Toposequence Effects on Selected Physical and Chemical Properties of Arable Soils in Ikono and Oruk Anam L. G. A, Akwa Ibom State, Nigeria

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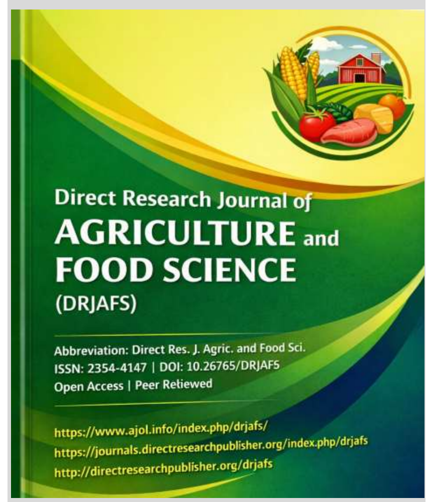
ABSTRACT

Understanding the spatial variability of soils across landscape positions is critical for sustainable agricultural planning in the humid tropics. This study was conducted to assess the effect of toposequence on selected physical and chemical properties of arable soils in Mbiabong Ekpip (Ikono) and Obio Akpa (Oruk Anam) Local Government Areas, Akwa Ibom State. Two toposequences comprising crest, middle slope, and valley bottom positions were investigated. Six profile pits were excavated, and twenty-two composite soil samples were collected from genetic horizons for laboratory analysis using standard procedures. The results revealed that surface horizons were predominantly sandy loam, while subsoils were sandy clay loam, indicating clay illuviation. Sand content ranged from 58.0% to 81.8%, while clay content varied from 12.8% to 38.0%. Soil pH ranged from 4.6 to 5.0, reflecting strongly to moderately acidic conditions. Organic carbon (0.20% to 1.92%) and total nitrogen (0.028% to 0.168%) were low in surface horizons and valley bottom positions. Effective cation exchange capacity (ECEC) ranged from 5.54 to 8.37 cmolkg^{-1}, with base saturation between 56.99% and 79.68%. Slope position influenced clay content, organic carbon, total nitrogen, and ECEC ($p \le 0.05$). Positive correlations were observed between clay content and ECEC ($r = 0.91^{**}$ for Ikono; $r = 0.88^{**}$ for Obio Akpa, $n = 22$), and between organic carbon and total nitrogen. The results demonstrate strong topographic control on soil variability and highlight the need for slope-specific management strategies including liming, organic amendments, and erosion control to enhance sustainable agricultural productivity in the study area.

Keywords: *Toposequence; Slope position; Coastal plain sands; Soil acidity; Clay illuviation; Akwa Ibom State*



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INTRODUCTION

Soil topography plays a major role in the variation of soil physical, chemical, morphological, and mineralogical characteristics. Landscape position influences effective rainfall, drainage, and erosion. According to Hall and

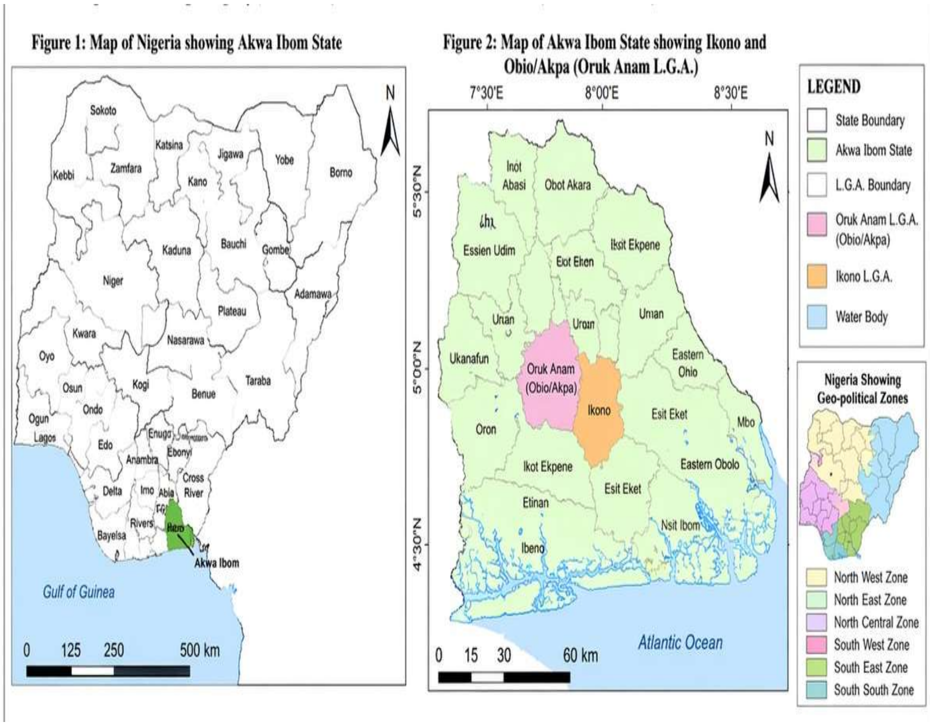

Figure 1: Map of Nigeria Showing Akwa Ibom State and Map of Akwa Ibom State Showing Ikono and Obio Akpa (Oruk Anam L.G.A)

Olson (1991), Nsor and Adesemuyi (2016), and Iyanam et al. (2024), topography influences water velocity on a slope, variation in drainage conditions, and deposition of minerals. This causes a series of changes in soil properties such as horizon differentiation, textural contrasts, changes in soil depth, and chemical properties. Topography refers to a succession of sites from the crest to the valley bottom which contains a range of soil profiles that are representative of the landscape and soils (Okusami et al., 1985). Soil properties vary in vertical and lateral directions, and such variations follow systematic changes as a function of landscape position (slope), soil-forming factors, and/or soil management practices. Different soil properties encountered along a landscape will affect the patterns of plant production, litter production, and decomposition, which will definitely have effects on carbon (C) and nitrogen (N) contents of the soil. Soil properties such as clay content and its distribution with depth, sand content, and pH have been reported to be highly correlated with landscape position (Wang et al., 2000), while organic matter has been reported to vary with slope position (Akpan et al., 2023). Several researchers (Edem et al., 2012; Edem et al., 2013; Umoh et al., 2021; Ijah et al., 2024; Ijah et al., 2025) reported that agriculture in Nigeria faces significant challenges including a decline in soil fertility and crop yield, partly due to bush burning, inappropriate land use, nutrient leaching, and fixation. Soils of Akwa Ibom State are inherently low in fertility and highly susceptible to degradation under poor management conditions. Furthermore, data regarding toposequential variations in Mbiabong Ekpip (Ikono) and Obio Akpa (Oruk Anam) remain sparse compared to other regions in Akwa Ibom State, presenting a critical gap for localized agricultural planning. There is therefore a need to study arable soils along toposequences for proper identification, technology transfer, and optimized soil management. The general aim of this study was to assess the effect of toposequence on soil properties, with the specific objectives to:

(i) Determine the physical properties of arable soils across different slope positions in Mbiabong Ekpip and Obio Akpa.
(ii) Assess the chemical properties across the toposequences; and
(iii) Examine the statistical relationships between soil physical and chemical parameters.

MATERIALS AND METHODS

Location

The study was conducted in two locations in Akwa Ibom State, South-Southern Nigeria namely: Mbiabong Ekpip in Ikono Local Government Area and Obio Akpa Oruk Anam Local Government Area (Figure 1). Both areas fall within the humid tropical rainforest zone, characterized by high annual rainfall (exceeding 2000 mm), annual temperatures ranging from 26°C to 28°C. Relative humidity is consistently high, ranging from 75% to 95%, particularly during the wet season. The geology is dominated by coastal plain sands of the Benin Formation for Obio Akpa and majorly sandstone ridges with steep-sided hills and valleys for Ikono alongside coastal plain sands, and the predominant vegetation includes secondary forest and cultivated lands. Obio Akpa is primarily covered by secondary forest, while Ikono is dominated by arable farmland. Soils in both sites are developed from unconsolidated sandy parent materials with topography ranging from undulating uplands to valley bottoms. Obio Akpa lies within the coordinates of approximately 5°10'N to 5°15'N latitude and 7°40'E to 7°45'E longitude, while Ikono is located around 5°20'N to 5°25'N latitude and 7°45'E to 7°50'E longitude (Figure 1). (NIMET, 2011)

Field Work and Sampling

Reconnaissance tour of the study area was carried out to have an overview of the survey areas and to offer the opportunity to refine the provision soil sampling units. This provided information for planning the detailed field work. Two separate toposequences were studied, one in Ikono and the other in Obio Akpa. Each toposequence comprised three slope positions: crest, middle slope, and valley bottom. A total of six (6) soil profile pits were dug (three per location); twenty-two (22) composite soil samples were collected, with each profile excavated to a depth of 1.2 m or to a lithologic discontinuity. The soil samples were air-dried, crushed and passed through 2mm sieve before taken for laboratory analysis except for Soil organic matter and total nitrogen which were further passed through a 0.5mm sieve. Soil samples collected were packaged in soil plastic bags, labeled and transported to the laboratory for analysis.

Horizon Designations and Depths

Ikono Toposequence

Pedon A (Top slope): Ap (0-20 cm), B1 (20-50 cm), B2 (50-80 cm), C (80-120 cm)
Pedon B (Middle slope): Ap (0-18 cm), B1 (18-43 cm), B2 (43-73 cm), C (73-120 cm)
Pedon C (Valley bottom): Ap (0-20 cm), B1 (20-48 cm), B2 (48-70 cm)

Obio Akpa Toposequence

Pedon A (Top slope): Ap (0-20 cm), B1 (20-45 cm), B2 (45-86 cm), C (86-110 cm)
Pedon B (Middle slope): Ap (0-20 cm), B1 (20-56 cm), B2 (56-86 cm), C (86-110 cm)
Pedon C (Valley bottom): Ap (0-20 cm), B1 (20-50 cm), B2 (48-70 cm)

Soil Physical and Chemical analysis

Soil samples were subjected to routine analysis to determine selected physical and chemical properties as described by Udo *et al.,* 2009. The particle size distribution was determined using hydrometer method. Soil pH was measured using a glass electrode pH meter in a 1:2.5 soil-to-1N KCl ratio. Organic carbon was measured using the Walkley and Black digestion method, while organic matter was calculated by multiplying organic carbon by Van Bemmelen factor of 1.724. Total nitrogen was determined using the Micro-Kjeldhal Digestion method and distillation method. The amounts of potassium (K) and sodium (Na) was determined using the flame photometer with appropriate filters while the amounts of magnesium (Mg) and calcium (Ca) was determined using the atomic absorption spectrometer (AAS). Exchangeable acidity was determined by the 1 MKCl extraction method. Effective cation exchange capacity (ECEC) was determined using the summation of exchangeable bases and exchangeable acidity. Base saturation was determined using the formula:

$$\text{Base Saturation (\%)} = \frac{\text{Total Exchangeable Bases (TEB)}}{\text{Cation Exchange Capacity (CEC)}} \times 100$$

Statistical Analysis

Data collected were subjected to descriptive statistics (average). Pearson correlation matrices were utilized to evaluate linear relationships among some physical and chemical properties across the toposequences. All analyses followed standard procedures for tropical soils.

RESULTS AND DISCUSSION

Physical Properties of Soils of Ikono and Obio Akpa

Physical Properties of Soils of Ikono

The physical properties of soils of Ikono as presented in Table 1 showed that sand content ranged from 58.0 to 79.8%, silt from 1.4 to 10.0%, and clay from 12.8 to 38.0%. Higher clay contents in the B horizons indicate stronger pedogenic development compared to Obio Akpa soils. This agrees with the findings of Osodeke and Kamalu (2019) in inland forest soils. Surface horizons were mostly sandy loam, while subsurface horizons were sandy clay loam. The higher clay accumulation improves nutrient retention but may restrict root penetration if compacted. The physical characteristics reflect advanced weathering typical of humid rainforest zones developed on coastal plain sands (Brady and Weil, 2016; Esu, 2010). Ikono soils showed slightly higher clay accumulation, suggesting more advanced soil development. These findings are consistent with earlier studies on soils of Akwa Ibom State (Esu, 2010).

Table 1: Physical Properties of Soil Samples for Ikono

Pedon	Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural Class
Pedon 1	Ap	0–20	77.80	3.40	18.80	SL
Pedon 1	B1	20–50	79.80	5.40	14.80	SL
Pedon 1	B2	50–80	69.80	5.40	24.80	SCL
Pedon 1	C	80–120	71.80	5.40	22.80	SCL
Pedon 2	Ap	0–18	79.80	7.40	12.80	SL
Pedon 2	B1	18–43	61.80	3.40	34.80	SCL
Pedon 2	B2	43–73	65.80	1.40	32.80	SCL
Pedon 2	C	73–120	73.80	5.40	20.80	SCL
Pedon 3	Ap	0–20	75.00	10.00	15.00	SL
Pedon 3	B1	20–48	58.00	4.00	38.00	SCL
Pedon 3	B2	48–70	62.00	2.00	36.00	SCL
Average	**—**	**—**	**70.50**	**4.80**	**24.70**	**—**

Table 2: Physical Properties of Soil Samples for Obio Akpa

Pedon	Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural Class
Pedon 1	Ap	0–20	81.80	5.40	12.80	SL
Pedon 1	B1	20–45	65.80	5.40	28.80	SCL
Pedon 1	B2	45–86	63.80	3.40	32.80	SCL
Pedon 1	C	86–110	65.80	7.40	26.80	SCL
Pedon 2	Ap	0–20	75.80	3.40	20.80	SCL
Pedon 2	B1	20–56	63.80	5.40	30.80	SCL
Pedon 2	B2	56–86	66.20	3.40	30.40	SCL
Pedon 2	C	86–110	66.20	5.40	28.40	SCL
Pedon 3	Ap	0–20	72.20	7.40	20.40	SCL
Pedon 3	B1	20–50	74.20	5.40	20.40	SCL
Pedon 3	B2	50–80	68.20	5.40	26.40	SCL
Average	**—**	**—**	**69.40**	**5.20**	**25.30**	**—**

Physical Properties of Soils of Obio Akpa

The physical properties of soils of Obio Akpa presented in Table 2 showed dominance of sand fractions (63.8 to 81.8%), with silt ranging from 3.4 to 7.4% and clay from 12.8 to 32.8%. Surface horizons generally recorded higher sand content, while subsurface horizons showed clay accumulation, indicating illuviation under humid tropical conditions (Esu, 2005; Udoh *et al*., 2009). Textural classes ranged from sandy loam at the surface to sandy clay loam in the subsoil. These textures suggest good aeration but low water and nutrient retention at the surface, typical of highly weathered tropical soils on coastal plain sands as reported by Eshett *et al.,* (1990a) and Ijah *et al.,* (2023).

Chemical Properties of Soils of Ikono and Obio Akpa

Chemical Properties of Soils of Ikono

The chemical properties of soils of Ikono presented in Table 3 showed strong acidity (pH 4.5–4.8) throughout the profiles, slightly lower than Obio Akpa, suggesting greater leaching of basic cations. A similar finding was reported by Ijah *et al.,* (2024) on soils of Akwa Ibom State formed from different parent materials. Organic carbon ranged from 0.20 to 1.77% (organic matter 0.35–3.05%), with sharp declines down the profile. A similar finding was reported by Akpan *et al*., (2023) on distribution of organic carbon along a toposequence in humid tropics of Nigeria. Total nitrogen ranged from 0.042 to 0.140%. This pattern has been reported by Iyanam *et al*., (2024) for arable soils in Akwa Ibom State and is attributed to low organic inputs. Available phosphorus ranged from 6.0 to 36.3 mg kg^{-1}. Low pH favours phosphorus fixation by iron and aluminum oxides, a phenomenon widely documented for soils of Akwa Ibom State (Umoh *et al*., 2021). Exchangeable bases were dominated by calcium (2.0–3.2 $cmolkg^{-1}$), with ECEC 5.71–8.75 $cmolkg^{-1}$ and base saturation 53.8–77.98%. These values reflect low nutrient reserves and weak buffering capacity consistent with cultivated coastal plain sandy soils (Essien *et al*., 2018). These findings agree with earlier studies conducted within Akwa Ibom State by several researchers and reinforce the need for liming, organic matter incorporation, and balanced fertilization for sustainable arable crop production (Ijah *et al*.,2021; Ijah *et al*., 2023; Uwah *et al*., 2024: Ijah *et al*., 2025).

Chemical Properties of Soils of Obio Akpa

The chemical properties of soils of Obio Akpa are

Table 3: Chemical Properties of Soil Samples from Ikono

Pedon	Horizon	Depth (cm)	pH	Avail. P (mg/kg)	Total N (mg/kg)	OC (%)	OM (%)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	EA (cmol/kg)	ECEC (cmol/kg)	BS (%)
1	Ap	0–20	4.50	36.30	0.14	1.52	2.62	3.20	1.60	0.43	0.16	1.52	6.92	77.98
1	B1	20–50	4.60	28.00	0.14	1.27	2.18	2.40	1.20	0.38	0.10	2.00	6.08	67.12
1	B2	50–80	4.50	12.80	0.06	0.41	0.70	2.00	0.80	0.27	0.10	2.72	5.89	53.80
1	C	80-120	4.50	9.70	0.04	0.46	0.79	2.40	0.80	0.16	0.12	2.64	6.12	56.81
2	Ap	0–18	4.70	32.50	0.14	1.77	3.05	3.20	1.20	0.38	0.12	2.08	6.98	70.23
2	B1	18–43	4.60	11.70	0.06	0.30	0.52	3.20	2.00	0.16	0.19	3.20	8.75	63.41
2	B2	43–73	4.50	7.50	0.06	0.41	0.70	2.80	1.60	0.17	0.31	3.12	8.00	61.00
2	C	73-120	4.60	25.80	0.08	1.61	2.01	2.40	0.80	0.31	0.20	2.00	5.71	64.96
3	Ap	0–20	4.80	28.00	0.13	1.60	2.76	3.00	1.10	0.35	0.11	2.00	6.56	68.00
3	B1	20–48	4.60	10.00	0.05	1.25	0.43	2.80	1.80	0.14	0.18	3.00	7.92	60.00
3	B2	48–70	4.50	6.00	0.50	0.20	0.35	2.50	1.50	0.12	0.15	3.20	7.52	55.00
Average	—	—	**4.58**	**18.94**	**0.13**	**0.98**	**1.46**	**2.72**	**1.31**	**0.26**	**0.16**	**2.50**	**6.95**	**63.48**

Table 4: Chemical Properties of Soil Samples from Obio Akpa

Pedon	Horizon	Depth (cm)	pH	Avail. P (mg/kg)	Total N (mg/kg)	Organic Carbon (%)	Organic Matter (%)	Ca (Cmol/kg)	Mg (Cmol/kg)	K (Cmol/kg)	Na (Cmol/kg)	EA (Cmol/kg)	ECEC (Cmol/kg)	BS (%)
Pedon 1	Ap	0–20	4.80	39.10	0.17	1.77	3.05	3.20	1.20	0.46	0.16	2.08	7.10	70.66
	B1	20–45	4.60	16.80	0.07	0.61	1.05	3.60	1.60	0.28	0.14	2.48	8.10	69.33
	B2	45–86	4.60	10.90	0.04	0.20	0.35	3.20	0.80	0.19	0.14	2.72	7.05	61.48
	C	86-110	4.60	9.30	0.03	0.35	0.61	3.60	1.60	0.13	0.11	2.24	7.69	70.82
Pedon 2	Ap	0–20	4.70	25.30	0.10	1.32	2.27	2.00	1.20	0.41	0.39	2.64	6.64	60.29
	B1	20–56	4.60	9.90	0.04	0.35	0.61	2.80	0.80	0.18	0.40	2.96	7.14	58.53
	B2	56–86	4.60	12.50	0.06	0.51	0.88	3.20	1.60	0.18	0.10	2.16	7.24	70.17
	C	86-110	4.60	20.20	0.08	1.01	1.75	2.40	1.20	0.16	0.06	2.88	6.70	56.99
Pedon 3	Ap	0–20	5.00	24.50	0.17	1.92	3.32	4.00	1.60	0.31	0.03	1.52	7.46	79.68
	B1	20–50	4.80	20.50	0.10	1.06	1.83	3.60	2.00	0.30	0.31	2.16	8.37	74.19
	B2	50–80	4.90	18.20	0.08	0.71	1.22	2.00	0.80	0.21	0.37	2.16	5.54	60.96
Average	**—**	**—**	**4.71**	**18.84**	**0.09**	**0.89**	**1.54**	**3.05**	**1.31**	**0.26**	**0.20**	**2.36**	**7.18**	**66.65**

presented in Table 4. Soil pH ranged from 4.6 to 5.0, indicating strongly to moderately acidic conditions, with lowest values in subsurface horizons. This acidity is characteristic of soils in Obio Akpa and adjoining areas, where intense leaching results in depletion of basic cations (Esu, 2010; Ijah *et al.,* 2021). Acidic soil reaction at this range is known to limit the availability of essential nutrients such as phosphorus as reported Ijah *et al*., (2021) while increasing aluminum activity in tropical soils (Brady and Weil, 2017). Organic carbon values ranged from 0.20 to 1.92% (organic matter 0.35 to 3.32%), highest in surface horizons. The highest values occurred in the surface horizons (Ap) and reduced along the slope. Similar organic matter ranges have been reported for Obio Akpa soils, attributed to continuous cultivation and low clay content (Umoh *et al*., 2021; Isaac *et al.,* 2024). Total nitrogen ranged from 0.028 to 0.168%, decreasing with depth. The low nitrogen is attributed to low organic inputs and rapid mineralization under high temperatures and rainfall (Essien *et al*., 2018). Available phosphorus ranged from 9.3 to 39.1 mg kg^{-1}. Similar moderate but low available phosphorus has been reported in Obio Akpa soils by Ijah *et al*., (2024). Exchangeable bases were low to moderate, dominated by calcium (2.0–4.0 $cmolkg^{-1}$), with ECEC ranging from 5.54 to 8.37 $cmolkg^{-1}$ and base saturation 56.99 to 79.68%. These indicate low to moderate nutrient-holding capacity.

Effect of Toposequence on Soil Physical Properties

The effect of toposequence on soil physical properties is presented in figure 2 and figure 3. Toposequence significantly influenced physical properties in both locations. Sand content was higher at crest positions, while clay content increased toward the middle slope and valley bottom due to erosion and deposition (Esu, 2005; Obi and Esu, 2013). This pattern reflects the processes of erosion and deposition along the slope gradient. This finding is consistent with reports that soils of Akwa Ibom derived from coastal plain sands are generally sandy at upland positions but become increasingly clayey downslope due to particle translocation (Esu, 2005; Obi and Esu, 2013). The relatively higher clay accumulation in the valley bottom soils of Ikono compared to Obio Akpa suggests more pronounced illuviation processes (Udoh *et al*., 2009).

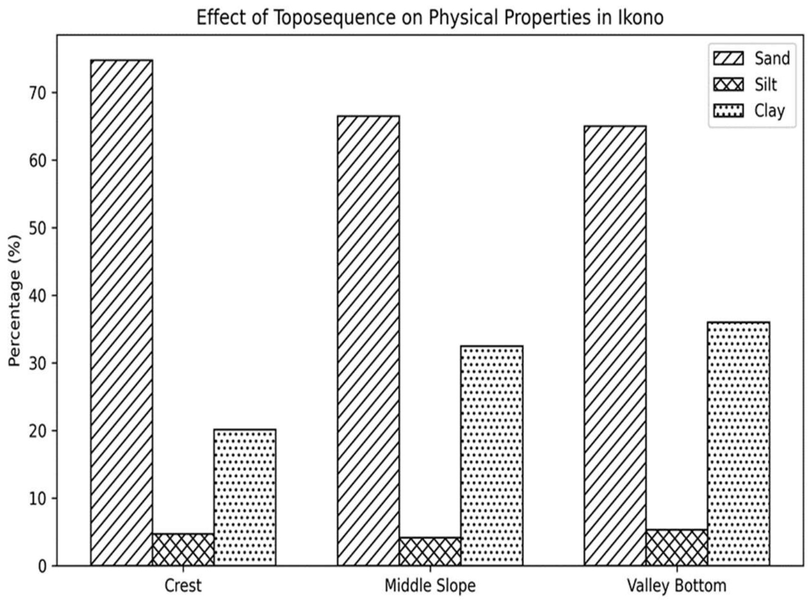

Figure 2: Effect of Toposequence on Physical Properties (Ikono)

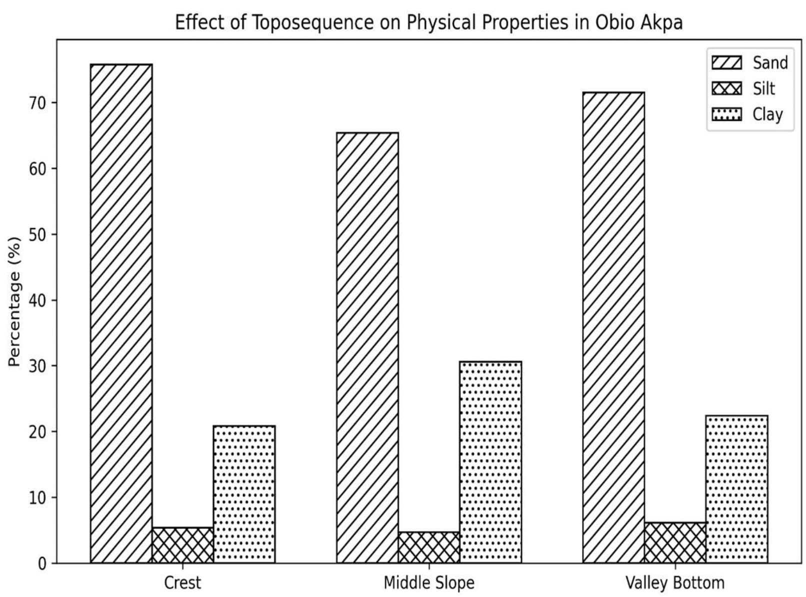

Figure 3: Effect of Toposequence on Physical Properties (Obio Akpa)

Effect of Toposequence on Soil Chemical Properties

The Effect of Toposequence on Soil Chemical Properties is presented in Figure 4 and Figure 5. Toposequence influenced organic carbon, total nitrogen, available phosphorus, and ECEC with accumulation tendencies in lower slopes due to runoff and sediment deposition (Enwezor *et al*., 1990; Umoh *et al.,* 2021). Soil pH variation across slopes was non- significant, consistent with uniform leaching under humid conditions as reported by (Ojanuga (2006) and Ijah *et al*., (2024). Organic carbon and total nitrogen were observed to be highest at the crest and valley bottom but lowest at the middle slope. This pattern may be attributed to erosion of organic materials from upper slopes and their deposition in lower slope positions. This finding agrees with reports that organic matter distribution in southeastern Nigerian soils is strongly influenced by topography and erosion processes Akpan *et al*., (2023). Available phosphorus varied significantly across slope positions, with higher values at the crest.

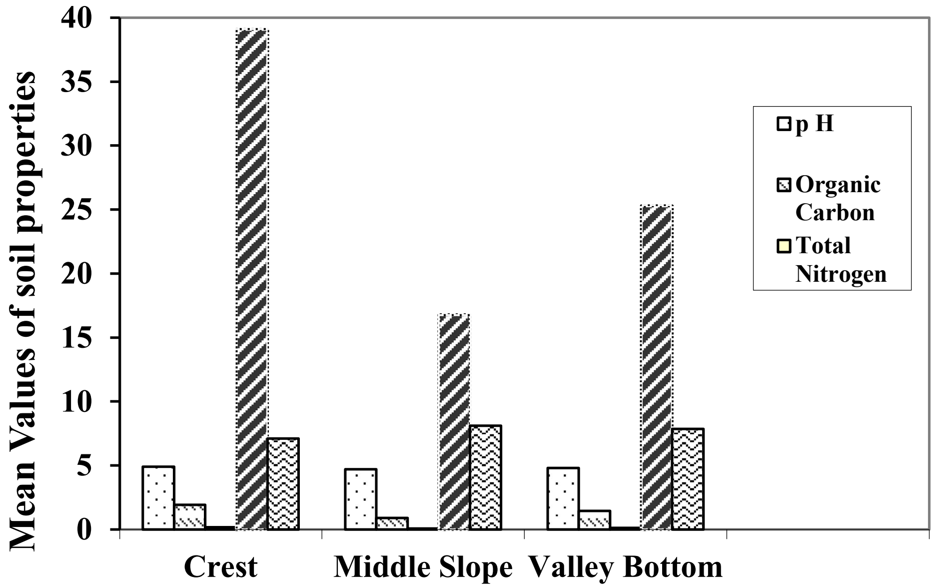

Figure 4: Effect of Toposequence on Chemical Properties (Ikono)

Figure 5: Effect of Toposequence on Chemical Properties (Obio Akpa)

ECEC was also observed to vary significantly, increasing with clay content and organic matter. The non-significant variation in soil pH across slope positions indicates that leaching processes are relatively uniform across the landscape (Ojanuga, 2006).

Relationship between Soil Properties in Obio Akpa

Correlation matrix between soil properties in Obio Akpa is presented in Table 5. The result showed strong positive relationships between clay and ECEC (r = 0.88**), organic

Table 5: Relationship between Soil Properties in Obio Akpa

Variable	Sand	Clay	pH	OC	TN	ECEC
Sand	1.00	-0.91**	0.42	-0.78*	-0.74*	0.85**
Clay	-0.91**	1.00	-0.39	0.81**	0.76*	0.88**
pH	0.42	-0.39	1.00	0.30	0.28	0.35
OC	-0.78*	0.81**	0.30	1.00	0.96**	0.84**
TN	-0.74*	0.76*	0.28	0.96**	1.00	0.80**
ECEC	-0.85**	0.88**	0.35	0.84**	0.80**	1.00

Correlation Matrix (R-values with significance)
OC- organic carbon, TN-Total Nitrogen, ECEC- Effective Cation Exchange Capacity
$p < 0.05$ → Significant (*) $p < 0.01$ → Highly significant (**)

Table 6: Relationship between Soil Properties in Ikono

Variable	Sand	Clay	pH	OC	TN	ECEC
Sand	1.00	-0.94**	0.36	-0.81**	-0.79*	-0.87**
Clay	-0.94**	1.00	-0.33	0.85**	0.83**	0.91**
pH	0.36	-0.33	1.00	0.25	0.22	0.31
OC	-0.81**	0.85**	0.25	1.00	0.97**	0.88**
TN	-0.79*	0.83**	0.22	0.97**	1.00	0.86**
ECEC	-0.87**	0.91**	0.31	0.88**	0.86**	1.00

Correlation Matrix (R-values with significance)
OC- organic carbon, TN-Total Nitrogen, ECEC- Effective Cation Exchange Capacity
$p < 0.05$ → Significant (*) $p < 0.01$ → Highly significant (**)

carbon and total nitrogen (r = 0.96**), and clay and organic carbon (r = 0.81**). Strong negative relationships existed between sand and clay (r = -0.91**), sand and ECEC (r = -0.85**) (Table 5). These confirm that clay and organic matter primarily control nutrient retention in these sandy soils (Brady and Weil, 2016; Eshett *et al*., 1990b).

Relationship between Soil Properties in Ikono

Stronger correlations were observed in Ikono (Table 6) clay and ECEC (r = 0.91**), Organic carbon and total nitrogen (r = 0.97**), sand and clay (r = -0.94**), sand and ECEC (r = -0.87**). The stronger relationship observed in Ikono suggest more advanced pedogenic development and greater influence of clay accumulation (Brady and Weil, 2016; Eshett *et al*., 1990c). These results are in consonant with earlier studies on soil properties along a toposequences on coastal plain sands of Akwa Ibom State (Esu, 2010; Obi and Esu, 2013).

Conclusion and Recommendation

The study has demonstrated that soils of Mbiabong Ekpip in Ikono Local government area and Obio Akpa in Oruk Anam Local government area, Akwa Ibom state are strongly influenced by topography. The soils are generally sandy at the surface with clay-enriched sub soils, reflecting active pedogenic processes under humid tropical conditions. The strong acidity observed across both locations indicates significant leaching of basic cations, which may limit nutrient availability. Although the soils possess moderate base saturation and cation exchange capacity, their sandy nature and acidic condition suggest inherent fertility constraints. The variation in soil properties along the toposequence highlights the importance of site-specific soil management. Valley bottom soils exhibit relatively better fertility due to accumulation of organic matter and finer particles, while upland soils are more prone to erosion, nutrient leaching, and reduced productivity. Based on the observed physical and chemical properties, the soils were low in fertility, and the need for liming, organic matter incorporation, and balanced fertilization for sustainable agricultural productivity.

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