	1.28	51.7	SL
AB	18-35	740	40	220	1.32	50.2	SL
Bt1	35-80	730	20	250	1.35	49	SL
Bt2	80-135	700	20	280	1.48	44.1	SL
Bt3	135-200	740	20	240	1.52	42.6	SL

BD = Bulk Density, TP = Total Porosity, TC = Textural Class, LS = Loamy Sand, SL = Sandy Loam.

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3.2. Properties of Soils in the Midslopes

Thickness of epipedons increased in midslope soil profiles irrespective of slope orientations (Table 2). Numerically, sandiness decreased and clayness increased in all soil profiles. However, sandy loam textures dominated all horizons of SW-lying slope while epipedons of NE and NW-lying slopes were loamy sand. The Bt_2 horizon of SW-lying slope exhibited high clay content (290 g/kg) indicating that horizon as the peak value for argillation in all midslope soil profiles. However, bulk density (1.21mg/m^3) and total porosity (45.3%) values of NW and SW-lying slopes were similar suggesting that slope orientation did not influence the strength of soils

Table 2: Physical Properties of Soils (Midslope)

Horizon	Depth Cm	Sand g/kg	Silt g/kg	Clay g/kg	BD g/cm3	TP %	TC
	Ohafia 1 (15% slope) NE 5° 41^1 736^{11}N 7° 42^1 54^{11}E						
A	0-13	840	60	100	1.23	53.6	LS
AB	13-26	750	40	210	1.3	50.9	SL
Bt1	26-72	730	20	250	1.35	49	SL
Bt2	72-140	730	10	260	1.48	48.1	SL
Bt3	140-188	740	30	230	1.51	43	SL
	Ohafia 2 (4% slope) NW 5° 41' 840''N 7° 48' 188''E						
A	0-13	800	40	160	1.21	54.3	LS
AB	13-36	750	20	230	1.29	51.3	SL
Bt1	36-80	720	10	270	1.41	46.8	SL
Bt2	80-130	730	20	250	1.48	44.1	SL
Bt3	130-170	740	20	240	1.52	42.6	SL
	Ohafia 3 (3% slope) SW 5° 40' 336''N 7° 48' 222''E						
A	0-19	740	40	220	1.21	54.3	SL
AB	19-32	730	20	250	1.26	52.4	SL
Bt1	32-75	700	20	280	1.46	44.9	SL
Bt2	75-125	700	10	290	1.48	44.1	SL
Bt3	125-165	730	10	260	1.51	43	SL

BD = Bulk Density, TP = Total Porosity, TC = Textural Class, LS = Loamy Sand, SL = Sandy Loam

3.3. Properties of Soils in the Footslope

Properties of footslope soils are given in Table 3, showing least value of sand-sized fraction in all the toposequences. Sand ranged from 670 -700 g/kg (NE), 690-760 g/kg (NW) and 660-700 g/kg (SW). Sandy clay loam and sandy clay characterized soil textures of SW-lying slope soils while it was a mix of sandy loam, sand clay loam and sandy clay for the NE and SW-lying slopes. Bulk density value was least (1.18 mg/m^3) in the epipedon of SW-lying footslope soils while its total porosity was 55.4 %.

Table 3: Physical Properties of Soils (Footslope)

Horizon	Depth Cm	Sand g/kg	Silt g/kg	Clay g/kg	BD g/cm3	TP %	TC
	Ohafia 1 (2% slope) NE 5° 02' 666''N 7° 48' 646''E						
A	0-16	700	40	260	1.23	53.6	SCL
AB	16-33	690	30	280	1.32	50.2	SCL
Bt1	33-79	670	10	320	1.41	46.8	SCL
Bt2	79-135	700	20	280	1.47	44.5	SCL
Bt3	135-205	750	30	220	1.52	42.6	SCL
	Ohafia 2 (3% slope) NW 5° 41' 930''N 7° 49' 126''E						
A	0-15	730	160	110	1.31	50.5	SL
AB	15-31	750	100	150	1.32	50.2	SL
Bt1	31-73	700	20	280	1.43	46	SCL
Bt2	73-129	690	10	300	1.48	44.1	SL
Bt3	12-195	760	40	200	1.58	40.4	SCL
	Ohafia 3 (1% slope) SW 5° 41' 728''N 7° 49' 129''E						
A	0-18	680	40	280	1.18	55.4	SCL
AB	18-37	690	20	290	1.23	53.6	SCL
Bt1	37-80	660	20	320	1.33	49.8	SL
Bt2	80-140	680	10	310	1.52	42.6	SL
Bt3	140-215	700	30	270	1.55	41.5	SL

BD = Bulk Density, TP = Total Porosity, TC = Textural Class, LS = Loamy Sand, SL = Sandy Loam

3.4. Variations among Soil Physical Properties

Spatial variations among the physical properties in the three toposequences are shown in Table 4. The physical properties of the soils slope exhibited low variation using the ranking of Wilding & Dress (1983) except for silt content of midslope soils. These low variations could suggest that soils of the area could be managed alike or conditioned alike.

Table 4: Spatial Variation among Physical Properties in the Three Toposequences of Different Orientations

Property	Sand	Silt	Clay	BD	TP
		Summit			
CV%	1.8	5.9	1.8	1.7	1.8
Ranking	LV	LV	LV	LV	LV
		midslpe			
CV%	0.7	31.4	3.8	2.1	2.02
Ranking	LV	MV	LV	LV	LV
		Footslope			
CV%	1	10.2	4.3	1.1	1
Ranking	LV	MV	LV	LV	LV

BD = Bulk Density, TP = Total Porosity, LV = Low Variation, MV = Moderate Variation.

4. Conclusion

Some soil physical properties of three toposequences were studied. Generally, SW-lying slopes showed more clay content and high bulk density and total porosity values especially for arable crop production. These soil physical properties showed minimal variability along space.

References

Efeturi, E.E. Wapa, J.M., Musa, B.I. & Chude, V.O. (2014). Physicochemical properties and distribution of available boron in soils along two opposite toposequences in University of Abuja. *Journ. of Soil Sci*., 6, 398-406.

FAO (Food and Agricultural Organization) (1997). Guidelines for soil profile description. 2nd edition, Food and Agricultural Organization of the United Nation. 2, 97.

Foth, H. D. (1984). Fundamentals of soil science. 7th edition. John Wiley and Sons. New York. 7, 432.

Gee, G.W. & Or, D. (2002). Particle and size analysis. In: Methods of soil analysis. Dane, J.H. and Topp, G.C. (eds). Part 4, Physical methods. Soil Sci. Society of America Book Series No. 5 *ASA and SSSA Madison,* W1. 4, 225-293.

Grossman, R.B. & Reinsch, T.G. (2002). Bulk density and linear extensibility in: Methods of soil analysis. Dane, J.H. and Topp, G.C. (eds). Part 4, Physical Methods. Soil Sci. Soc. Am. Book Series No. 5, *ASA and SSSA Madison*, W1.4, 201-228.

Hart, E. A. & Gbaranch, I. D. (2015). Petogenesis of Andoni Forest in Rivers State, Nigeria. *Acta Agron. Niger*, 15(1), 76 – 89.

Hoosebeck, M. R., Amudson, G. K. & Bougal, R. B. (2000). Pedological modeling In: Handbook of Soil Science. Sommers, L.E. (ed). *CRC Press Boca Raton*. 77-116.

Igwe, C.A., (2004). Soil properties influencing stability of structure of b-horizons of ultisols in semiarid Nsukka, Eastern Nigeria. Arid Land Res. Manage., 18, 185-195.

Lrvin, B. J. (1996). Spatial information tools for delineating land form element to support soil/landscape analysis, PhD Thesis, University of Wisconsin, *Madison*. 431.

Maniyunda, L.M. Raji, B. A., Odunze, A. C. & Malgwi, W. B. (2014). Morphological and physical properties of soils on basement complex in Northern Guinea Savanna of Nigeria. *Nigeria J. Soil Sci*. 24(1), 36-50.

Miller, R. W. & Donahue, R. L. (1990). Soil introduction and plant growth. 6th edition. Education Prentice Hall New Delhi, India. 6, 68.

Ndukwu, B. N. Onweremadu, E. U., Ukeme, O, Ahukaemere, C. M. & Njoku, G. U. (2015). Distribution and concentration of Boron in soils with constrasting parent materials in Edo state, Southern Nigeria. *Acta Agron Niger*. 15(1), 90-102.

Onweremadu, E. U. (2009). Magnesium content of two soil groups in southeastern Nigerian in relation the selected pedological properties. *American-Euroasian J. of Sust. Agric.* 1(1), 1-7.

Onweremadu, E. U. & Duruigbo, C. I. (2007). Assessment of cd concentration of crude oil polluted arable soils. *Int. J. Environ. Sci. Technol*., 4(3), 409-412.

Onweremadu, E. U., Opara, C. C., Nkwopara, U. N. & Ibeawuchi, I. I. (2006). Yield response of a cowpea variety on groundseashells on isohypethermic aremic kandiuduct of Owerri, Southeastern Nigeria. *Int. J. Soil Sci*. 1, 251-257.

Onwudike, S. U, Uzoho, B. U., Ihem, E.E, Ahukaemere, C.M., Nkwopara, U., Irokwe, I. F., & Echeanyanwu, G. I. (2016). Evaluation of the fertility status of selected soils in

Mbaise, Imo State Southeastern Nigeria using nutrient index method. *Agrosearch Journal*. 16(1), 75 - 86

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

Soltanpour, P. N. (1985). Use of AB-DTPA soil test to evaluate elemental availability and toxiality. Commun. *Soil Sci. and plant Anal*. 16 (3), 323-328.

Sunday E. O, John C. N , James O , Charles A. I & Toshiyuki W. (2011). Variations in Selected Soil Physical Properties with Landforms and Slope within an Inland Valley Ecosystem in Ashanti Region of Ghana. Soil & Water Res., 6(2), 73–82

Wang, Y., Zhang, X. & Huang, C. (2009). Spatial variability of soil total nitrogen and total phosphorus under different land uses in a small watershed on the less plateau, China. *Geoderma* 150, 141-149.

Wilding, L.P. & Dress, L.R. (1983). Spatial variability and pedology. In: Pedogenesis and soil taxonomy. Wilding, L.P, Smeck, W. and Hall, G.F. (eds). Wagenmgen, Netherlands. 83-116.