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EFFECTS OF TOPO POSITION ON PHYSICO-CHEMICAL PROPERTIES OF THE SOIL AT EZEAGU AREA OF ENUGU STATE, SOUTHEASTERN NIGERIA.

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ABSTRACT

Topographic position is a key landscape control on soil redistribution and the spatial organization of soil physicochemical properties along hillslopes. This study examined the influence of topo-position (upper, middle, and bottom slopes) on selected soil physico-chemical properties in Olo, Ezeagu Local Government Area, Enugu State, Southeastern Nigeria. A stratified transect sampling design was applied across three representative topo positions. Transects extended from crest to foot slope and soil samples were collected at a uniform depth of 0 – 20 cm using a stainless steel, soil auger and core samplers at 20 m intervals. A total of 27 disturbed and undisturbed soil samples were collected at Nine sampling points on each topo position. The samples were subjected to laboratory analyses using standard procedures, and data were evaluated using Analysis of Variance and correlation analysis with spatial variability discussed using Coefficients of Variation (CV). Results showed systematic topo position controls on soil physico-chemical properties. Particle Size Distribution showed low variability (CV $< 15\%$) with sand content decreasing downslope (24.70–20.40%) and clay content increasing (39.90–44.80%). Bulk Density and total porosity also exhibited low variability (CV $< 2\%$), declining downslope from 1.35 to 1.31 g cm^{-3} and increasing from 48.93 to 50.52%, respectively reflecting relatively uniform soil structural conditions across the topo positions. Soil pH showed low variability (CV = 5.27%) and increased downslope from moderately to slightly acidic conditions (5.77–6.40). Organic Carbon displayed moderate variability (CV $\approx 21\%$), which was highest at the middle slope (1.09%), suggesting partial deposition and stabilization zones. In contrast, total nitrogen (CV = 51.70%) and Available Phosphorus (CV = 82.65%) exhibited high variability with pronounced downslope declines from 0.18% to 0.07% and from 11.20 to 2.80 mg kg^{-1} respectively. This shows strong sensitivity of nutrient pools to slope-driven redistribution. Cation exchange capacity showed low variability (CV $< 10\%$) and was highest at the middle slope (5.60 cmol kg^{-1}). These findings emphasize that topo-position exerts strong control over both physical redistribution and chemical differentiation along the hillslope.

Keywords: Topo-Position; Soil, Physico-Chemical Properties; Soil Fertility; Land Degradation

1.0 INTRODUCTION

Soil forms the foundation of terrestrial ecosystems and agricultural production. In humid tropical landscapes, soil physico-chemical properties vary considerably across the landscape due to interactions among several inanimate and animate factors (Brady and Weil, 2022). Topographic position is commonly expressed in terms of slope gradient and slope segments along a toposequence. These segments are typically classified into upper, middle, and lower slope positions, which represent distinct landscape units that influence soil formation processes, drainage patterns, and the redistribution of sediments and nutrients across the slope (Yacob and Nigussie, 2022; Ojedokun *et al.*, 2021). These slope segments represent systematic variations in erosional energy, sediment transport, and moisture redistribution, which collectively influence soil texture, structure, organic matter dynamics, and nutrient availability (Abate and Kibret, 2012). Upper slope soils frequently exhibit nutrient depletion due to continuous soil loss, leaching, and limited organic matter inputs, whereas lower slope segments often show nutrient enrichment through downslope transport and deposition of fertile materials (Abate and Kibret, 2012; Ziadat and Taimeh, 2013). Various studies across tropical and subtropical regions have shown consistent downslope trends in soil physical properties, largely driven by erosion, runoff, and sediment deposition processes that redistribute soil particles and organic matter along slope gradients (Jimoh *et al.,* 2022; Gebreselassie *et al.,* 2021; Oku *et al.,* 2010). Particle size distribution often shows a decline in sand content and a corresponding increase in silt and clay fractions toward lower slope positions as a result of selective erosion and sediment deposition (Bufebo *et al.,* 2021). These variations in soil texture exert strong control on soil physical properties such as bulk density, porosity, moisture retention, and aggregate stability which are key attributes governing soil productivity and erosion resistance. Ike *et al.* (2025), who worked on slope segments at a gully site in Amachalla, Awka, showed that slope position significantly influenced particle size distribution, moisture content, and aggregate stability across soil depths. However, the extent of such influences is often modified by management. Beyond physical attributes, soil chemical properties are also strongly regulated by topographic position. In Olo, Ezeagu Local Government Area of Enugu State, soils developed on undulating to rolling landscapes are increasingly subjected to cultivation, deforestation, and erosion pressures. The variability in topography, climate, geology, vegetation, and land use in Olo provides a suitable natural laboratory for investigating the influence of slope position on soil physicochemical properties, thereby justifying the selection of the area as the study site for this research (Ishaya *et al.,* 2024; Okoye *et al.,* 2024).

Therefore, this study evaluates the effects of topo-position on soil physicochemical properties in Olo, Ezeagu LGA, Southeastern Nigeria.

2.0 METHODOLOGY

2.1 Description of Study Area

The study was carried out in in Awene, Ezema Olo community, Ezeagu Local Government Area, Enugu State, Southeastern Nigeria as shown in Fig. 1. Olo lies approximately between latitudes 6°20′ – 6°30′ N and longitudes 7°05′–7°15′ E, with elevations ranging from 300 to 490 m above mean sea level, and forms part of the undulating terrain influenced by the Udi Hills (Ishaya *et al.,* 2024; Okoye *et al.,* 2024). The area is characterized by diverse topography, including hills, valleys, floodplains, and gentle to steep slopes (0.1°–19°), which create variations in runoff, erosion, and soil redistribution processes that directly influence soil properties along slope positions (Ishaya *et al.,* 2024). The climate is humid tropical savanna (Aw) with a distinct wet season (April–October) receiving 1600 – 2000 mm of rainfall annually and a dry season from November to March with mean temperatures around 28°C, conditions that strongly affect soil formation, nutrient leaching, and organic matter dynamics (Nebeokike *et al.,* 2020; Okoye *et al.,* 2024).

Soils in Olo are predominantly sandy loam to loam, classified mainly as Ultisols, Alfisols, and Inceptisols, with high sand content (74.3 – 94.8%), low organic matter (average 0.97%), and moderate fertility, making them highly susceptible to erosion and nutrient loss, especially on upper slope positions (Ishaya *et al.,* 2024; Nwankwo *et al.,* 2022). These soils are derived from the Ajali Sandstone, Nsukka Formation, and Imo Formation of the Anambra Basin, which further influence soil texture, permeability, and structural stability (Nebeokike *et al.*, 2020). Agriculture is the dominant land use, with about 80% of the population engaged in farming, cultivating crops such as cassava, yam, maize, and vegetables, while vegetation ranges from tropical rainforest to Guinea savanna.

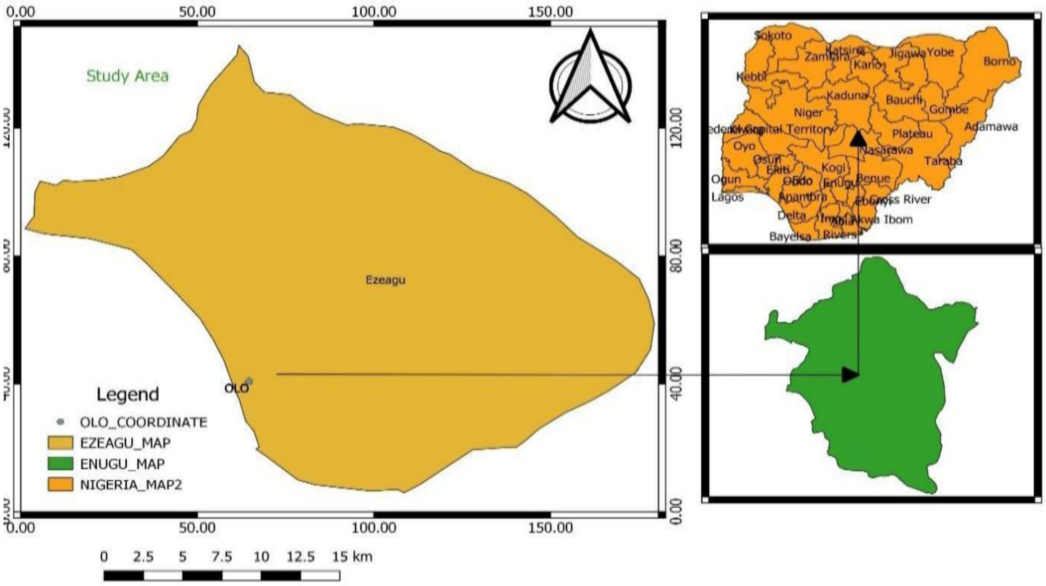

Fig. 1: The study area map of Olo, Ezeagu L.G.A., Enugu State, Nigeria

2.2 Field Delineation and Sampling method

A field-based, stratified transect sampling design was used to capture systematic variation along slope positions. Three representative hillslopes within Olo were selected purposely to represent typical land uses and slope gradients. On each hillslope, a transect running from the upper slope down to the bottom slope was established. A total of 27 disturbed and undisturbed soil samples were collected for analysis using Core samplers and a stainless-steel soil Auger. These soil samples were collected randomly at nine (9) different locations (replications) on each slope position 20 m apart from each point of sample collection at the depths of 0-20 cm to capture local heterogeneity. These samples were air-dried, crushed using mortar and pestle and pass through 2 mm sieve before subjecting them to laboratory analysis using standard procedures for determination of the following physicochemical properties of the soil samples:

- Particle Size Analysis using the Bouyoucos (1935) hydrometer method by Gee and Or (2002),
- Dry Bulk Density by Carter and Grossman (2002), Total Porosity by Chancellor (1994),
- Gravimetric Soil Moisture content using ASABE Standards, (2008) method,
- Soil Organic Carbon Content by Walkley Black wet oxidation method as described by Nelson and Somners (1982),

- pH was determined in distilled water at a ratio of 1:2.5 (soil: Water) suspension using pH meter (McLean ,1982),
- Exchangeable Bases ($Ca^{2+} + Mg^{2+} + K^{+} + Na^{+}$) extracted in 1N-$NH_4OAC$ buffered at pH 7 and their concentrations determined with Atomic Adsorption Spectrophotometer for calcium and magnesium and Flame photometer for potassium and sodium,
- Total Exchangeable Acidity by titration method using 1N KCl extract as described by McLean (1982),
- Total Nitrogen using Kjeldahl digestion method as described by Bremmer and Mulvancy. (1982),
- Available Phosphorus by Bray-1 method (0.03N NH_4F + 0.025N HCl),
- Base Saturation calculated on a percentage basis by diving total exchangeable bases ($Ca^{2+} + Mg^{2+} + K^{+} + Na^{+}$) by cation exchange capacity multiplied by 100%, and
- Cation Exchange Capacity (CEC) was measured by the 1N-NH_4OA_c extraction method and obtained by summation of the exchangeable bases and exchangeable acidity.

2.4 Statistical Analysis:

Data were subjected to Descriptive Statistics using Correlation analysis and Coefficient of Variation. The Correlation analysis was used to quantify relationships between the selected physical and chemical variables, while Coefficient of Variation (% CV) was used to determine the degree of variation from one data series to the other. CV of 0-15 % = low variation, 16-35% = moderate variation and 36-100% = high variation (Wilding *et al.*, 1994).

3.0 RESULTS AND DISCUSSION

3.1: Results of the Effect of Topo Positions on Soil Physical Properties

Table 1 shows that soil physical properties varied systematically with topo position, although most parameters showed low spatial variability based on coefficient of variation (CV < 15%). Sand content at the upper slope was 0.9% and 4.30% higher than at the middle and lower slopes. In contrast, clay content increased downslope, rising from 39.90% at the upper position to 39.40% at the middle and reaching 44.80% at the lower slope. The low CVs recorded for sand (9.87%), silt (4.69%), and clay (7.21%) indicate that parent material strongly controlled particle size distribution, despite ongoing erosion and deposition processes. This pattern is characteristic of tropical hillslope catenas, where selective erosion removes fine particles from upper slopes and deposits them downslope through runoff-driven sediment redistribution (Zhou *et al.*, 2023; Liu *et al.*, 2024). Bulk density showed a slight but consistent decline downslope (1.35–1.31 g cm^{-3}), while total porosity increased from 48.93% to 50.52%. Both parameters exhibited very low variability (CV = 1.56–1.69%), suggesting relatively uniform soil compaction and management across the topographic positions. Similar trends have been reported in toposequence studies across tropical regions, where higher bulk density is often observed on upper slopes due to erosion and lower organic matter, while lower slopes tend to accumulate finer particles and organic materials that improve soil structure and increase porosity. Studies in Nigeria and other tropical landscapes have likewise documented decreases in bulk density and increases in porosity downslope as a result of sediment deposition and improved aggregation in lower slope positions (Gebreselassie *et al.,* 2021; Jimoh *et al.,* 2022; Ojedokun *et al.,* 2021; Brady and Weil, 2017).

Conversely, soil moisture content displayed moderate variability (CV = 15.88%) and decreased downslope from 25.03% to 18.16%. This finding does not fully agree with the results reported by Ezeaku and Anikwe (2006), who observed higher soil moisture content in lower slope positions due to the accumulation of runoff water and finer soil particles that enhance water retention.

Table 1: Effect of Topo Positions on Soil Physical Properties

Slope Position	**SAND** →	**SILT (%)**	← **CLAY**	**TC**	**BD (g/cm^3)**	**Ft (%)**	**MC (%)**
U	24.70	34.59	39.90	Clay	1.35	48.93	25.03
M	23.80	37.44	39.40	Clay loam	1.34	49.27	21.72
B	20.40	34.52	44.80	Clay	1.31	50.52	18.16
CV (%) **Ranking**	9.87 LV	4.69 LV	7.21 LV		1.56 LV	1.69 LV	15.88 MV

TC= Textural Class, BD= Bulk Density, Ft = Soil Total Porosity, MC= Moisture Content, U = Upper Slope, M = Middle Slope, B = Bottom Slope, CV = Coefficient of Variation, LV = Low variation, MV = Moderate variation.

3.2: Effects of Topo positions on Soil Chemical Properties

Table 2 shows that soil chemical properties varied systematically with slope position. Soil pH (H_2O) increased downslope from 5.77 at the upper slope to 6.21 at the middle slope and 6.40 at the lower slope, with low variability (CV = 5.27%), reflecting a gradual reduction in soil acidity along the slope gradient. This trend aligns with observations from other studies in tropical toposequences, where downslope positions typically accumulate basic cations and experience lower leaching intensity, resulting in higher pH values compared to upper slopes (Asadu and Akamigbo, 1990; Obi and Ezeaku, 2020). Organic carbon content showed moderate variability (CV = 21%) and increased from 0.71% at the upper slope to 1.09% at the middle slope, before declining slightly to 0.87% at the lower slope. This pattern indicates that middle slopes often act as zones of partial deposition and organic matter stabilization, benefiting from both inputs from upslope positions and reduced oxidation rates, which is consistent with trends reported in other tropical landscapes (Addis *et al.,* 2015; Ezeaku, 2014). Total nitrogen and available phosphorus showed very high variability, indicating that these nutrients are highly sensitive to slope position. Total nitrogen decreased markedly downslope, with higher values at the upper slope and progressively lower concentrations at the middle and lower slopes, mirroring the pattern observed for organic carbon and underscoring the strong linkage between soil organic matter and nitrogen content (Six *et al.,* 2002; Liu *et al.,* 2020). The lower TN at the footslope suggests nutrient depletion despite improvements in physical properties. Conversely, available phosphorus was highest at the upper slope (11.20 mg kg^{-1}) and declined downslope to 3.20 mg kg^{-1} and 2.80 mg kg^{-1} at the middle and lower slopes, reflecting common patterns in tropical soils where phosphorus often accumulates in upper slopes due to fertilizer inputs, erosion processes, or strong fixation in clay-rich lower slope soils (Akamigbo and Asadu, 1983; Brady and Weil, 2022).

Exchangeable bases, total exchangeable acidity, cation exchange capacity, and base saturation all showed low variability (CV < 10%), indicating that the soil nutrient-holding capacity remains relatively stable across slope positions. This observation is consistent with findings from other studies where base saturation and cation exchange capacity exhibit minimal variation along toposequences, even when more mobile nutrients such as nitrogen and phosphorus show strong positional sensitivity. Exchangeable magnesium (Mg^{2+}) increased downslope from 1.36 cmolkg^{-1} (upper slope) to 1.53 cmolkg^{-1} (middle slope) before slightly decreasing to 1.44 cmolkg^{-1} at the bottom slope, showing its relative mobility and tendency to accumulate in zones of deposition (Nnaji *et al.*, 2002). Exchangeable potassium (K^{+}) varied between 0.28 cmolkg^{-1} and 0.25 cmolkg^{-1} at the upper slope and middle slope, and 0.**27** cmolkg^{-1} at the lower slope. This shows moderate redistribution as possibly influenced by organic matter content and washing down long the toposequence with the soil mineral fractions. The cation exchange capacity (CEC) distribution along the soil topo position mirrored the organic C pattern with the middle slope position having the highest concentration (5.60cmolkg^{-1}). Base saturation (BS) remained relatively high across all slope positions, ranging from 76.19% to 78.07%, indicating moderate inherent fertility despite the potential effects of erosion-induced nutrient redistribution. This pattern is consistent with the observations of Ezeaku and Anikwe (2006), who reported similarly high base saturation across toposequences in Southeastern Nigeria, with only slight decreases in upper slopes due to nutrient loss by runoff.

Table 2: Effects of Topo positions on soil Chemical Properties

Slope Position		**pH (H_2O)**	**OC (%)**	**TN (%)**	**AV.P (mg/kg)**	**Al^{3+}**	**H^+**	**K^+**	**Mg^{2+}** (cmol/kg)	**Na^+**	**Ca^{2+}**	**TEA**	**CEC**	**BS (%)**
U		5.77	0.71	0.18	11.20	0.70	0.34	0.28	1.36	0.18	1.96	1.04	4.73	78.07
M		6.21	1.09	0.09	3.20	0.91	0.37	0.25	1.53	0.16	2.33	1.28	5.60	76.19
B		6.40	0.87	0.07	2.80	0.80	0.36	0.27	1.44	0.16	2.16	1.16	5.24	77.72
CV (%)		5.27	21.44	51.70	82.65	13.08	4.28	5.73	5.89	6.93	8.61	10.34	8.42	1.29
Ranking		LV	MV	HV	HV	LV	LV	LV	LV	LV	LV	LV	LV	LV

OC = Organic Carbon, O.M = Organic matter, TN = Total Nitrogen, Av. P = Available Phosphorus, CV = Coefficient of Variation, LV = Low Variation, MV = Moderate Variation, HV = High Variation, TEA = Total Exchangeable Acidity, CEC = Cation Exchange Capacity, BS = Base Saturation, U = Upper Slope, M = Middle Slope, B = Bottom Slope.

3.3: Correlation Between the Soil Physicochemical Properties

Table 3 shows the results of correlation among the soil variables measured across the top positions. Total N and available P had a strong and significant positive relationship (r = 0.99**), reflecting their shared biological origin primarily on organic matter mineralization and accumulation (Liu *et al.,* 2020). Organic carbon and Total exchangeable acidity correlate positively with Al^{3+} and H^+ showing that higher organic matter increases soil acidity through decomposition (Ezeaku, 2014), especially the H^+. CEC has positive correlations with OC, Mg^{2+}, and TEA, demonstrating that organic matter and clay are the primary drivers of exchange capacity (Nnaji *et al.,* 2002).

3.3.1 Physicochemical Relationship

Clay and CEC correlated positively and consistently with the clay increase downslope. Bulk density (BD) shows significant negative correlation with porosity (Ft) and with clay, meaning as soils become finer, porosity increases and BD decreases (Mbagwu, 1995). Sand has strong negative correlations with clay and porosity, confirming textural redistribution across the slope. There were strong negative correlations between pH and acidity parameters (H^+, Al^{3+}). This shows the tendencies of acidic soil in parts of the slope. MC correlates positively with BD and sand but negatively with clay and porosity, suggesting that coarser-textured areas hold less stable moisture, a pattern noted in tropical sandy soils (Addis *et al.,* 2015). Based on the observed relationships, soil fertility in Olo appears to be strongly influenced by organic matter content and the distribution of clay along the slope. Improving soil organic carbon would therefore enhance key fertility indicators, including TN, CEC, Available P, and Base saturation. The correlation patterns indicate that slope position plays a key role in controlling both the redistribution of soil materials and associated chemical properties. This observation is consistent with findings from similar toposequence studies in Nigeria and other tropical landscapes (Ezeaku and Anikwe, 2006; Onwuka and Mang, 2018).

Table 3: Correlation Results of the Soil Physicochemical Properties of Olo

	pH (H2O)	***OC***	***TN***	***AV. P***	Al^{3+}	H^{+}	K^{+}	Mg^{2+}	Na^{+}	***TEA***	***CEC***	***BS***	***SAND***	***SILT***	***CLAY***	***BD***	***Ft***	***MC***
pH (H2O)	1.00																	
OC	-0.11	1.00																
TN	0.77**	-0.73**	1.00															
AV. P	0.69**	-0.79**	0.99**	1.00														
Al^{3+}	-0.17	1.00**	-0.76**	-0.83**	1.00													
H^{+}	-0.50*	0.92**	-0.94**	-0.97**	0.94**	1.00												
K^{+}	0.26	-0.99**	0.82**	0.88**	-1.00**	-0.97**	1.00											
Mg^{2+}	-0.20	1.00**	-0.78**	-0.84**	1.00**	0.95**	-1.00**	1.00										
Na^{+}	0.53*	-0.90**	0.95**	0.98**	-0.93**	-1.00**	0.96**	-0.94**	1.00									
TEA	-0.21	1.00**	-0.79**	-0.85**	1.00**	0.95**	-1.00**	1.00**	-0.94**	1.00								
CEC	-0.29	0.98**	-0.84**	-0.89**	0.99**	0.98**	-1.00**	0.99**	-0.97**	1.00**	1.00							
BS	-0.15	-0.97**	0.52*	0.61*	-0.95**	-0.79**	0.92**	-0.94**	0.76**	-0.94**	-0.90**	1.00						
SAND	1.00**	-0.11	0.77**	0.69*	-0.17	-0.50*	0.26	-0.20	0.53*	-0.21	-0.29	-0.15	1.00					
SILT	0.34	0.90**	-0.35	-0.44	0.87**	0.65*	-0.82**	0.86**	-0.62*	0.85**	0.80**	-0.98**	0.34	1.00				
CLAY	-0.96**	-0.17	-0.55*	-0.46	-0.11	0.23	0.02	-0.09	-0.27	-0.07	0.02	0.42	-0.96**	-0.59*	1.00			
BD	1.00**	-0.12	0.77**	0.70**	-0.17	-0.50*	0.27	-0.20	0.53*	-0.22	-0.30	-0.14	1.00**	0.33	-0.96**	1.00		
Ft	-1.00**	0.12	-0.77**	-0.70**	0.17	0.50*	-0.27	0.20	-0.53*	0.21	0.30	0.14	-1.00**	-0.33	0.96**	-1.00**	1.00	
MC	0.95**	-0.40	0.92**	0.88**	-0.46	-0.73**	0.54*	-0.48	0.76**	-0.49	-0.57*	0.15	0.95**	0.04	-0.83**	0.96**	-0.96**	1.00

4.0 CONCLUSION

This study demonstrated that topo positions exert a strong and systematic control on the physicochemical properties of soils in Olo, Ezeagu LGA. along the slope, soil particle redistribution driven by erosion and deposition processes resulted in higher sand content at upper slopes and increased clay accumulation downslope. Consequently, bulk density decreased while total porosity increased toward the lower slope, indicating improved structural conditions at the bottom slope. Topo positions also significantly influenced soil fertility parameters. Middle slope positions showed the most favourable soil conditions, likely due to a balance between erosion and deposition along the slope. In contrast, lower slopes, despite higher clay content and porosity, exhibited depletion of total nitrogen and available phosphorus, suggesting possible nutrient losses through leaching or saturation effects. Upper slopes recorded comparatively higher available phosphorus but were more susceptible to erosion-induced nutrient losses. Correlation analysis confirmed the central role of organic matter in regulating nutrient availability, exchange capacity, and soil acidity. Organic matter showed strong positive relationships with soil fertility indicators, highlighting its importance in maintaining soil productivity. In contrast, bulk density exhibited an inverse relationship with total porosity, indicating that increased soil compaction reduces pore space. Similarly, soil acidity indices were negatively correlated with Base Saturation, suggesting that higher acidity is associated with lower levels of exchangeable base cations.

REFERENCES

Abate, N., and Kibret, K. (2012). Effects of land use, soil depth and topography on soil physicochemical properties along the toposequence at the Wadla Delanta Massif, Northcentral Highlands of Ethiopia. Environment and Pollution.

Addis, H. K., Nega, E., and Abera, W. (2015). Effects of topographic position on soil properties in the Ethiopian Highlands. *Journal of Soil Science and Environmental Management*, 6(7), 92–100.

ASABE Standards. (2008). Soil and water terminology (ASAE S526.3). American Society of Agricultural and Biological Engineers.

Bouyoucos, G. J. (1935). The hydrometer method for making mechanical analysis of soils. *Agronomy Journal*, 27(9), 738–743. https://doi.org/10.2134/agronj1935.00021962002700090007x

Brady, N. C., and Weil, R. R. (2017). *The nature and properties of soils* (15th ed.). Pearson Education.

Brady, N. C., and Weil, R. R. (2022). The nature and properties of soils (16th ed.). Pearson Education.

Bray, R. H., and Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. Soil Science, 59(1), 39–45. https://doi.org/10.1097/00010694-194501000-00006

Bremner, J. M., and Mulvaney, C. S. (1982). Nitrogen—Total. In A. L. Page (Ed.), Methods of soil analysis: Part 2. Chemical and microbiological properties (pp. 595–624). ASA and SSSA.

Bufebo, B., Elias, E., and Agegnehu, G. (2021). Effects of landscape positions on soil physicochemical properties at Shenkolla Watershed, South Central Ethiopia. Environmental

Systems Research.

Carter, M. R., and Grossman, R. B. (2002). Bulk density and linear extensibility. In J. H. Dane and G. C. Topp (Eds.), Methods of soil analysis: Part 4. Physical methods (pp. 493–532). Soil Science Society of America.

Chancellor, W. J. (1994). Soil physical properties. In R. Lal and B. A. Stewart (Eds.), Soil processes and water quality (pp. 1–20). CRC Press.

Ezeaku, P. I. (2014). Evaluation of soil degradation in relation to soil productivity in southeastern Nigeria. *Agro-Science*, 13(2), 15–28.

Ezeaku, P. I., and Anikwe, M. A. N. (2006). A model for description of water and solute movement in tropical soils of southeastern Nigeria. *International Agrophysics*, 20(2), 147–155.

Gebreselassie, H., Elias, E., and Haile, M. (2021). Effects of landscape positions on soil physicochemical properties at Shenkolla watershed, South-Central Ethiopia. Environmental Systems Research, 10, 1–15.

Gee, G. W., and Or, D. (2002). Particle-size analysis. In J. H. Dane and G. C. Topp (Eds.), Methods of soil analysis: Part 4. Physical methods (pp. 255–293). Soil Science Society of America. https://doi.org/10.1097/00010694-193401000-00003

Ike, C. R., Orakwe, C. L., Okore, I. K., Nnabuihe, E. C., Ibeh, C. U., Ibigweh, M. N., Egwunatum, A. E. Monday, A.E., Okonkwo, C.L., and Ozoagu, C.S. (2025). Effects of slope segments on physical, hydraulic, and structural stability properties at three soil depths in Amachalla, Awka, Nigeria. FAIC-UNIZIK 2025 Conference Proceedings.

Ishaya, S. D., Nwankwo, F. C., Okoye, C. O., and Nebeokike, U. P. (2024). Spatial analysis of soil erosion risk and erosivity patterns in Ezeagu Local Government Area, Enugu State, Nigeria. *Journal of Environmental Earth Science*, 14(3), 122–139.

Jimoh, A. I., Abdullahi, A. A., and others. (2022). Assessment of the impacts of toposequence on soil properties and quality in Tula, Gombe State, Nigeria. Agricultura Tropica et Subtropica, 55(1), 99–107.

Johannes, A., Weisskopf, P., Schulin, R., and Boivin, P. (2017). Soil organic matter thresholds for maintaining soil structure. *European Journal of Soil Science*, 68(5), 585–595. https://doi.org/10.1111/ejss.12447

Lehmann, P., Leuther, F., and Or, D. (2018). Hydraulic conductivity of structured soils: Influence of pore geometry. *Vadose Zone Journal*, 17(1), 1–11. https://doi.org/10.2136/vzj2017.09.0177

Liu, B., Wen, Y., Lin, L., Wen, X., Gao, R., Zhang, B., Li, T.-Y., and Yao, S. (2024). Variations in soil quality indicators under different cultivation ages and slope positions of arable land in the Mollisol region of China. Catena, 246, 108418.

Mbagwu, J. S. C. (1995). Soil aggregate stability and soil degradation in agricultural areas of southeastern Nigeria. Land Degradation and Development, 6(2), 111–120. https://doi.org/10.1002/ldr.3400060205

McLean, E. O. (1982). Soil pH and lime requirement. In A. L. Page (Ed.), Methods of soil analysis: Part 2. Chemical and microbiological properties (pp. 199–224). ASA and SSSA.

Nebeokike, U. P., Nwankwo, F. C., and Okoye, A. C. O. (2020). Assessment of soil physicochemical properties and erodibility factors in parts of Enugu State, Nigeria. *Nigerian Journal of Soil and Environmental Research*, 18(1), 1–14.

Nelson, D. W., and Sommers, L. E. (1982). Total carbon, organic carbon, and organic matter. In A. L. Page (Ed.), Methods of soil analysis: Part 2. Chemical and microbiological properties (pp. 539–579). ASA and SSSA.

Nnaji, G. U., Ezeaku, P. I., and Mbagwu, J. S. C. (2002). Variability of soils along toposequences in southeastern Nigeria. Agro-Science, 3(2), 20–29.

Nwakwasi, R. N., Onyia, V. N., and Nwite, J. N. (2021). Effects of slope position on soil physical properties in humid tropical soils of Nigeria. *Nigerian Journal of Soil Science*, 31(2), 85–98.

Nwankwo, F. C., Nebeokike, U. P., and Ishaya, S. D. (2022). Soil erodibility and geotechnical characterization of selected soils in Enugu State, Nigeria. *Journal of Geoscience and Environmental Protection*, 10(4), 77–92. https://doi.org/10.4236/gep.2022.104006

Obi, J. C., and Ezeaku, P. I. (2020). Clay mineralogy, cation exchange capacity and nutrient distribution along toposequences in southeastern Nigeria. *Journal of Applied Agricultural Research*, 12(1), 44–58.

Ojedokun, R. O., Fawole, O. A., Asabia, L. O., Oluwaponle, A. I., and Adeola, M. J. (2021). Properties of soils along a toposequence underlain by coarse-grained granite gneiss in Ile-Ife area, South-West Nigeria. *FUDMA Journal of Agriculture and Agricultural Technology*, *7*(2), 75–86.

Okoye, C. O., Nebeokike, U. P., and Nwankwo, F. C. (2024). Topographic and climatic influences on soil properties and erosion susceptibility in the Udi–Ezeagu area of Enugu State. *African Journal of Environmental Research*, 8(1), 55–70.

Oku, E. E., Babalola, O., & Essoka, A. N. (2010). Profile distribution of some physical properties and infiltration behaviour along a Paleustalf toposequence in south-western Nigeria. Tropical Agriculture, 87(1), 1–9.

Onwuka, B. M., and Mang, B. (2018). Effects of soil conservation practices on soil properties and crop productivity in southeastern Nigeria. International Soil and Water Conservation Research, 6(2), 120–127.

Six, J., Feller, C., Denef, K., Ogle, S. M., de Moraes Sá, J. C., and Albrecht, A. (2002). Soil tillage. *Agronomy Journal*, 94(3), 449–456.

Walkley, A., and Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science, 37(1), 29–38.

Wilding, L.P., Bouma, J., and Boss, W.D. (1994). Impact of Spatial Variability on Interpretative Modeling, in: Bryant, R.B., and Arnold, R.W. Quantitative Modeling of Soil Forming Process. SSSA Special Pib. No. 39: 61-75.

Yacob, A., and Nigussie, A. (2022). Characterization and classification of soils along the toposequence of Medo sub-watershed at Wondo Genet District, Ethiopia. International Journal of Natural Resource Ecology and Management, 7(2), 73–85.

Ziadat, F., and Taimeh, A. (2013). Effect of topographical characteristics on some soil properties and nutrient availability. Catena.

Zhou, P., Zhuang, W., Zhao, N., Fang, K., and Zhang, D. (2023). Exploring soil particle size fraction and spatial redistribution of ^137Cs in sloping landscapes with different lynchet heights of terracing hedgerows. Sustainability, 15(4), 3532. https://doi.org/10.3390/su15043532

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