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Original Research

Pedological Characterization and Taxonomic Classification of Schist-Derived Soils in Erinmope-Ekiti, Southwestern Nigeria

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Abstract

Understanding soil variability along landscapes is essential for interpreting pedogenesis, improving soil classification, and supporting sustainable land management. This study characterized and classified schist-derived soils along a toposequence in Erinmope-Ekiti, southwestern Nigeria. Six representative pedons, comprising two at each slope position, were described and sampled by genetic horizons, for laboratory analysis of selected soil properties using standard procedures. The soils were moderately deep to deep (81 to 146 cm) and showed clear horizon differentiation. Surface horizons were predominantly sandy loam to loam, whereas subsurface horizons were dominantly clayey, reflecting pronounced clay translocation and accumulation. Clay films and textural differentiation provided morphological evidence of argillic horizon development, particularly in the middle-slope pedons. The soils were acidic to slightly acidic (5.36 to 6.77), while base saturation ranged from 50.77 to 94.48%. Sand and clay showed relatively low variability, whereas K, OC, OM, and exchangeable hydrogen exhibited greater variability. Lower-slope pedons recorded higher pH, OC, available phosphorus, exchangeable bases, ECEC, and base saturation, indicating the influence of downslope redistribution and accumulation of soil materials. Significant relationships among texture, OC, pH, and exchangeable bases further demonstrated the interdependence of soil properties along the landscape. Under USDA Soil Taxonomy, the soils were classified as Typic Paleustalfs, Typic Haplustalfs, and Aquic Haplustalfs, while under WRB they were classified as Haplic Lixisols and Gleyic Lixisols. The findings demonstrate that topography strongly influences soil development, property distribution, and taxonomic differentiation of schist-derived soils in the study area, providing a useful basis for soil evaluation, management, and agricultural planning.

1. Introduction

Soils constitute a fundamental natural resource that supports agricultural production, regulates hydrological processes, stores carbon, and sustains terrestrial ecosystems (Lal *et al*., 2021). Their ability to perform these functions is largely governed by their morphological, physical, chemical, and biological characteristics, which develop through the interaction of soil-forming factors, including climate, organisms, relief, parent material, and time (Kafle *et al*., 2023). Among these factors, parent material and topography exert particularly strong influences on soil genesis by controlling horizon development, nutrient dynamics, drainage conditions, and variability of soil properties, especially in tropical environments (Zhao and Riaz, 2024). Consequently, detailed pedological characterization remains essential for understanding soil development, evaluating land capability, and supporting sustainable land-use planning. In the humid tropical region of southwestern Nigeria, soils have developed predominantly from Precambrian Basement Complex rocks, including granite, granite gneiss, migmatite, quartzite, and schist. These geological materials differ considerably in their weathering behaviour, nutrient release capacity, and influence on soil formation, resulting in substantial variations in soil characteristics even within relatively small landscapes. Schist-derived soils commonly exhibit moderate to deep profiles, pronounced weathering features, kaolinitic clay dominance, and variable fertility status; however, their morphological development and chemical properties are strongly modified by landscape position, drainage conditions, and pedogenic processes (Guerreiro *et al*., 2026). Along a toposequence, processes such as erosion, sediment deposition, clay translocation, and lateral water movement interact to produce systematic changes in horizon differentiation and soil properties.

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Accurate identification of diagnostic horizons is fundamental to modern soil classification because these features provide essential information for interpreting soil genesis, evaluating land potential, and establishing correlations among different soil classification systems. The USDA Soil Taxonomy and the World Reference Base for Soil Resources (WRB) both utilize diagnostic horizons and measurable soil properties as key criteria for taxonomic classification. Therefore, detailed field description supported by laboratory analyses is necessary to differentiate soils formed under contrasting pedogenic environments and to establish reliable taxonomic relationships. In schist-derived landscapes, the combined influence of weathering intensity, clay illuviation, drainage variability, and topographic redistribution often produces considerable differences in subsurface horizon development, highlighting the importance of integrated morphological and analytical investigations. Several studies have investigated Basement Complex soils in southwestern Nigeria and demonstrated the significant influence of geology and landscape position on soil morphology, fertility status, and classification (Fasina, 2007; Ojetade *et al*., 2022). These studies revealed that variations in parent materials and geomorphic settings contribute to differences in profile development, drainage characteristics, nutrient availability, and taxonomic classification. Despite the agricultural importance of southwestern Nigeria, detailed information regarding the genesis, morphological characteristics, and taxonomic classification of schist-derived soils remains limited, particularly along slope gradients where soil-forming processes vary considerably. Such information is necessary for improving soil correlation, enhancing land evaluation, guiding sustainable soil management practices, and promoting efficient agricultural utilization of these landscapes. Therefore, this study was undertaken to characterize the morphological, physical, and chemical properties of schist-derived soils along a toposequence in Erinmope-Ekiti, southwestern Nigeria; identify their diagnostic horizons; and classify the soils according to the USDA Soil Taxonomy, the WRB, and the local soil series classification system.

2 Materials and Methods

2.1 Study Area

The study was conducted in Erinmope-Ekiti, Moba Local Governmnt Area of Ekiti State, southwestern Nigeria. The study area lies approximately between 7°26′ and 7°29′ N latitude and 5°52′ and 5°55′ E longitude, covering about 20 ha of cultivated land. Elevation ranges from approximately 430 to 485 m above sea level, with gently undulating terrain characterized by distinct upper-, middle-, and lower-slope positions that form a well-defined toposequence. The climate is humid tropical with distinct wet and dry seasons. Rainfall is unimodal, extending from approximately April to October, with a mean annual rainfall of about 1,200–1,500 mm, while the dry season occurs between November and March. Mean annual temperature ranges from 26 to 28°C, with relative humidity generally exceeding 70% during the rainy season. Based on long-term climatic records, the area exhibits an ustic soil moisture regime and an isohyperthermic soil temperature regime according to USDA Soil Taxonomy (Soil Survey Staff, 2022). Natural vegetation belongs to the Derived Savanna,

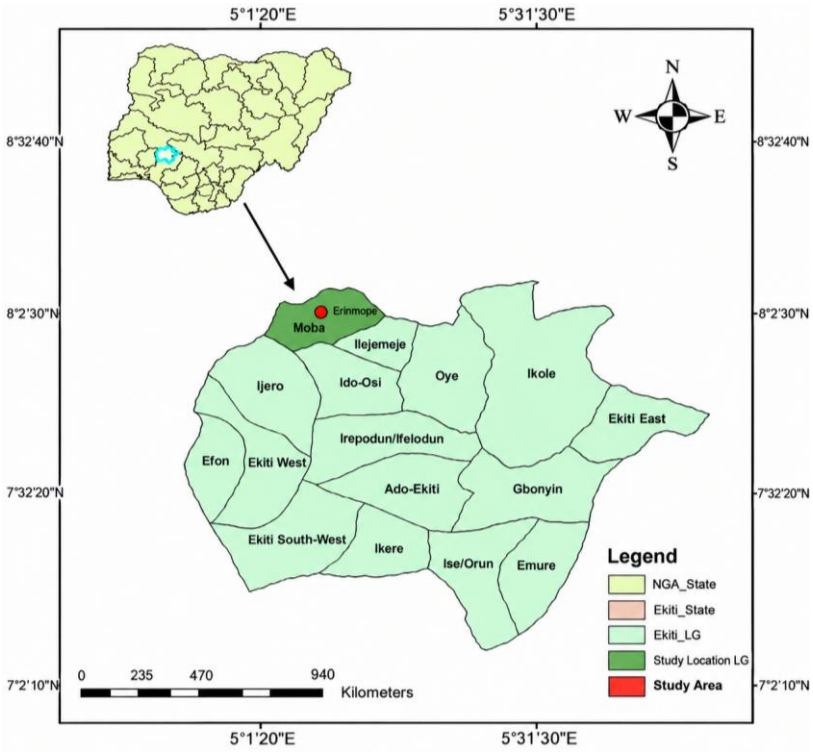


Figure 1. Map of the study area

although much of the original vegetation has been replaced by cultivated farmland supporting crops such as maize (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), yam (*Dioscorea* spp.), and vegetables. Geologically, study area is situated within the Precambrian Basement Complex of southwestern Nigeria, which comprises schist, quartz schist, granite gneiss, migmatite, and associated metamorphic rocks. Geological maps of the area indicate that the investigated sites are located within the schist formation. During field investigations, the parent material of each pedon was further confirmed by the occurrence of weathered schist and abundant schist fragments within the soil profiles, indicating that the soils developed predominantly from residual schist under prolonged tropical weathering.

2.2 Field Survey and Soil Sampling

A reconnaissance survey was first conducted to examine the general landscape characteristics, identify variations in relief, drainage, vegetation, and surface soil properties, and delineate relatively homogeneous soil mapping units. A free survey method was adopted because of the relatively simple landscape and the absence of complex geomorphic discontinuities. A representative toposequence traversing the upper, middle, and lower slope positions was established across the study area. The slope positions were identified based on differences in elevation, slope gradient, runoff characteristics, and drainage conditions. Two representative pedons were excavated within each slope position, giving a total of six pedons. The selection of two pedons per landscape position was intended to capture within-slope variability while ensuring that each pedon remained representative of its geomorphic unit. Each profile pit measured approximately 2.0 m long × 1.5 m wide × 2.0 m deep, or to lithic contact where encountered. Morphological descriptions were carried out in situ following the procedures outlined in the USDA Soil Survey Manual (Soil Survey Staff, 2017) and the Guidelines for Soil Description (FAO, 2006). Profile characteristics recorded included horizon boundaries, colour (moist and dry), texture by feel, structure, consistence, roots, pores, clay films (cutans), mottles, concretions, drainage characteristics, and other pedogenic features. Disturbed soil samples were collected separately from each genetic horizon for laboratory analyses.

2.3 Laboratory Analysis

All laboratory analyses were carried out following standard procedures. Particle-size distribution was determined using the Bouyoucos hydrometer method after dispersion with 5% sodium hexametaphosphate (Calgon) following Gee and Bauder (1986). Organic matter was removed with hydrogen peroxide before dispersion to ensure complete separation of soil particles. Soil pH was measured potentiometrically in distilled water and 0.01 M $CaCl_2$ using a 1:2.5 soil-to-solution ratio after equilibration. Electrical conductivity (EC) was determined in a 1:2 soil-water suspension using a conductivity meter.

Organic carbon was determined using the Walkley and Black wet oxidation method (Walkley and Black, 1934), while soil organic matter was estimated by multiplying organic carbon by the Van Bemmelen factor (1.724). Total nitrogen was determined by the micro-Kjeldahl digestion method (Bremner and Mulvaney, 1982). Available phosphorus was extracted using the Bray-1 extractant and determined colorimetrically (Bray and Kurtz, 1945). Exchangeable calcium (Ca) and magnesium (Mg) were extracted with 1 M ammonium acetate (NH_4OAc) buffered at pH 7.0 and determined using an Atomic Absorption Spectrophotometer, whereas exchangeable potassium (K) and sodium (Na) were determined using a flame photometer.

Exchangeable acidity (Al + H) was extracted with 1 M KCl and determined by titration with standardized sodium hydroxide solution.

Total Exchangeable Bases (TEB) were calculated as:

$$TEB = Ca + Mg + K + Na \quad (1)$$

Effective cation exchange capacity (ECEC) was calculated as:

$$ECEC = TEB + (Al + H) \quad (2)$$

Base saturation (BS) was calculated as:

$$BS = \frac{TEB}{ECEC} \times 100 \quad (3)$$

2.4 Identification of Diagnostic Horizons and Soil Classification

Diagnostic horizons were identified using field morphological characteristics together with laboratory analytical data in accordance with the criteria established in the Soil Survey Staff (2022). The identification of argillic horizons was based on the presence of evidence of clay illuviation, including clay films (cutans) on ped faces and pores, together with the required increase in clay content relative to the overlying horizon as specified in Soil Taxonomy. Soils were classified using the USDA Soil Taxonomy (Soil Survey Staff, 2022) and correlated with the World Reference Base for Soil Resources (FAO/UNESCO, 2015). Local soil series classification was done using Smyth and Montgomery (1962).

2.5 Statistical Analysis

Data obtained from the soil physicochemical properties were summarized using descriptive statistics. Relationships among the measured soil properties were evaluated using Spearman's rank-order correlation coefficient (r_s). Statistical significance was evaluated at $p < 0.05$.

3. Results and Discussion

3.1 Morphological Characteristics

The morphological characteristics of the pedons developed on schist along the upper, middle, and lower slope positions in Erinmope-Ekiti are presented in Table 1. The soils were generally deep, well-developed, and exhibited distinct horizon

differentiation, reflecting prolonged pedogenic processes under humid tropical conditions. Profile depths ranged from 81 to 146 cm, terminating in saprolite or partially weathered schist in some pedons. Similar studies by Fawole (2025) noted that the occurrence of weathered schist fragments and saprolitic materials in the deeper horizons confirms that the soils developed in situ from schist residuum, consistent with the geological characteristics of the study area. The surface horizons were predominantly dark brown to very dark brown (7.5YR 2.5/2–7.5YR 3/3), whereas the subsurface horizons displayed reddish brown, yellowish red, and red colours (5YR 4/4 to 2.5YR 4/8). The darker surface colours are attributable to relatively higher organic matter accumulation resulting from litter decomposition and root activity, while the brighter red hues of the Bt horizons reflect the accumulation of iron oxides formed during prolonged weathering of the schist parent material. The predominance of red colours in the upper- and middle-slope pedons indicates generally well-drained and oxidizing conditions that favour the formation of hematite, whereas the relatively browner colours and abundant mottles in the lower-slope pedons suggest periodic fluctuations in soil moisture (Brady and Weil, 2022). Surface horizons were mainly loam and sandy loam, while the subsurface horizons became progressively finer, consisting predominantly of sandy clay loam, clay loam, sandy clay, and clay. This systematic increase in clay content with depth corresponds with the laboratory results and indicates active clay translocation from the surface to the subsurface horizons. Moreover, the occurrence of clay films (cutans) in the Bt horizons of the middle-slope pedons provides direct morphological evidence of clay illuviation. Together with the marked textural differentiation between the overlying A horizons and the underlying Bt horizons, these observations satisfy the field evidence required for the identification of argillic horizons under USDA Soil Taxonomy (Soil Survey Staff, 2022). The pronounced clay accumulation is indicative of advanced profile development resulting from long-term weathering and eluviation–illuviation processes. Mottles were absent in all surface horizons but occurred in varying abundance within several subsurface horizons, particularly in the lower-slope pedons. These features indicate periodic fluctuations in soil moisture resulting from temporary saturation during the rainy season

Soil texture showed clear differentiation with depth and along the toposequence. Surface horizons were predominantly sandy loam or loam, whereas subsurface horizons became sandy clay loam, clay loam, or clay, reflecting progressive enrichment of fine particles below the surface. The increase in clay content was most pronounced in the middle- and lower-slope pedons, where clay coatings (cutans) were observed on ped faces and within pores. The combined occurrence of textural differentiation and clay films provide strong field evidence for clay illuviation, indicating that lessivage has been an important pedogenic process in these soils. Such clay redistribution is characteristic of mature tropical soils developed under alternating wetting and drying cycles and contributes directly to the formation of argillic horizons. Consistence varied within the profiles. Surface horizons were generally slightly sticky and slightly plastic when wet and loose, friable, or firm when moist, reflecting their coarser texture and relatively higher organic matter content. In contrast, the Bt horizons were predominantly very sticky and very plastic under wet conditions and firm to very firm when moist. The increase in stickiness, plasticity, and firmness with depth reflects the accumulation of illuvial clay and greater particle cohesion within the argillic horizons. Root abundance declined from numerous in the surface horizons to few or absent in the deeper Bt horizons, where increased soil penetration resistance and reduced pore continuity likely restricted root penetration and proliferation.

3.2 Physicochemical Properties

The physicochemical properties of the soils presented in Table 2 shows that sand was the dominant particle-size fraction in all pedons, ranging from 495.2 to 755.2 g kg^{-1}, whereas clay ranged from 104.8 to 384.8 g kg^{-1}. The CVs of sand (3.04%) and clay (4.01%) were low, indicating limited overall variability across the pedons Table 3. Silt showed greater variability, with a CV of 19.03%. Clay generally increased with depth, accompanied by a reduction in sand. This was particularly evident in middle slope 1, where clay increased from 104.8 g kg^{-1} in the surface horizon to 384.8 g kg^{-1} in the Bt horizon, while sand declined from 755.2 to 495.2 g kg^{-1}. A similar pattern occurred in upper slope 2, where clay increased from 124.8 to 324.8 g kg^{-1}. Soil pH ranged from 5.36 to 6.77, indicating moderately acidic to slightly acidic conditions. Its CV of 5.19% indicates low variability. Surface horizons generally had higher pH values than deeper horizons. The highest pH of 6.77 occurred in lower slope 1, whereas the lowest value of 5.36 occurred in the deepest horizon of upper slope 1. The generally acidic reaction is consistent with prolonged weathering and leaching of basic cations under humid tropical conditions (Babalola *et al*., 2024).

Organic carbon ranged from 0.84 to 64.01 g kg^{-1}, while organic matter ranged from 1.45 to 110.35 g kg^{-1}. Both properties had CVs of 39.63%, showing high variability. Organic carbon and organic matter were concentrated in surface horizons and declined markedly with depth. Lower slope 2 recorded the highest surface organic carbon and organic matter values, whereas the lowest values occurred in a deep horizon of lower slope 1. According to Fakorede et al. (2025), surface enrichment reflects greater inputs from litter, roots, and other organic residues, while the decline with depth reflects decreasing organic inputs and decomposition.

Total nitrogen ranged from 0.56 to 3.36 g kg^{-1} and had a CV of 13.19%, indicating comparatively moderate variability. The highest value occurred in the surface horizon of middle slope 1, whereas the lowest was recorded in the Bt horizon of lower slope 2. The association between higher nitrogen and higher organic carbon suggests that soil organic matter contributes substantially to nitrogen storage in these profiles.

Table 1. Morphological characteristics of the study area

Horizon	Depth (cm)	Colour (Moist)	Mottles	Texture	Structure	Consistence (Wet/Moist)	Roots	Other Features
Upper Slope 1								
A1	0–20	7.5YR 3/2 Dark brown	None	Gravelly Sandy Loam	Weak medium crumb	Slightly sticky, slightly plastic / Loose	Many	Many stones
A2	20–33	5YR 3/3 Dark reddish brown	None	Gravelly Sandy Loam	Weak coarse crumb	Slightly sticky, slightly plastic / Loose	Many	Stones
Bt1	33–52	2.5YR 4/6 Red	Few medium distinct mottles	Gravelly Sandy Clay	Strong coarse crumb	Very sticky, very plastic / Firm	Few	Weathered schist fragments
Bt2	52–117	2.5YR 4/4 Reddish brown	Many coarse prominent mottles	Sandy Clay Loam	Moderate medium angular blocky	Slightly sticky, slightly plastic / Firm	Few	Weathered schist fragments
Bt3	117–143	2.5YR 4/8 Red	Medium prominent mottles	Sandy Clay	Strong medium angular blocky	Very sticky, very plastic / Firm	None	Saprolite and partially weathered schist
Upper Slope 2								
A1	0–18	7.5YR 2.5/3 Very dark brown	None	Sandy Loam	Strong fine crumb	Slightly sticky, slightly plastic / Firm	Many	–
Bt1	18–29	5YR 5/3 Reddish brown	None	Gravelly Sandy Loam	Strong coarse crumb	Very sticky, very plastic / Firm	Many	Stones
Bt2	29–65	2.5YR 4/6 Red	Few medium faint mottles	Sandy Clay Loam	Strong coarse angular blocky	Very sticky, very plastic / Firm	Few	Stones
Bt3	65–81	5YR 4/6 Yellowish red	Common fine faint mottles	Sandy Clay Loam	Strong medium angular blocky	Very sticky, very plastic / Firm	Few	Stones
Middle Slope 1								
A1	0–13	7.5YR 2.5/3 Very dark brown	None	Loam	Moderate medium crumb	Slightly sticky, slightly plastic / Firm	Many	–
A2	13–25	7.5YR 3/2 Very dark greyish brown	None	Sandy Clay Loam	Moderate coarse crumb	Slightly sticky, slightly plastic / Firm	Many	–
Bt1	25–44	2.5YR 4/4 Reddish brown	Few coarse faint mottles	Sandy Clay Loam	Strong medium subangular blocky	Very sticky, very plastic / Firm	Few	Clay films (cutans)
Bt2	44–88	5YR 4/6 Yellowish red	Many mottles	Sandy Clay	Strong medium subangular blocky	Slightly sticky, slightly plastic / Firm	Few	Weathered schist fragments
Bt3	88–107	5YR 4/6 Yellowish red	Common medium prominent mottles	Clay	Strong medium subangular blocky	Very sticky, very plastic / Firm	Few	–
Bt4	107–146	2.5YR 4/6 Dark red	Many medium prominent mottles	Sandy Clay	Strong medium angular blocky	Very sticky, very plastic / Firm	Few	–

Table 1. Cont'd.

Horizon	Depth (cm)	Colour (Moist)	Mottles	Texture	Structure	Consistence (Wet/Moist)	Roots	Other Features
Middle Slope 2								
A1	0–22	7.5YR 3/3 Dark brown	None	Loam	Moderate medium crumb	Slightly sticky, slightly plastic / Firm	Many	–
Bt1	22–36	7.5YR 3/4 Dark brown	Few medium faint mottles	Sandy Clay Loam	Strong medium subangular blocky	Very sticky, very plastic / Firm	Many	–
Bt2	36–75	5YR 4/6 Yellowish red	Many medium prominent mottles	Clay	Moderate medium subangular blocky	Very sticky, very plastic / Very firm	Few	Clay films (cutans)
Bt3	75–140	2.5YR 4/6 Red	Many medium prominent mottles	Clay	Strong medium subangular blocky	Very sticky, very plastic / Firm	Few	Clay films (cutans)
Lower Slope 1								
A1	0–6	7.5YR 3/1 Very dark grey	None	Loam	Moderate medium crumb	Slightly sticky, slightly plastic / Very friable	Many	–
A2	6–21	7.5YR 4/2 Brown	None	Sandy Loam	Moderate fine crumb	Slightly sticky, slightly plastic / Firm	Many	Weathered schist fragments
Btg1	21–39	7.5YR 4/4 Brown	Many medium prominent mottles	Clay Loam	Strong medium subangular blocky	Very sticky, very plastic / Very firm	Few	–
Btg2	39–60	10YR 5/8 Dark Yellowish Brown	Many medium prominent mottles	Clay	Strong medium subangular blocky	Very sticky, very plastic / Very firm	Few	–
Btg3	60–110	10YR 5/6 Yellowish Brown	Many medium prominent mottles	Clay	Strong medium subangular blocky	Very sticky, very plastic / Very firm	Few	–
Lower Slope 2								
A1	0–10	7.5YR 2.5/2 Very Dark Brown	None	Loam	Moderate medium subangular blocky	Slightly sticky, slightly plastic / Firm	Many	–
A2	10–36	7.5YR 3/3 Dark Brown	None	Clay Loam	Moderate fine crumb	Slightly sticky, slightly plastic / Firm	Many	Few stones
Btg1	36–52	5YR 4/4 Reddish Brown	Common medium distinct mottles	Silty Clay Loam	Strong medium subangular blocky	Very sticky, very plastic / Firm	Few	–
Btg2	52–92	2.5YR 4/8 Red	Many medium prominent mottles	Clay	Strong medium subangular blocky	Very sticky, very plastic / Very firm	Few	–
Btg3	92–120	2.5YR 4/6 Red	Many medium prominent mottles	Clay	Strong medium subangular blocky	Very sticky, very plastic / Very firm	Few	–

Table 2. Physicochemical properties of the study area

Depth	Sand	Silt	Clay	TC	pH	EC	OC	OM	TN	AvP	K	Na	Ca	Mg	TEB	ExAl	Ex. H	ECEC	BS
cm	g kg^{-1}				(H_2O)	dS m^{-1}	g kg^{-1}			mg kg^{-1}	cmol kg^{-1}								%
Upper Slope 1																			
0–20	695.2	160	144.8	SL	6.1	1.06	22.44	38.69	1.68	11.88	0.26	0.18	1.4	0.5	2.34	0.08	0.16	2.58	90.7
20–33	675.2	160	164.8	SL	5.75	0.97	9.97	17.2	1.4	10.94	0.16	0.17	1.8	0.3	2.43	0.04	0.68	3.15	77.14
33–52	595.2	100	304.8	SCL	5.38	0.7	7.48	12.9	1.12	10.31	0.17	0.12	0.7	0.4	1.39	0.04	1	2.43	57.2
52–117	655.2	120	224.8	SCL	5.5	0.77	2.49	4.3	1.82	9.53	0.19	0.19	0.8	0.4	1.58	0.32	0.88	2.78	56.83
117–143	595.2	160	244.8	SCL	5.36	0.46	5.46	9.41	1.26	8.44	0.12	0.17	0.7	0.3	1.29	0.08	0.16	1.53	84.31
Upper Slope 2																			
0–18	755.2	120	124.8	SL	5.75	1.28	25.62	44.17	1.26	12.03	0.13	0.09	1	0.3	1.52	0.12	0.44	2.08	73.08
18–29	655.2	140	204.8	SCL	5.53	1.06	15.79	27.23	1.12	11.09	0.08	0.1	0.6	0.4	1.18	0.08	0.24	1.5	78.67
29–65	635.2	60	304.8	SCL	5.83	1.29	3.78	6.52	0.98	9.38	0.12	0.21	1	0.3	1.63	0.08	0.24	1.95	83.59
65–81	595.2	80	324.8	SCL	5.76	1.27	3.74	6.45	1.26	9.53	0.09	0.11	1	0.4	1.6	0.08	0.24	1.92	83.33
Middle Slope 1																			
0–13	755.2	140	104.8	SL	6.34	2.39	47.46	81.82	3.36	11.72	0.59	0.21	0.9	0.4	2.1	0.12	0.36	2.58	81.4
13–25	735.2	140	124.8	SL	6.37	1.07	17.64	30.41	1.68	11.09	0.29	0.16	0.8	0.4	1.65	0.36	1.24	3.25	50.77
25–44	655.2	100	244.8	SCL	6.09	1.33	9.66	16.65	0.84	10.63	0.41	0.17	1.7	1	3.28	0.08	0.24	3.6	91.11
44–88	615.2	140	244.8	SCL	5.55	0.87	1.68	2.9	0.98	10.31	0.12	0.18	1.1	0.4	1.8	0.32	0.48	2.6	69.23
88–107	495.2	120	384.8	SC	5.38	0.67	8.31	14.33	1.68	11.25	0.25	0.14	0.7	0.3	1.39	0.16	0.48	2.03	68.47
107–146	635.2	60	304.8	SCL	5.84	0.56	1.68	2.9	1.54	11.56	0.17	0.17	0.8	0.6	1.74	0.08	1.12	2.94	59.18
Middle Slope 2																			
0–22	755.2	120	124.8	SL	6.02	1.44	20.78	35.83	1.26	17.19	0.19	0.19	1.5	0.8	2.68	0.08	0.96	3.72	72.04
22–36	675.2	160	164.8	SL	5.78	0.74	10.39	17.91	1.54	10.47	0.13	0.21	0.9	0.4	1.64	0.2	0.84	2.68	61.19
36–75	655.2	60	284.8	SCL	5.64	0.93	4.2	7.24	1.4	9.53	0.11	0.15	0.7	0.4	1.36	0.16	0.32	1.84	73.91
75–140	595.2	100	304.8	SCL	5.58	0.69	9.14	15.76	1.26	9.69	0.37	0.13	0.7	0.5	1.7	0.16	0.32	2.18	77.98
Lower Slope 1																			
0–6	715.2	160	124.8	SL	6.77	2.26	22.26	38.38	1.68	26.72	0.42	0.25	1.8	1.1	3.57	0.08	0.16	3.81	93.7
6–21	695.2	160	144.8	SL	6.07	2.61	10.92	18.83	0.98	11.56	0.24	0.14	0.8	0.6	1.78	0.12	0.2	2.1	84.76
21–39	535.2	160	304.8	SCL	6.12	0.75	3.36	5.79	1.54	9.84	0.16	0.19	0.8	0.7	1.85	0.08	0.4	2.33	79.4
39–60	635.2	160	204.8	SCL	6.43	0.59	5.46	9.41	1.54	10.63	0.13	0.17	0.7	0.6	1.6	0.04	0.28	1.92	83.33
60–110	495.2	180	324.8	SCL	6.12	2.6	0.84	1.45	2.52	8.28	0.24	0.36	1.3	0.8	2.7	0.08	0.16	2.94	91.84
Lower Slope 2																			
0–10	675.2	160	164.8	SL	6.6	3.66	64.01	110.35	2.38	44.84	0.59	0.37	1.8	0.7	3.46	0.16	0.96	4.58	75.55
10–36	715.2	100	184.8	SL	6.44	1.01	34.86	60.1	1.54	15.31	0.25	0.21	1.6	0.6	2.66	0.04	0.28	2.98	89.26
36–52	595.2	140	264.8	SCL	6.61	1.23	6.72	11.59	0.56	13.91	0.43	0.24	1.2	0.7	2.57	0.08	0.16	2.81	91.46
52–92	635.2	60	304.8	SCL	6.22	2.22	4.62	7.96	0.7	10.94	0.59	0.24	0.9	0.6	2.33	0.16	0.4	2.89	80.62
92–120	695.2	40	264.8	SCL	6.38	2.32	3.78	6.52	1.54	11.88	0.54	0.3	1.4	0.5	2.74	0.04	0.12	2.9	94.48

Note: TC = textural class; SL = Sandy loam; SCL = Sandy clay loam; SC = Sandy clay; EC = Electrical conductivity; OC = Organic carbon; OM = Organic matter; TN = Total nitrogen; AvP = Available phosphorus; TEB = Total Exchangeable Bases; ExAl = Exchangeable aluminium; ExH = Exchangeable hydrogen; ECEC = Effective Cation Exchange Capacity; BS = Base saturation

Table 3. Pedon-level physicochemical properties of the study area

Pedon	Sand	Silt	Clay	pH	EC	OC	OM	TN	AvP	K	Na	Ca	Mg	TEB	ExAl	ExH	ECEC	BS
		g kg^{-1}			dS m^{-1}	mg kg^{-1}			mg kg^{-1}	cmol kg^{-1}								%
Upper slope 1	643.2	140	216.8	5.62	0.79	9.57	16.5	1.46	10.22	0.18	0.17	1.08	0.38	1.81	0.11	0.58	2.49	73.24
Upper slope 2	660.2	100	239.8	5.72	1.23	12.23	21.09	1.16	10.51	0.11	0.13	0.9	0.35	1.48	0.09	0.29	1.86	79.67
Middle slope 1	648.53	116.67	234.8	5.93	1.15	14.41	24.84	1.68	11.09	0.3	0.17	1	0.52	1.99	0.19	0.65	2.83	70.03
Middle slope 2	670.2	110	219.8	5.76	0.95	11.13	19.18	1.36	11.72	0.2	0.17	0.95	0.53	1.85	0.15	0.61	2.6	71.28
Lower slope 1	615.2	164	220.8	6.3	1.76	8.57	14.77	1.65	13.41	0.24	0.22	1.08	0.76	2.3	0.08	0.24	2.62	86.61
Lower slope 2	663.2	100	236.8	6.45	2.09	22.8	39.3	1.34	19.38	0.48	0.27	1.38	0.62	2.75	0.1	0.38	3.23	86.27
Mean	650.39	121.78	228.47	5.96	1.33	13.12	22.61	1.44	12.72	0.25	0.19	1.06	0.53	2.03	0.12	0.46	2.61	77.85
SD	19.74	23.17	9.16	0.31	0.48	5.2	8.96	0.19	3.24	0.13	0.05	0.17	0.14	0.46	0.04	0.18	0.48	7.06
CV (%)	3.04	19.03	4.01	5.19	36.09	39.63	39.63	13.19	25.47	52	26.32	16.04	26.42	22.66	33.33	39.13	18.39	9.07

Note: SD = Standard deviation; CV = Coefficient of variation. SL = Sandy loam; SCL = Sandy clay loam; SC = Sandy clay; EC = Electrical conductivity; OC = Organic carbon; OM = Organic matter; TN = Total nitrogen; AvP = Available phosphorus; TEB = Total Exchangeable Bases; ExAl = Exchangeable aluminium; ExH = Exchangeable hydrogen; ECEC = Effective Cation Exchange Capacity; BS = Base saturation.

Available phosphorus ranged from 8.28 to 44.84 mg kg^{-1} and had a CV of 25.47%, indicating moderate variability. Surface horizons generally contained more available phosphorus than corresponding subsurface horizons (Ajayi *et al*., 2025). The highest value occurred in lower slope 2, while lower concentrations were common in deeper horizons. Greater phosphorus concentrations at lower slope positions may be associated with downslope movement and accumulation of fine materials and organic residues, whereas retention by Fe and Al minerals may contribute to lower phosphorus availability in some subsurface horizons (Liu *et al*., 2024). Exchangeable calcium, magnesium, potassium, and sodium ranged from 0.60–1.80, 0.30–1.10, 0.08–0.59, and 0.09–0.37 cmol kg^{-1}, respectively. Their CVs were 16.04, 26.42, 52.00, and 26.32%, showing that potassium was the most variable basic cation. Calcium was the dominant exchangeable base, followed by magnesium, potassium, and sodium. Total exchangeable bases ranged from 1.18 to 3.57 cmol kg^{-1}, with a CV of 22.66%. Relatively higher base contents in some lower slope horizons suggest redistribution and accumulation of weathering products and basic cations downslope (Gama *et al*., 2026). Zacharias *et al*. (2026) indicated that the high variability of potassium may reflect differences in mineral weathering, leaching, plant uptake, and localized nutrient redistribution across the slope positions. Exchangeable aluminium ranged from 0.04 to 0.36 cmol kg^{-1} and exchangeable hydrogen from 0.12 to 1.24 cmol kg^{-1}, with CVs of 33.33 and 39.13%, respectively. Effective cation exchange capacity ranged from 1.50 to 4.58 cmol kg^{-1} and had a CV of 18.39%, indicating moderate variability. Sharma *et al*. (2025) noted that the generally low ECEC suggests limited nutrient-retention capacity, which may be related to the sandy nature of the soils and strongly weathered, low-activity clay materials. Base saturation (BS) ranged from 50.77 to 94.48% and had the lowest CV of 9.07%, indicating relatively low variability compared with most other soil properties. Most horizons recorded base saturation above 50%, showing that a considerable proportion of exchange sites was occupied by basic cations.

3.3 Soil Classification

The classification pattern showed clear differentiation among the six pedons, as presented in Table 4. Under USDA Soil Taxonomy, upper slope 1 and middle slope 2 were classified as Typic Paleustalfs, upper slope 2 and middle slope 1 as Typic Haplustalfs, while lower slope 1 and lower slope 2 were classified as Aquic Haplustalfs. Under WRB, the upper and middle slope soils were classified as Haplic Lixisols, whereas both lower slope soils were classified as Gleyic Lixisols. The pedons were correlated with the Iwo, Okemesi and Oba series, with the Iwo Series occurring at upper slope 1 and middle slope 2, the Okemesi Series at upper slope 2 and middle slope 1, and the Oba Series at both lower slope positions. The occurrence of Paleustalfs at upper slope 1 and middle slope 2 reflects the relatively advanced development of these profiles. Both pedons possess well-developed argillic horizons with substantial clay accumulation and persistent reddish subsurface colours (Soil Survey Staff, 2022). Their clay distribution and morphological development distinguish them from the Haplustalf pedons and indicate prolonged pedogenic development under the prevailing moisture regime. The Typic subgroup designation reflects the absence of the distinctive characteristics.

Upper slope 2 and middle slope 1 were classified as Typic Haplustalfs. Both pedons possess clearly expressed argillic horizons and relatively high base status, confirming their placement within the Ustalfs. However, their clay distribution does not show the same persistence required for Paleustalf placement. The absence of prominent gley features further supports their classification as Typic Haplustalfs. The classification of the upper and middle slopes as Haplic Lixisols under WRB is consistent with the dominance of argic horizon development without a stronger diagnostic feature controlling the reference soil group (FAO/UNESCO, 2015). The lower slope soils exhibited a distinct hydromorphic expression. Lower slope 1 and sower slope 2 were classified as Aquic Haplustalfs because of the occurrence of Btg horizons and

Table 4. Soil classification of the study area

Pedon	USDA	WRB	Series	Supporting evidence
Upper Slope 1	Typic Paleustalf	Haplic Lixisol	Iwo	Bt horizon (33–143 cm), maximum clay 30.48%, only 19.69% decline at depth, strong 2.5YR colours and high base saturation.
Upper Slope 2	Typic Haplustalf	Haplic Lixisol	Okemesi	Bt horizon (18–81 cm), clay increases to 32.48%, high base saturation and no prominent aquic morphology.
Middle Slope 1	Typic Haplustalf	Haplic Lixisol	Okemesi	Bt horizon (25–146 cm), maximum clay 38.48% with >20% decline at depth; high base saturation and no Btg horizon.
Middle Slope 2	Typic Paleustalf	Haplic Lixisol	Iwo	Deep Bt horizon (22–140 cm), clay remains at 30.48% in the lower profile, strong 2.5YR colours and high base saturation.
Lower Slope 1	Aquic Haplustalf	Gleyic Lixisol	Oba	Btg begins at 21 cm and continues to 110 cm, with many prominent mottles and high base saturation.
Lower Slope 2	Aquic Haplustalf	Gleyic Lixisol	Oba	Btg begins at 36 cm and extends to 120 cm, with common to many prominent mottles and high base saturation.

prominent mottling within the subsurface. These features indicate periodic water saturation and restricted internal drainage, which become more pronounced toward the lower landscape position. Their corresponding classification as Gleyic Lixisols under WRB reflects the same influence of periodic wetness on soil morphology.

The distribution of the local series follows the same pattern (Smyth and Montgomery, 1962). The Iwo Series was associated with the Paleustalfs, the Okemesi Series with the Typic Haplustalfs, and the Oba Series with the Aquic Haplustalfs. The classification pattern demonstrates progressive differentiation of the soil's downslope, from strongly developed, well-drained soils through moderately differentiated Haplustalfs to hydromorphic soils at the lower slope.

3.4 Relationship Among Soil Physicochemical Properties

The correlation analysis revealed several significant relationships among the physical and chemical properties of the soils (Table 5), indicating strong interdependence between particle-size distribution, organic matter and exchange properties. Sand showed a strong negative correlation with clay (r_s = −0.885, $p < 0.05$), while silt was also negatively correlated with clay (r_s = −0.408, $p < 0.05$). This inverse relationship reflects the complementary distribution of particle-size fractions and the textural differentiation of the horizons. Similar interactions between soil texture and organic carbon have been reported, with clay content influencing the retention and stabilization of organic carbon through organo-mineral associations (Carvalho *et al*., 2023). Sand exhibited significant positive relationships with OC and OM (r_s = 0.714, $p < 0.05$), AvP (r_s = 0.646, $p < 0.05$), Ca (r_s = 0.411, $p < 0.05$) and ExH (r_s = 0.389, $p < 0.05$). Conversely, clay was strongly and negatively correlated with OC and OM (r_s = −0.766, $p < 0.05$) and AvP (r_s = −0.592, $p < 0.05$). The negative clay–organic carbon relationship may reflect the distribution of organic matter across horizons and the contrasting properties of coarse- and fine-textured materials. Recent studies similarly show that the relationship between organic carbon and clay varies with soil type, mineralogy and depth rather than being universally consistent (Jing *et al*., 2026).

Soil pH showed significant positive correlations with K (r_s = 0.625), Na (r_s = 0.657), TEB (r_s = 0.684) and ECEC (r_s = 0.559), while it was negatively correlated with ExAl (r_s = −0.743, $p < 0.05$). This pattern indicates that increasing soil acidity was associated with greater exchangeable acidity and reduced contribution of exchangeable bases. The strong positive relationship between TEB and ECEC (r_s = 0.829, $p < 0.05$) further demonstrates the importance of exchangeable base cations in determining the effective exchange capacity of these soils. Among the exchangeable cations, Ca showed strong relationships with Mg (r_s = 0.731), ECEC (r_s = 0.743) and TEB, while K was significantly correlated with ECEC (r_s = 0.640). ExH exhibited a very strong negative relationship with BS (r_s = −0.922, $p < 0.05$), confirming the close relationship between exchangeable acidity and base saturation (Regasa *et al*., 2025).

Table 5. Spearman rank correlation matrix among soil physicochemical properties across all horizons

	Silt	Clay	pH	EC	OC	OM	TN	AvP	K	Na	Ca	Mg	TEB	ExAl	ExH	ECEC	BS
Sand	0.024	−.885*	0.362	.459*	.714*	.714*	0.22	.646*	0.259	0.116	.411*	0.049	0.301	0.049	0.113	.389*	−.003
Silt		−.408*	0.179	0.05	0.257	0.257	0.359	0.065	−.004	0.182	0.126	0.169	0.171	0.017	−.124	0.091	0.146
Clay			−.315	−.324	−.766*	−.766*	−.230	−.592*	−.190	−.081	−.328	−.051	−.238	−.100	−.106	−.317	0.025
pH				0.555	0.29	0.29	0.253	0.562	.625*	.657*	0.55	.684*	.743*	−.214	−.258	0.559	0.524
EC					0.323	0.323	0.034	.400*	0.484	.451*	.602*	.397*	.616*	0.019	−.302	.419*	.467*
OC						1	0.179	.700*	0.363	−.033	0.28	0.048	0.218	0.022	0.078	0.246	0.035
OM							0.179	.700*	0.363	−.033	0.28	0.048	0.218	0.022	0.078	0.246	0.035
TN								0.153	0.266	0.318	0.105	0.055	0.168	0.119	0.158	0.267	−.101
AvP									0.549	0.24	0.474	0.359	0.509	−.121	0.052	0.502	0.129
K										0.533	.409*	0.509	.689*	0.087	−.067	.640*	0.29
Na											.594*	0.492	.717*	−.057	−.201	.590*	.408*
Ca												.413*	.852*	−.235	−.162	.743*	.421*
Mg													.731*	−.201	−.210	0.573	.437*
TEB														−.217	−.204	.829*	0.509
ExAl															.398*	−.021	−.520
ExH																0.25	−.922*
ECEC																	0.046

*$p < 0.05$

4. Conclusion

This study established that the schist-derived soils of Erinmope-Ekiti have developed under strong landscape control, with topography influencing profile development, drainage conditions, soil properties, and taxonomic classification along the toposequence. The six pedons were moderately deep to deep and exhibited distinct horizon differentiation, with clay translocation and accumulation contributing to subsurface development. The presence of clay films and pronounced textural differentiation, particularly in the middle-slope pedons, provided evidence of clay illuviation and argillic horizon development, while mottling and Btg horizons at the lower slope indicated periodic saturation and restricted drainage. The soils were acidic to slightly acidic and generally had low ECEC, although base saturation remained above 50% throughout the profiles. Organic carbon, organic matter, available phosphorus, exchangeable bases, and other soil properties varied considerably with depth and landscape position. Greater accumulation of several soil constituents at the lower slope reflected downslope redistribution, while variability analysis showed that K, OC, OM, exchangeable hydrogen, and EC were more variable than sand, clay, pH, and base saturation. Significant relationships among texture, OC, pH, exchangeable bases, and exchangeable acidity further demonstrated the interdependence of soil properties. Under USDA Soil Taxonomy, the soils were classified as Typic Paleustalfs, Typic Haplustalfs, and Aquic Haplustalfs, while WRB classified them as Haplic Lixisols and Gleyic Lixisols, corresponding to the Iwo, Okemesi, and Oba series. These findings provide a sound pedological basis for land evaluation, soil management, and sustainable agricultural use of schist-derived landscapes in southwestern Nigeria.

References

Ajayi, S. O., Fasina, A. S., Babalola, T. S., Fakorede, B. M., & Amoloja, O. (2025). Spatial Distributions of Soil Chemical Properties in Wetland Soil Horizons of Ekiti State, Southwest Nigeria. *Open Journal of Agricultural Science (ISSN: 2734-214X)*, *6*(1), 1-17. DOI: 10.52417/ojas.v6i1.724.

Babalola, T. S., Ajayi, S. O., Fakorede, B. M., Amoloja, O., Fasina, A. S., Ogunwole, J. O., Ojo C. A., Obiekwe, C. D., & Ogunwale, K. J. (2024). Sustainable Management of Fadama Soils in Derived Savanna: Characterization, Classification, Land Evaluation, And Suitability for Hot Pepper Cultivation. *Studia Universitatis "Vasile Goldis", Seria Stiintele Vietii*. 34;4, PP. 148–159.

Brady, N. C., & Weil, R. R. (2022). *The Nature and Properties of Soils* (16th ed.). Pearson Education.

Bray, R. H., & Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil Science, 59*(1), 39–45.

Bremner, J. M., & Mulvaney, C. S. (1982). Nitrogen—Total. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), *Methods of soil analysis. Part 2. Chemical and microbiological properties* (2nd ed., Agronomy Monograph No. 9, pp. 595–624). American Society of Agronomy.

Carvalho, M. L., Maciel, V. F., Bordonal, R. D. O., Carvalho, J. L. N., Ferreira, T. O., Cerri, C. E. P., & Cherubin, M. R. (2023). Stabilization of organic matter in soils: drivers, mechanisms, and analytical tools–a literature review. *Revista Brasileira de Ciência do Solo*, *47*, e0230130.

Fakorede, B. M., Babalola, T. S., Ajayi, S. O., & Fasina A. S. (2025). Influence of iron and manganese forms on pedogenesis in residual soils of the Savanna ecosystem. *Research on Crops*, *26*(1): 68-75.

FAO. (2006). *Guidelines for soil description* (4th ed.). Food and Agriculture Organization of the United Nations.

FAO/UNESCO. (2015). World Reference Base for Soil Resources 2014. International Soil Classification System for Naming Soils and Creating Legends for Soil Maps. FAO, Rome, 203 pp.

Fasina, A. S., Omolayo, F. O., Ajayi, O. S., & Falodun, A. A. (2007). Influence of land use on soil properties of three mapping units in Southwestern Nigeria: Implications for sustainable soil management. *Research Journal of Applied Sciences, 2*(8), 879–883.

Gama, M. G., Selfeko, D. T., & Aemero, F. L. (2026). Characterization and classification of acidic soils in the Akuma Watershed, Tocha District, Dawuro Zone, southwestern Ethiopia. *Geoderma Regional*, e01122.

Gee, G. W., & Bauder, J. W. (1986). Particle-size analysis. In A. Klute (Ed.), *Methods of soil analysis. Part 1. Physical and mineralogical methods* (2nd ed., Agronomy Monograph No. 9, pp. 383–411). American Society of Agronomy.

Guerreiro, S., Arsénio, P., Florentino, V., & Madeira, M. (2026). Operational harmonisation of soil maps in Portugal using legacy data and WRB classification. *Geoderma Regional*, e01070.

IITA (1979). Selected methods for soil and plant analysis. International Institute of Tropical Agriculture (IITA) Manual Series No. 1, Ibadan, pp. 62.

Jing, H., Karunaratne, S., Pan, B., Liang, X., Gupta, D., & Pang, A. (2026). Unravelling depth-dependent pedoclimatic controls on measurable soil organic carbon fractions across climatic gradients in Australian agricultural soils. *Scientific Reports*, *16*(1), 8474.

Kafle, G. (2023). Abiotic and biotic factors affecting formation of soil in the Earth. *Journal of Agriculture and Natural Resources*, *6*(1), 20-31.

Lal, R., Monger, C., Nave, L., & Smith, P. (2021). The role of soil in regulation of climate. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *376*(1834), 20210084.

Liu, J., Sævarsson, H. T., Bechmann, M., Krogstad, T., & Øgaard, A. F. (2024). Chemical processes and prediction of dissolved phosphorus leaching in mineral and organic soils. *Geoderma*, *445*, 116890.

Ojetade, J. O., Adegbenro, R. O., Adesemuyi, E. A., Muda, S. A., & Amusan, A. A. (2022). Assessment of sesquioxides status of some uplands soils in humid southwest Nigeria. *Annals of Tropical Research*, *44*(1), 1-16.

Regasa, A., Haile, W., & Abera, G. (2025). Effects of lime and vermicompost application on soil physicochemical properties and phosphorus availability in acidic soils. *Scientific Reports*, *15*(1), 25544.

Sharma, U. C., Datta, M., & Sharma, V. (2025). Managing soil acidity. In *Soil acidity: management options for higher crop productivity* (pp. 427-522). Cham: Springer Nature Switzerland.

Smyth, A. J., & Montgomery, R. F. (1962). *Soils and land use in Central Western Nigeria*. Government Printer.

Soil Survey Staff. (2017). *Soil survey manual*. U.S. Department of Agriculture, Natural Resources Conservation Service. USDA Handbook No. 18.

Soil Survey Staff. (2022). *Keys to soil taxonomy* (13th ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.

Srivastava, P., & Pal, D. K. (2023). New Criteria to Identify Argillans as Evidence of Clay Illuviation. In *Micromorphology of Soils and Paleosols of India* (pp. 7-20). Singapore: Springer Nature Singapore.

Walkley, A., & 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.

Zacharias, Q. C., Rioux, R., Sun, F., Tatge, W., Pihlap, E., Nyavor, E., & Saiers, J. (2026). Spatiotemporal soil fertility responses to enhanced rock weathering along a hillslope catena within a temperate, agricultural watershed. *Nutrient Cycling in Agroecosystems*, *132*(2), 25.

Zhao, S., & Riaz, M. (2024). Plant–soil interactions and nutrient cycling dynamics in tropical rainforests. In *Environment, climate, plant and vegetation growth* (pp. 229-264). Cham: Springer Nature Switzerland.

Zhong, Z., Chen, Z., Xu, Y., Ren, C., Yang, G., Han, X., & Feng, Y. (2018). Relationship between soil organic carbon stocks and clay content under different climatic conditions in Central China. *Forests*, *9*(10), 598.