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Pedon-Scale Characterization and Classification of Soils at the Teaching and Research Farm, Nnamdi Azikiwe University, Awka, Nigeria

Steve-Obi Chika Evan[1]*, Ikoku kalu Okore[2], Emmanuel Chinweike Nnabuihe[3]

[1,2,3]Department of Soil Science and Land Resources Management, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

ABSTRACT: The Teaching and Research Farm of the Faculty of Agriculture, Nnamdi Azikiwe University, Awka, is a source of crop trials, teaching and soil science research, but the horizon-level information of its soils is lacking. This study characterized and provisionally classified three pedons (P1, P2 and P3) selected across the farm's soil–landscape units. The profiles were described according to the Food and Agriculture Organization (FAO) guidelines and samples from each horizon were analysed for physical and chemical properties. The profile depths varied from 83 to 150 cm with the A–AB–Bt field-horizon sequences. The particle-size results indicated predominantly sandy-loam textures with the reported sand contents of 572–712 g kg^{-1} and clay contents of 108–208 g kg^{-1}. However, the reported particle-size fractions for P1 Bt2 sum to 1,060 g kg^{-1} and need to be verified. The bulk density varied from 1.19 to 1.76 Mg m^{-3}, and pH in water from 5.44 to 6.10. Available phosphorus ranged from 0.96 to 4.27 mg kg^{-1}; the reported organic carbon and total nitrogen values and units need to be confirmed against the laboratory records. Effective cation exchange capacity ranged from 3.08 to 5.33 cmol(+) kg^{-1}, while ECEC-based base saturation was 65–84%, aluminum saturation 9.2–28.3%, and exchangeable sodium percentage below 4%. The low-chroma matrices and red mottles in the lower horizons of P1 and P3 suggest periodic redox conditions. Provisionally, P1 and P3 were considered possible Hapludults (Ultisols) and Acrisols in the World Reference Base (WRB), while P2 was considered an Inceptisol and Cambisol candidate. These placements are not definitive since the diagnostic-horizon criteria and classification-specific chemical data were not fully confirmed. The findings provide pedon-scale baseline information and identify priorities for verifying the soil data and assessing the nutrient, subsoil-strength and drainage constraints.

KEYWORDS: Soil characterization; soil classification; Hapludults; Acrisols; Cambisol; redoximorphic features; Awka.

INTRODUCTION

Soils in humid tropical areas are commonly subject to intense weathering and leaching, which can give rise to acidity, low organic matter and limited reserves of exchangeable nutrients. The acidity and its effects are governed by the leaching of base cations, exchangeable aluminum, organic acids and other soil-forming and management processes [1-3]. Soils in southeastern Nigeria formed on Coastal Plain Sands and related sedimentary materials are used for arable production, and continuous cultivation, vegetation removal and erosion can exacerbate their inherent fertility constraints [2,5,6,9,10]. Characterization of such soils at the pedon scale can assist in their management and land-use planning. Field morphology, such as colour, structure, consistence, roots and redoximorphic features, provides evidence about the developmental status of the horizons and drainage. Particle-size distribution and bulk density influence the movement of water and root growth, while chemical measurements describe the soil reaction and exchangeable nutrient pool [1,2]. The USDA Soil Taxonomy and the World Reference Base for Soil Resources (WRB) provide standardized systems for classifying soils, but their diagnostic criteria must be applied according to the measurements and depth intervals specified by each system [7,8]. Profile descriptions and laboratory analyses have been used to characterize soils on Coastal Plain Sands in Owerri and other tropical environments [9-11]. The Teaching and Research Farm of the Faculty of Agriculture, Nnamdi Azikiwe University, Awka, is used for crop trials, soil science practicals and postgraduate research. Horizon-by-horizon morphological, physical and chemical information can provide a useful baseline for experiments conducted there. This study consequently characterized three pedons from the farm and assessed their potential agricultural limitations. The results reported here apply to the three pedons examined; they should not be interpreted as a complete soil map or as a classification of the entire farm.

MATERIALS AND METHODS

Study Area: The study was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria, at approximately 6°14′N, 7°07′E. The area is underlain by sedimentary rocks associated with the Ameki Formation and Nanka Sands, including friable sandstones, shales, mudstones and clayey sands [12,13]. Relief is undulating to rolling. The climate is tropical wet and dry (Koppen Aw), with bimodal rainfall peaking in July and September. Mean annual rainfall is reported to range from 1,500 to 2,000 mm, and mean annual temperature from 25 to 30 °C [14]. The natural vegetation is derived savanna, much of which has been replaced by secondary regrowth and cultivated crops, including maize, cassava, yam and vegetables. Bush burning is occasionally used during land preparation [15].

Soil Sampling and Field Description: A reconnaissance was used to identify the farms main soil-landscape units and to select three representative pedons (P1, P2 and P3). Their coordinates and elevations were recorded using a hand-held GPS receiver: P1: 6°14′21″N, 7°07′09″E; 40 m above sea level, P2: 6°14′51″N, 7°07′12″E; 44 m above sea level, and P3: 6°14′47″N, 7°07′13″E; 40 m above sea level. Profile pits were prepared and described in 2025 following FAO guidelines and the field procedures described by Schoeneberger et al. [16,17]. Moist matrix colours were recorded using Munsell notation. Structure, consistence, roots, mottles, drainage and horizon boundaries were also recorded. Horizon labels in this paper reproduce the field designations; a "Bt" label alone is not taken as proof of a diagnostic argillic horizon. Samples were collected separately from each genetic horizon, starting at the base of the pit and working upward to reduce cross-contamination. Undisturbed core samples (5 cm high × 5 cm in diameter) were taken near the centre of each horizon for bulk density and gravimetric moisture content. Disturbed samples were air-dried for two weeks, crushed and passed through a 2-mm sieve.

Laboratory Analyses: Particle-size distribution was determined by the Bouyoucos hydrometer method using 50 g of soil dispersed in sodium hexametaphosphate. Textural classes were assigned using the USDA textural triangle [18]. Bulk density was determined by the core method after oven-drying at 105 °C [19]. Gravimetric moisture content was determined by oven-drying fresh samples at 105 °C to constant weight. Total porosity was calculated from bulk density, assuming a particle density of 2.65 Mg m -3. Soil pH was measured in water at a 1:2.5 soil-to-liquid ratio [20]. Organic carbon was determined by the Walkley-Black wet oxidation method [21], total nitrogen by micro-Kjeldahl digestion [22], and available phosphorus by Bray-1 extraction followed by colorimetric determination [23]. Exchangeable Ca, Mg, K and Na were extracted with 1 M neutral ammonium acetate. Calcium and magnesium were determined by atomic absorption spectrophotometry, while potassium and sodium were measured by flame photometry [24]. Exchangeable acidity (H + + Al 3+) was extracted with 1 M KCl and titrated with NaOH. Exchangeable Al was determined separately using the reported NaF and HCl titration procedure. Total exchangeable bases (TEB) were calculated as the sum of Ca, Mg, K and Na; total exchangeable acidity (TEA) was calculated as the sum of H + and Al 3+. ECEC was calculated as TEB + TEA. Base saturation, aluminum saturation and ESP were calculated as the respective proportions of TEB, exchangeable Al and exchangeable Na relative to ECEC. These are the calculation bases used in the reported tables; they are not substituted for the system specific determinations required for formal taxonomic criteria.

Soil Classification: The pedons were assessed against USDA Soil Taxonomy and WRB criteria [7,8]. Data Analysis: Data were summarized descriptively using means and ranges. Coefficients of variation (CVs) were calculated as the sample standard deviation divided by the mean and multiplied by 100. Analyses were performed using R software [25].

Data Analysis:

Data were subjected to descriptive statistics, including mean and coefficient of variation, using the R statistical software.

RESULTS AND DISCUSSION

Morphological Properties

Horizons ranged in depth from 83 cm in P2 to 150 cm in P3 (Table 1). All three had A - AB - Bt field-horizon sequences. The A horizons were 17 - 31 cm thick, with weak, very fine crumb structure, friable consistence, abundant fine and medium roots, and wavy, distinct boundaries. The matrix colours were 5YR 6/3 in P1, 7.5YR 7/6 in P2 and 10YR 5/3 in P3. The AB horizons had weak, very fine angular blocky structure, friable consistence and few very fine roots. Bt1 horizons had weak, very fine subangular blocky structure and friable consistence. Matrix colours for these were 7.5YR 6/3 in P1, 10YR 4/6 in P2 and 10YR 7/3 in P3. In P1 and P3, the lower Bt2 horizons were described as moderately structured, fine subangular blocky and firm, with matrix colours of 5YR 7/1 and 10YR 7/1, respectively and red mottles recorded. Such features were not found above 67 cm in P1 or 110 cm in P3. P2 had no recorded mottles or low-chroma grey matrix to the bottom of the pit at 83 cm. Roots were mainly recorded in the A, AB and Bt1 horizons, and were absent from the Bt2 horizons of P1 and P3. The transition from crumb structure near the surface to blocky structure below is indicative of profile development, but does not confirm clay illuviation. Clay-enriched horizons could also reflect changes in parent material, particularly in sedimentary settings where sandier and finer layers may occur in association. Pennock et al. discuss the possibility of Bt-like horizons that are not formed by illuviation [26]. In the present study, the field description and particle-size data do not clarify the origin of the differences in texture. Additional evidence such as clay

coatings, short-interval particle-size measurements and, where necessary, micromorphology is needed to confirm an argillic or argic horizon. The low-chroma matrices and red mottles in the lower P1 and P3 horizons are consistent with periodic redox conditions and iron redistribution [27]. These features suggest episodic saturation in such horizons, but no water-table monitoring was undertaken to establish whether water perched above a restrictive layer or rose from below. P2 showed no recorded redox features within the 83-cm pit. Such interpretations are most convincing when morphology is considered with the profile data and landscape position [11,28].

Table 1: Morphological properties of Profiles 1, 2 and 3

Horizon	Depth (cm)	Matrix colour (moist)	Mottles	Structure	Consistence (moist)	Drainage
PEDON 1 LAT. 6° 14′ 21″ N LONG. 7° 07′ 09″ E						
A	0–28	5YR 6/3	–	Weak, very fine crumb	Friable	Well drained
AB	28–44	5YR 6/3	–	Weak, very fine angular blocky	Friable	Well drained
Bt1	44–67	7.5YR 6/3	–	Weak, very fine sub-angular blocky	Friable	Well drained
Bt2	67–110	5YR 7/1	Red	Moderate, fine sub-angular blocky	Firm	Poorly drained
PEDON 2 LAT. 6° 14′ 51″ N LONG. 7° 07′ 12″ E						
A	0–17	7.5YR 7/6	–	Weak, very fine crumb	Friable	Well drained
AB	17–30	10YR 6/3	–	Weak, very fine angular blocky	Friable	Well drained
Bt1	30–83	10YR 4/6	–	Weak, very fine sub-angular blocky	Friable	Well drained
PEDON 3 LAT. 6° 14′ 47″ N LONG. 7° 07′ 13″ E						
A	0–31	10YR 5/3	–	Weak, very fine crumb	Friable	Well drained
AB	31–64	2.5YR 7/4	–	Weak, very fine angular blocky	Friable	Well drained
Bt1	64–110	10YR 7/3	–	Weak, very fine sub-angular blocky	Friable	Well drained
Bt2	110–150	10YR 7/1	Red	Moderate, fine sub-angular blocky	Firm	Poorly drained

Physical Properties

Sand predominated in the reported particle-size results (Table 2). Most horizons with particle-size fractions that close to 1000 g kg -1 were classified as sandy loam, and the P3 Bt2 was sandy clay loam. The reported P1 Bt2 fractions, however, sum to 1060 g kg -1; its textural class and contribution to the P1 particle size means cannot be confirmed until the original laboratory record is checked. Using the reported values, sand ranged from 572 to 712 g kg -1, silt from 140 to 320 g kg -1 and clay from 108 to 208 g kg -1. Clay increased from 108 g kg -1 in the P3 A to 208 g kg -1 in its Bt2 horizon, but the intermediate values were not monotonic. In P2, clay varied between 108 and 148 g kg -1, and had no consistent depth-related increase. The reported silt-to-clay ratios ranged from 0.87 to 2.96, and the P1 Bt2 ratio is provisional because the fractions do not close. P2 had the highest mean bulk density (1.64 Mg m -3), increasing from 1.45 Mg m -3 in the A horizon to 1.76 Mg m -3 in Bt1. Its total porosity decreased from 45.28% to 33.58%. P1 and P3 had lower mean bulk densities (1.30 and 1.35 Mg m -3, respectively). Gravimetric moisture content at sampling ranged from 12.06% to 16.54%; the P2 mean is 14.04%, recalculated from the listed horizons. The bulk-density difference is the most striking variation among pedons. High bulk density can limit root growth, depending on texture, water status and crop species [1,19]. P2's Bt1 value of 1.76 Mg m -3 and associated porosity of 33.58% deserve further study, but are not conclusive of a compacted pan. Penetration resistance, root distribution and infiltration measurements would test whether compaction is a management constraint. The lower bulk density in P1 Bt1 (1.19 Mg m -3) than in the overlying AB (1.42 Mg m -3) is also worthy of note; the available information does not explicate this variation. Texture and organic matter can influence water retention, but water-retention curves and plant-available water were not measured here [30-32]. The reported moisture contents describe the samples at the time of collection and should not be extrapolated to field capacity or plant-available water.

Rootable depth and the subsoil horizons' properties can affect crop-available soil volume [29], but the effects on crop performance at this farm need field validation.

Table 2: Physical properties of Profiles 1, 2 and 3

(SCR = silt-to-clay ratio; MC = gravimetric moisture content; BD = bulk density; TP = total porosity; SL = sandy loam; SCL = sandy clay loam)

Depth (cm)	Horizon	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	SCR	Texture	MC (%)	BD (Mg m^{-3})	TP (%)
P1 LAT. 6° 14′ 21″ N LONG. 7° 07′ 09″ E									
0–28	A	612	220	168	1.31	SL	15.28	1.27	52.08
28–44	AB	612	200	188	1.06	SL	15.81	1.42	46.42
44–67	Bt1	572	240	188	1.28	SL	16.54	1.19	55.09
67–110	Bt2	592	260	208	1.25	SCL	15.97	1.32	50.19
Mean		**597**	**230**	**188**	**1.23**	**SL**	**15.90**	**1.30**	**50.95**
P2 LAT. 6° 14′ 51″ N LONG. 7° 07′ 12″ E									
0–17	A	632	240	128	1.88	SL	12.06	1.45	45.28
17–30	AB	712	140	148	0.95	SL	14.49	1.70	35.85
30–83	Bt1	572	320	108	2.96	SL	15.58	1.76	33.58
Mean		**639**	**233**	**128**	**1.93**	**SL**	**14.03**	**1.64**	**38.05**
P3 LAT. 6° 14′ 47″ N LONG. 7° 07′ 13″ E									
0–31	A	632	260	108	2.41	SL	15.42	1.31	50.57
31–64	AB	632	220	148	1.49	SL	15.01	1.26	52.45
64–110	Bt1	652	220	128	1.72	SL	15.62	1.54	41.89
110–150	Bt2	612	180	208	0.87	SCL	16.28	1.28	51.70
Mean		**632**	**220**	**148**	**1.62**	**SL**	**15.58**	**1.35**	**49.15**

Chemical Properties

Soil pH in water ranged from 5.44 to 6.10, with means of 5.66 in P1, 5.96 in P2 and 5.88 in P3 (Table 3). The recalculated pH coefficients of variation, using the sample standard deviation, were 3.21%, 2.10% and 1.87%, respectively. Organic carbon and total nitrogen are reported as 0.15 - 1.77 g kg -1 and 0.013 - 0.150 g kg -1, respectively. These values are maintained as provided, but the units should be checked against the original laboratory sheets before interpreting soil fertility. If the measurements were recorded in percentages and subsequently labelled g kg -1, the values and interpretation will differ by a factor of ten. Available phosphorus ranged from 0.96 to 4.27 mg kg -1. The P2 Bt1 horizon has higher values of organic carbon, nitrogen and available phosphorus than the AB immediately above, and also has the highest bulk density and silt content and lowest clay content in that pedon. This combination should be checked against sample labels and laboratory records before a pedogenic explanation is proposed. The exchange complex was dominated by Ca2+, followed by Mg2+, K+ and Na+. TEB ranged from 2.08 to 4.43 cmol(+) kg -1, and ECEC from 3.08 to 5.33 cmol(+) kg -1. Exchangeable Al3+ ranged from 0.30 to 0.90 cmol(+) kg -1. ECEC-based base saturation ranged from 65.41% to 84.29%, aluminum saturation from 9.23% to 28.30% and ESP from 1.85% to 3.98%. The reported ESP values show that sodicity was not a factor in these samples. The pH values suggest acidic to moderate acidity. Tropical humid soil acidity is commonly associated with leaching and exchangeable aluminum behaviour, although these effects were not directly measured [1-3]. the lowest pH was 5.44 in the P1 Bt1 horizon. Aluminum saturation reached 28.30% in the P1 Bt2, but crop response cannot be inferred from this value alone: aluminum effects vary by crop and genotype and should be considered with soil pH, rooting and plant response [33]. Liming decisions should be based on crop-specific recommendations and locally calibrated soil tests. Available phosphorus was low in these reported samples. In strongly weathered soils, phosphorus availability may be affected by sorption and other soil processes, but this study did not measure phosphorus fractions or the relevant mineral surfaces [2,3]. Organic amendments and phosphorus management are reasonable priorities for field testing, but fertilizer and lime rates should not be extrapolated from these profile data.

Table 3: Chemical properties of Profiles 1, 4 and 7 (OC = organic carbon; TN = total nitrogen; AP = available phosphorus; TEB = total exchangeable bases; TEA = total exchangeable acidity; ECEC = effective cation exchange capacity; BS = base saturation; ESP = exchangeable sodium percentage)

Depth (cm)	Horizon	pH (H_2O)	OC (g kg^{-1})	TN (g kg^{-1})	AP (mg kg^{-1})	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	TEB	H^{+}	Al^{3+}	TEA	ECEC	BS (%)	Al sat. (%)	ESP (%)
P1 LAT. 6° 14′ 21″ N LONG. 7° 07′ 09″ E																	
0–28	A	5.79	1.77	0.150	4.27	2.40	1.60	0.17	0.26	4.43	0.20	0.70	0.90	5.33	83.11	13.13	3.19
28–44	AB	5.82	0.26	0.022	1.80	1.60	1.20	0.15	0.27	3.22	0.20	0.40	0.60	3.82	84.29	10.47	3.93
44–67	Bt1	5.44	0.51	0.049	1.60	1.60	1.20	0.11	0.24	3.15	0.30	0.50	0.80	3.95	79.75	12.66	2.78
67–110	Bt2	5.57	0.23	0.020	0.96	1.20	0.60	0.08	0.20	2.08	0.20	0.90	1.10	3.18	65.41	28.30	2.52
Mean		**5.66**	**0.69**	**0.0603**	**2.16**	**1.70**	**1.15**	**0.13**	**0.24**	**3.22**	**0.23**	**0.63**	**0.85**	**4.07**	**78.14**	**16.14**	**3.11**
P2 LAT. 6° 14′ 51″ N LONG. 7° 07′ 12″ E																	
0–17	A	6.10	0.57	0.049	2.16	1.60	1.20	0.09	0.21	3.10	0.40	0.70	1.10	4.20	73.81	16.67	2.14
17–30	AB	5.90	0.15	0.013	1.32	1.20	0.80	0.11	0.17	2.28	0.20	0.60	0.80	3.08	74.03	19.48	3.57
30–83	Bt1	5.87	1.07	0.090	2.20	2.20	1.60	0.17	0.23	4.20	0.30	0.60	0.90	5.10	82.35	11.76	3.33
Mean		**5.96**	**0.60**	**0.051**	**1.89**	**1.67**	**1.20**	**0.12**	**0.20**	**3.19**	**0.30**	**0.63**	**0.93**	**4.13**	**76.73**	**15.97**	**3.01**
P3 LAT. 6° 14′ 47″ N LONG. 7° 07′ 13″ E																	
0–31	A	6.02	0.67	0.058	1.60	2.20	1.20	0.10	0.16	3.66	0.40	0.80	1.20	4.86	75.31	16.46	2.06
31–64	AB	5.91	0.34	0.027	1.49	1.60	1.20	0.09	0.23	3.12	0.50	0.90	1.40	4.52	69.03	19.91	1.99
64–110	Bt1	5.82	0.25	0.022	1.50	1.20	1.00	0.13	0.24	2.57	0.10	0.60	0.70	3.27	78.59	18.35	3.98
110–150	Bt2	5.77	0.16	0.013	1.35	1.40	0.80	0.06	0.19	2.45	0.50	0.30	0.80	3.25	75.38	9.23	1.85
Mean		**5.88**	**0.36**	**0.030**	**1.49**	**1.60**	**1.05**	**0.095**	**0.205**	**2.95**	**0.38**	**0.65**	**1.03**	**3.98**	**74.58**	**15.99**	**2.47**

Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, TEB, H^{+}, Al^{3+}, TEA and ECEC are in cmol(+) kg^{-1}.

Soil Classification

P1 and P3 were classified as Ultisols (Acrisols in WRB) and P2 as an Inceptisol (Cambisol) (Table 4). All three pedons have ochric epipedons. In P1, an ochric epipedon overlies a weakly expressed argillic horizon in which clay increases from 168 to 208 g kg^{-1} (a ratio of about 1.24), with redoximorphic features (light grey matrix and red mottles) below 67 cm; the pedon is fine-loamy and was placed in the Aquic Hapludults. In P3, the ochric epipedon overlies an argillic horizon (clay 108 to 208 g kg^{-1}) in which gleying occurs only below 110 cm, so the pedon is largely well drained and was placed in the Typic Hapludults. P2 has a cambic horizon rather than an argillic one because clay does not increase (it declines slightly). It is well drained, yellowish brown and unmottled, and was classified as a Typic Dystrudept. The classification follows from the morphology and clay data above. The two pedons with a clay increase and Bt2 horizons (P1 and P3) key out as Hapludults, with an aquic subgroup in P1 as grey matrices and mottles begin at 67 cm, and a typic subgroup in P3 since they begin only below 110 cm. Their correlation with Acrisols in the WRB is consistent with soils of the Coastal Plain Sands of southeastern Nigeria, which carry low-activity clays and an argillic horizon. P2 is placed in the Inceptisols and Cambisols because it lacks a qualifying clay increase, so its Bt1 designation in the field reflects colour and structure development that is better described as a cambic horizon.

Table 4: Classification of Profiles 1, 2 and 3

Profile	Diagnostic horizons and features	USDA Soil Taxonomy	WRB
P1	Ochric epipedon over a weakly expressed argillic horizon (clay 168 to 208 g kg^{-1}); redoximorphic features below 67 cm	Fine-loamy, kaolinitic, isohyperthermic Aquic Hapludult	Stagnic Cutanic Acrisol (Loamic, Ochric, Hyperdystric)
P2	Ochric epipedon over a cambic horizon (no qualifying clay increase); well drained, no mottles	Fine-loamy, kaolinitic, isohyperthermic Typic Dystrudept	Haplic Cambisol (Loamic, Ochric, Dystric)

Profile	Diagnostic horizons and features	USDA Soil Taxonomy	WRB
P3	Ochric epipedon over an argillic horizon (clay 108 to 208 g kg^{-1}); gleying only below 110 cm	Fine-loamy, kaolinitic, isohyperthermic Typic Hapludult	Cutanic Acrisol (Loamic, Ochric, Hyperdystric)

CONCLUSION

The three pedons are moderately deep to very deep (83-150 cm) and have A-AB-Bt horizon sequences with friable, weakly structured surface horizons over sub-angular blocky subsoils. P1 and P3 have firm (67 cm) and grey, red-mottled and poorly drained Bt2 horizons at 67 cm and 110 cm, whereas P2 is shallower, well drained and unmottled but has a dense subsoil (1.76 Mg m -3). Texture is predominantly sandy loam, with clay increasing to sandy clay loam in the Bt 2 horizons of P1 and P3. The soils are moderately acid and very low in organic carbon, total nitrogen and available phosphorus, with low ECEC that appears to depend largely on organic matter, moderate to high base saturation, aluminum saturation up to 28% in the P 1 subsoil, and no sodicity. P1 and P3 were classified as Ultisols (an Aquic Hapludult and a Typic Hapludult) and as Acrisols in the WRB, and P2 as an Inceptisol (Typic Dystrudept) and a Cambisol. These results provide baseline pedon-scale data for the farm and indicate that management should focus on organic matter, phosphorus and subsoil drainage and compaction

REFERENCES

1) Weil, R. R., & Brady, N. C. (2022). *The nature and properties of soils* (16th ed.). Pearson Education Limited.
2) Sanchez, P. A. (2019). *Properties and management of soils in the tropics* (2nd ed.). Cambridge University Press. https://doi.org/10.1017/9781316806463
3) Sharma, U. C., Datta, M., & Sharma, V. (2025). Chemistry, microbiology, and behaviour of acid soils. In *Soil acidity* (Progress in Soil Science). Springer. https://doi.org/10.1007/978-3-031-76357-1_3
4) Afu, S., Olim, D., & Asadu, C. L. A. (2025). Clay mineralogy and chemistry of selected soils in Northern Cross River State, Nigeria. *Journal of Agriculture, Forestry & Environment, 8*(1), 146–158.
5) Nwite, J. C., Igwe, C. A., & Obalum, S. E. (2021). Soil degradation and sustainable land management options in southeastern Nigeria. *International Journal of Agricultural Sustainability, 19*(3-4), 245–258.
6) Nnabuihe, E. C., Isi, P. O., Orizu, G. E., & Steve-Obi, C. E. (2026). A multi-indicator assessment of soil degradation under contrasting land use systems in Coastal Plain Sands of Imo State, southeastern Nigeria. *International Journal of Horticulture and Agriculture Research, 2*(4), 142–149. https://doi.org/10.58806/ijhar.2026.v2i4n01
7) Soil Survey Staff. (2022). *Keys to soil taxonomy* (13th ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.
8) IUSS Working Group WRB. (2022). *World reference base for soil resources 2022: International soil classification system for naming soils and creating legends for soil maps* (4th ed.). International Union of Soil Sciences.
9) Nnabuihe, E. C., Chukwu, E. D., Apalowo, O. A., Ugochukwu, G. U., Osisi, F. A., Madueke, C. O., Mbe, J. O., Chukwu, O., Chukwuma, T. R., & Uko, I. (2025). Profile characteristics and classification of selected Ultisols under varying land use types in Owerri, southeastern Nigeria. *International Journal of Horticulture and Agriculture Research, 1*(1), 37–47.
10) Nnabuihe, E. C., Madueke, C. O., Okafor, M. J., Nwosu, T. V., Ibeh, C. U., Ibigweh, M. N., Nwaiwu, C. J., Ike, C. R., Onunwa, A. O., Okore, I. K., & Nnabude, P. C. (2024, March 14). Morphology, physico-chemical properties and classification of soils of Coastal Plain Sands in Owerri, Imo State, southeastern Nigeria. In *E-proceedings of the Faculty of Agriculture International Conference* (pp. 232–239).
11) Nungula, E. Z., Mugwe, J., Massawe, B. H. J., & Gitari, H. I. (2024). Morphological, pedological and chemical characterization and classification of soils in Morogoro District, Tanzania. *Agricultural Research, 13*(2), 266–276. https://doi.org/10.1007/s40003-023-00693-4
12) Orajaka, S. O. (1975). Geology. In G. E. K. Ofomata (Ed.), *Nigeria in maps: Eastern states* (p. 5). Ethiope Publishing House.
13) Nwajide, C. S. (2013). *Geology of Nigeria's sedimentary basins*. CSS Press.
14) Inyang, P. E. B. (1975). Climatic regions. In G. E. K. Ofomata (Ed.), *Nigeria in maps: Eastern states* (p. 27). Ethiope Publishing House.
15) Musa, S. D., Onwuka, S. U., & Eneche, P. S. U. (2017). Geospatial analysis of land use/cover dynamics in Awka Metropolis, Nigeria: A sub-pixel approach. *Journal of Geography, Environment and Earth Science International, 11*(4), 1–19. https://doi.org/10.9734/JGEESI/2017/35209

16) FAO. (2006). *Guidelines for soil description* (4th ed.). Food and Agriculture Organization of the United Nations.
17) Schoeneberger, P. J., Wysocki, D. A., Benham, E. C., & Soil Survey Staff. (2012). *Field book for describing and sampling soils* (Version 3.0). U.S. Department of Agriculture, Natural Resources Conservation Service.
18) Gee, G. W., & Or, D. (2002). Particle-size analysis. In J. H. Dane, & G. C. Topp (Eds.), *Methods of soil analysis: Part 4. Physical methods* (pp. 255–293). Soil Science Society of America.
19) Grossman, R. B., & Reinsch, T. G. (2002). Bulk density and linear extensibility. In J. H. Dane, & G. C. Topp (Eds.), *Methods of soil analysis: Part 4. Physical methods* (pp. 201–228). Soil Science Society of America.
20) McLean, E. O. (1982). Soil pH and lime requirement. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), *Methods of soil analysis: Part 2. Chemical and microbiological properties* (2nd ed., pp. 199–224). American Society of Agronomy & Soil Science Society of America.
21) Nelson, D. W., & Sommers, L. E. (1982). Total carbon, organic carbon, and organic matter. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), *Methods of soil analysis: Part 2. Chemical and microbiological properties* (2nd ed., pp. 539–579). American Society of Agronomy & Soil Science Society of America.
22) Bremner, J. M. (1996). Nitrogen-total. In D. L. Sparks (Ed.), *Methods of soil analysis: Part 3. Chemical methods* (pp. 1085–1121). Soil Science Society of America.
23) Bray, R. H., & Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil Science, 59*(1), 39–46.
24) Thomas, G. W. (1982). Exchangeable cations. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), *Methods of soil analysis: Part 2. Chemical and microbiological properties* (2nd ed., pp. 159–165). American Society of Agronomy & Soil Science Society of America.
25) R Core Team. (2023). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.
26) Pennock, D., Fisher, K., & Naeth, M. A. (2021). Time for nonilluvial Bt horizons? *Canadian Journal of Soil Science, 102*(2), 385–407. https://doi.org/10.1139/cjss-2021-0088
27) Smirnova, M. A., & Kozlov, D. N. (2023). Soil properties as indicators of soil water regime: A review. *Eurasian Soil Science, 56*(3), 306–320. https://doi.org/10.1134/S1064229322602396
28) Hewitt, A. E., Balks, M. R., & Lowe, D. J. (2021). *The soils of Aotearoa New Zealand*. Springer International Publishing.
29) Leenaars, J. G. B., Claessens, L., Heuvelink, G. B. M., Hengl, T., Ruiperez González, M., van Bussel, L. G. J., Guilpart, N., Yang, H., & Cassman, K. G. (2018). Mapping rootable depth and root zone plant-available water holding capacity of the soil of sub-Saharan Africa. *Geoderma, 324*, 18–36. https://doi.org/10.1016/j.geoderma.2018.02.046
30) Libohova, Z., Seybold, C., Wysocki, D., Wills, S., Schoeneberger, P., Williams, C., Lindbo, D., Stott, D., & Owens, P. R. (2018). Reevaluating the effects of soil organic matter and other properties on available water-holding capacity using the National Cooperative Soil Survey Characterization Database. *Journal of Soil and Water Conservation, 73*(4), 411–421. https://doi.org/10.2489/jswc.73.4.411
31) Pérez-de-los-Reyes, C., Sánchez-Ormeño, M., Bravo Martín-Consuegra, S., García-Pradas, J., Pérez-de-los-Reyes, M. L., Ramírez, A., Ortíz-Villajos, J. Á. A., García Navarro, F. J., & Jiménez-Ballesta, R. (2022). The influence of depth on the water retention properties of vineyard soils. *Agricultural Water Management, 261*, 107384. https://doi.org/10.1016/j.agwat.2021.107384
32) Zhang, Y., Wang, K., Wang, J., Liu, C., & Shangguan, Z. (2021). Changes in soil water holding capacity and water availability following vegetation restoration on the Chinese Loess Plateau. *Scientific Reports, 11*, 9692. https://doi.org/10.1038/s41598-021-88914-0
33) Rahman, M. A., Lee, S.-H., Ji, H. C., Kabir, A. H., Jones, C. S., & Lee, K.-W. (2018). Importance of mineral nutrition for mitigating aluminum toxicity in plants on acidic soils: Current status and opportunities. *International Journal of Molecular Sciences, 19*(10), 3073. https://doi.org/10.3390/ijms19103073