

## MORPHOLOGICAL AND PHYSICAL CHARACTERIZATION OF SOILS AS INDICATORS OF SOIL DEGRADATION IN LAUTECH ISEYIN CAMPUS, NIGERIA

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### ABSTRACT

Soil degradation is the decline in the physical, chemical, and biological quality of soil, remains one of the most pressing global environmental challenges, threatening agricultural productivity and the stability of ecosystems. Human activities such as deforestation, overgrazing, and unsustainable farming practices, together with the increasing effects of climate change like flooding and erosion, have multiple effects on soil degradation. The study examined the land use types, evaluate the effects of farming practices on soil properties, and propose sustainable management strategies to reduce degradation and improve soil health at LAUTECH, Iseyin campus, Oyo state.

The study was, conducted at Iseyin campus Oyo State, which lies on latitude 7°58'N longitude 3°36'E within Southern Guinea Savanna Zone. A rigid grid sampling method was used across 30,000 m<sup>2</sup> area, with transverses cut at 100-meter intervals. Nine profile pits (1.5 m × 1.5 m × 2.0 m) were dug at each point, from which undisturbed soil samples were collected at 0-15cm depths. Laboratory analyses were conducted to determine particle size distribution, pH, exchangeable acidity, available phosphorus, organic carbon, total nitrogen and exchangeable bases (Ca, Mg, K, and Na). Field descriptions and degradation classifications followed the FAO guidelines.

The study revealed that soils in profiles 1, 2, 4, 5, and 6 were in good condition and classified as Class 1 (non or slightly degraded), while profiles 3, 7, and 8 showed Class 2 (moderate degradation) under FAO standards. The soils were mainly sandy loam, with sand content ranging from 66.8 to 89.2%, silt from 7.4 to 17.4%, and clay from 3.4 to 24.8%. Nitrogen (0.09-0.34%) and organic carbon (0.84-3.11%) levels indicated moderate degradation in some areas, particularly in profiles 3, 7, and 8. Phosphorus (8.0-38.65 mg/kg) and cation exchange capacity (8.08-13.26 cmol/kg) values were generally adequate, placing most soils in Class 1. Soil pH ranged from 5.62 to 6.84, showing slightly acidic to near-neutral conditions suitable for crop growth. Exchangeable bases and cation exchange capacity varied across profiles, while aluminium toxicity was minimal, appearing only in the basement complex horizon of profile 6. Overall, the soils are largely fertile and suitable for sustainable agricultural use, with only localized areas showing moderate degradation.

Most soils within LAUTECH, Iseyin campus are in good condition, showing only slight to moderate degradation and are largely suitable for sustainable agricultural use, although localized areas with reduced nitrogen and organic carbon require attention to prevent further decline. Appropriate soil management practices such as organic matter incorporation, controlled fertilizer application, use of contour farming, continuous soil fertility monitoring, and conservation-oriented land-use planning should be adopted to ensure sustained long-term soil productivity.

**Keywords:** *Soil morphology; bulk density; land degradation; Iseyin, soil quality*

### INTRODUCTION

The ability of soil to deliver these ecological functions, often referred to as ecosystem services, depends on how effectively it performs these underlying processes within specific geographic and climatic contexts. This functional capacity is captured by the concept of 'soil health, which reflects the soil's ability to carry out its ecological roles [Ref.]. A soil is considered 'healthy' if it delivers ecosystem services on par with, or better

than, those of undisturbed reference soils of the same type in the same region. If it falls short of this benchmark, it is deemed unhealthy and incapable of fulfilling the typical functions expected in its natural setting (FAO, 2021).

Soil quality plays a fundamental role in crop production, water regulation, and ecological functioning (Brady and Weil, 2017). Globally, soil degradation affects nearly one-third of land resources (FAO, 2015) and is a growing concern in Nigeria due to over-cultivation, erosion, and

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climate pressures (Lal, 2015). Physical and morphological indicators are among the earliest signs of degradation and provide immediate insight into soil structure, porosity, compaction, and organic matter decline (USDA, 2017).

Morphological characteristics such as soil colour, structure, consistency, and root distribution are used to interpret soil development and degradation patterns (Schaetzl and Thompson, 2015). Likewise, physical properties such as texture and bulk density influence aeration, water retention, compaction, and erosion susceptibility (Hillel, 2004). Identifying early degradation indicators is essential for sustainable agricultural management and long-term productivity.

The LAUTECH Iseyin Campus is frequently used for crop trials and student training, which increases disturbance and potential degradation. Baseline assessment of soil physical and morphological properties is necessary for sustainable land-use planning.

### Research Gap and Objectives

Despite the importance of soil physical and morphological indicators in land degradation assessment, limited site-specific information exists for teaching and research farms in southwestern Nigeria, particularly within the LAUTECH Iseyin Campus. Continuous agricultural uses of land without baseline data may accelerate unnoticed degradation. Therefore, this study aimed to:

- I. Characterize the morphological properties of soils at the LAUTECH Iseyin Campus.
- II. Evaluate key physical properties including texture and bulk density.
- III. Assess the degree of soil degradation using FAO (1979) criteria.

**Table 1:** Indicators and criteria for land degradation assessment.

Indicators	Degree of Degradation			
	1	2	3	4
Soil bulk density (g/cm)	<1.5	1.5-2.5	2.5-5	>5
Permeability (cm/hr)	<1.25	1.25-5	5.0-10	>20
Content of Nitrogen Element (multiple decrease %N)	>0.13	0.13-0.10	0.10-0.08	<0.08
Content of Phosphorus Element (Cmol/Kg)	>8	8.0-7.0	7.0-6.0	>6
K content (Cmol kg)	>0.16	0.16-0.14	0.14-0.12	<0.12
Content of ESP	<10	10.0-25.0	25-50	>50
Content of humus in soil	>2.5	2.5-2	2-1.0	<1.0
Content of base saturation	<2.5	2.5-5.0	5.0-10.0	>10

Source: FAO (1979)

KEY

Class1: Non slightly degraded Class2: Moderately degraded

Class3: Highly degraded Class4: Very highly degraded

## Materials and Methods

### Study Area

The study was, conducted on LAUTECH, Iseyin campus Oyo, State, which lies on latitude 7°58'N longitude 3°36'E within Southern Guinea Savanna Zone, the mean annual rainfall is about 1200 mm. with average range of 786.2 to 1413mm (Nigerian Meteorological Agency, 2023). It has bimodal monthly distribution that assumes the first peak in June and second in September with July/ August break during this period. The dry season follows immediately starting by November and terminating by February, with associated harmattan (Nigerian Meteorological Agency, 2023). The geology consists of basement complex rocks that influence soil parent materials (Areola, 1982).

### Field Methods

Eight profile pits were dug on a 100-m interval grid. Morphological and Physical descriptions followed FAO (1977) and USDA (2014) guidelines. Observations included horizon designation, Colour (using the Munsell soil Colour system), structure, consistency, root abundance, and boundary characteristics.

### Laboratory Analysis

Particle-size distribution was determined using the hydrometer method (Gee and Or, 2002), while bulk density was measured using the core method (Blake and Hartge, 1986). Bulk density interpretation followed FAO (1979) degradation classes. Although multiple degradation indicators are presented in Table 1, this study focused on bulk density as the primary physical indicator of degradation.

### Data Analysis

Descriptive statistical analysis was used to summarize soil physical properties across profiles. Soil textural classes were determined using the USDA textural triangle, while bulk density values were interpreted using FAO (1979) degradation thresholds. Morphological features were qualitatively analysed to identify indicators of soil development and degradation.

## Results and Discussion

### Morphological Characteristics

The results of the Morphological properties of LAUTECH teaching and research farm Iseyin, Oyo state are presented in Table 2. The morphological assessment of the eight soil profiles demonstrated uniform site characteristics, including a gentle slope of 0.05 (equivalent to 5%) and well-drained (wd)

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conditions, which facilitate effective water percolation and minimize erosion risks on these landscapes. Surface horizons (typically between 0 - 40cm) across all profiles exhibited darker moist colors ranging from dark yellowish brown (10YR 4/4 to 5/8) to strong brown, indicative of higher organic matter content that enhances soil aggregation and fertility in the topsoil.

Soil structures in the upper layers were predominantly very fine, fine and granular (vf, f, gr), promoting good tilth and root penetration, with consistence varying from soft (s) to slightly sticky (ss) and friable (fr) to loose (lo), supporting ease of cultivation. Root concentrations were higher near the surface, ranging from very few (vf) to dry loose (dlo), with fine to few (f, fe) mottles suggesting occasional redox activity but overall aerobic conditions. In contrast, subsurface layers (below 40-70 cm) showed lighter colors such as very pale brown (10YR 7/4 to 8/4) or yellowish brown, reflecting reduced organic influence and potential leaching processes over time. Structures transitioned to medium to coarse subangular blocky (me, co, sab) or granular, with harder (h) or very hard (vh) consistence, which could impede deep rooting and necessitate mechanical interventions for crop production.

Profiles 1 to 4 displayed subtle variations. Profile 1 had very fine granular surface structure with very few roots and faint mottles, while Profile 2 featured fine granular with slightly sticky consistence and faint mottles, potentially indicating slight differences in parent material or land use history. Deeper in Profile 3, very coarse granular structures at 86-140 cm suggested increased compaction or clay influence, whereas Profile 4 showed non-sticky surface consistence,

implying coarser textures. Mottles became more medium to coarse (me, co) with depth in most profiles, a common feature in well-drained soils where iron oxides redistribute under fluctuating moisture. Root absence below 60-80 cm across profiles highlights limitations for deep-rooted crops, possibly due to increasing density or nutrient depletion. These morphological traits align with tropical or subtropical pedogenesis, where weathering leads to distinct horizonation.

Profiles 5 to 8 mirrored similar patterns but with nuances; Profile 5 had soft surface consistence and medium mottles, Profile 6 showed medium roots with faint mottles, Profile 7 the darkest surface (10YR 4/4) suggesting higher humus, and Profile 8 included a reddish-brown layer (7.5YR 5/6) at 70-103 cm, possibly indicating iron enrichment. Overall, the soils exhibit cambic or argillic subsurface horizons based on structure and color changes, classifying potentially as Inceptisols or Ultisols under USDA taxonomy. Such properties support agriculture like maize or cassava cultivation but require conservation practices to prevent degradation on sloped terrains. The consistent well-drained nature reduces waterlogging risks, enhancing suitability for rainfed farming in regions with seasonal rainfall.

Morphological features such as lighter subsoil colours, blocky structures, and reduced rooting depth further indicate progressive soil development and moderate physical degradation. These characteristics are consistent with Ultisols commonly reported in savanna environments (Schaeztl and Thompson, 2015).

**Table 2:** Morphological properties of the different Profile pits

colour Soil Profile	depth(cm)	Slope	Moist	Dry	Structure	Consistence	root conc.	Mottles	Drainage
Profile 1	0 - 19	5%	10YR4/6	10YR5/6				f,fe	w d
	19 - 84		10YR6/8	10YR6/6	vf,gr	s,fr	vf,c	m,me	w d
	84 - 115		10YR7/8	10YR7/4	f,gr	ss,fr	vf,c	m,me	w d
	115 - 172		10YR7/4	10YR8/3	co,sab	ss,h	-	m,me	w d
Profile 2	0 - 40	5%	10YR5/6	10YR7/3	co,gr	ss,h	-	fe,f	w d
	40 - 64		10YR5/8	10YR8/3	f,gr	ss,fr,dlo	vf,c	fe,f	w d
	64 - 123		10YR6/8	10YR7/8	f,gr	ss,fr,dlo	vf,c	c,me	w d
	123 - 172		10YR7/6	10YR8/4	me,sab	ns,lo,vh	-	m,co	w d
Profile 3	0 - 32	5%	10YR5/8	10YR6/4	co,sab	ns,lo,vh	-	fe,f	w d
	32 - 52		10YR5/8	10YR8/2	vf,gr	ss,lo,dlo	f,c	fe,f	w d
	52 - 86		10YR6/6	10YR8/3	f,gr	ns,fr,h	me,c	c,co	w d
	86 - 140		10YR7/6	10YR7/6	co,gr	ns,vf,vh	-	m,co	w d
Profile 4	0 - 36	5%	10YR4/6	10YR6/6	v,co,gr	ns,vf,vh	-	f,fe	w d
	36 - 76		10YR5/6	10YR7/3	vf	ns,fo	f,fe	f,fe	w d
	76 - 115		10YR6/6	10YR7/8	vf,gr	ss,fr,so	vf,vfe	c,co	w d
	115 - 172		10YR6/6	10YR8/4	f,gr	vs,lo,h	-	m,co	w d
Profile 5	0 - 40	5%	10YR4/6	10YR6/6	me,sab	vs,lo,h	-	fe,f	w d
	40 - 66		10YR6/8	10YR6/6	vf,gr	s,f,so s,fr,so	f,m	fe,f	w d
	66 - 105		10YR6/8	10YR7/4	f,gr	ss,lo,h	vf,c	m,co	w d
	105 - 172		10YR6/8	10YR6/6	me,sab	ns,lo,vh	-	m,co	w d
Profile 6	0 - 39	5%	10YR5/8	10YR6/6	me,sab	s,fr,dlo	-	fe,f	w d
	39 - 65		10YR6/8	10YR7/4	vf,gr	s,fr,so	me,c	fe,f	w d
	65 - 92		10YR7/4	10YR8/3	f,gr	ns,lo,vh	me,fe	m,me	w d
	92 - 178		10YR7/6	10YR7/4	me,sab	ns,lo,vh	me,vf	m,co	w d
Profile 7	0 - 30	5%	10YR4/4	10YR7/4	co,sab	ss,f,dlo	f,m	fe,f	w d
	30 - 60		10YR6/8	10YR8/2	f,gr	s,fr,so	me,c	c,me	w d
	60 - 76		10YR6/6	10YR8/3	me,sab	ns,fr,h	-	m,co	w d
	76 - 159		10YR5/8	10YR7/8	co,sab	ns,vh	-	c,co	w d
Profile 8	0 - 36	5%	10YR5/6	10YR6/6	co,gr	ss,f,dlo	vf,m	fe,f	w d
	36 - 70		10YR6/8	10YR8/3	f,gr	ns,lo,dlo	vf,vfe	c,me	w d
	70 - 103		7.5YR5/6	7.5YR6/6	me,sab	ns,lo,dlo	f,fe	c,co	w d
	103 - 165		10YR7/4	10YR8/4	me,sab	ns,lo,dlo	-	m,co	w d

**Note: Structure:** f = fine, me = medium, co = coarse, cr = crumb, gr = granular, sab = subangular blocky, ab = angular blocky, b = blocky. **Consistency:** ns = non-sticky, ss = slightly sticky, s = sticky, vs = very sticky, lo = loose, dlo = dry loose, f = firm, fr = friable, vf = very firm, so = soft, h = hard, vh = very hard, sh = slightly hard **Roots:** vf = very fine, f = fine, me = medium, co = coarse (size), vfe = very few, fe = few, c = common, m = many (concentration). **Mottles:** f = fine, m = many, me = medium, c = common, co = coarse f = few, vm = very many. **Drainage:** wd = well drain.

### Particle Size Description

The particle size (Table 3) analysis revealed that all profiles were dominated by sandy loam (SL) textures, with sand percentages ranging from 66.8% to 89.2%, silt from 7.4% to 17.4%, and clay from 3.4% to 24.8%, reflecting coarse parent materials likely derived from sedimentary or granitic sources. This high sand content promotes rapid drainage and aeration, beneficial for root respiration but potentially leading to drought stress in low-rainfall periods and nutrient leaching. Surface layers generally had higher sand and lower clay, facilitating tillage, while clay accumulation in deeper horizons (e.g., up to 24.8% in Profile 1 at 115-172 cm) resulted in sandy clay loam (SCL) textures, indicative of illuviation processes that form Bt horizons.

Comparing profiles, Profile 7 stood out with the highest surface sand (89.2%) and lowest clay (3.4%), suggesting minimal weathering and high permeability, whereas Profile 6 maintained balanced SL textures throughout with sand decreasing from 77.5% to 71.2%. Profiles 1, 3, 5, and 8 showed clear textural shifts to SCL at depths below 100 cm, with clay increases of 10-15%, which could improve water retention but increase compaction risks. Profile 4 was the most uniform, with sand above 77% and clay below 11%, ideal for uniform water movement but prone to erosion on slopes.

The dominance of sandy loam textures across the profiles reflects the influence of coarse-textured parent materials typical of basement complex terrains in southwestern Nigeria. Similar textural trends have been reported by Lal (2015) and Brady and Weil (2017), who noted that sandy soils promote rapid drainage but are vulnerable to nutrient leaching and compaction under continuous cultivation.

**Table 3:** Particle Size Distribution of the different soil profiles

Soil Profile	Horizon	%SAND	%SILT	%CLAY	TEXTURE
Profile 1	AP	79.7	11.4	9.9	SL
	AB	79.2	12.4	9.4	SL
	B	74.2	13.4	18.6	SL
	BC	72.8	13.8	24.8	SCL
Profile 2	AP	74.2	15.4	11.4	SL
	AB	72.2	15.4	13.4	SL
	B	67.8	15.4	16.4	SL
	BC	66.8	16.4	16.8	SL
Profile 3	AP	74.2	15.4	11.4	SL
	AB	72.4	12.2	15.4	SL
	B	71.2	17.4	12.4	SL
	BC	67.2	17.4	24.5	SCL
Profile 4	AP	80.6	12.4	7.8	SL
	AB	79.8	11.4	8.8	SL
	B	77.5	12.4	10.1	SL
	BC	77.1	12.1	10.8	SL
Profile 5	AP	74.2	11.3	14.5	SL
	AB	74.8	13.4	12.8	SL
	B	71.8	13.4	14.8	SL
	BC	74.2	13.6	22.2	SCL
Profile 6	AP	77.5	13.4	14.4	SL
	AB	77.1	12.1	8.8	SL
	B	74.2	11.3	14.8	SL
	BC	71.2	15.4	12.2	SL
Profile 7	AP	89.2	7.4	3.4	SL
	AB	81.2	9.4	9.4	SL
	B	71.2	15.4	13.4	SL
	BC	68.9	16.4	23.9	SCL
Profile 8	AP	74.2	15.4	11.4	SL
	AB	72.4	12.2	15.4	SL
	B	71.2	17.4	12.4	SL
	BC	67.2	16.4	24.6	SCL

### Bulk Density

According to the FAO (1979) classification shown in Table 1, soils with bulk density below 1.5 g/cm<sup>3</sup> are considered non-slightly to slightly degraded, values between 1.5 and 2.5 g/cm<sup>3</sup> indicate moderate degradation, 2.5–5.0 g/cm<sup>3</sup> correspond to high degradation, and those above 5.0 g/cm<sup>3</sup> reflect very high degradation. Using these criteria, most of the soils in Table 3 fall within the non- to moderately degraded range. Specifically, profiles 1, 2, 4, 5, and 6, with bulk densities ranging from 1.47 to 1.49 g/cm<sup>3</sup>, are classified as non-degraded, while profiles 3, 7, and 8, with slightly higher values of 1.51–1.53 g/cm<sup>3</sup>, lie at the threshold of moderate degradation.

Bulk density is an important indicator of soil structure, porosity, and compaction. Lower bulk densities (<1.5 g/cm<sup>3</sup>) usually reflect well-aggregated soils with sufficient pore space for air and water movement, promoting healthy root growth (Brady and Weil, 2019). In contrast, higher bulk densities (>1.5 g/cm<sup>3</sup>) can signal some compaction, which may restrict root penetration, reduce water infiltration, and limit microbial activity (Hazelton and Murphy, 2016). The slightly higher values observed in profiles 3, 7, and 8 may therefore indicate minor compaction, possibly resulting from surface crusting or repeated cultivation.

The observed increase in bulk density in Profiles 3, 7, and 8 suggests early-stage compaction, likely associated with repeated human and machinery traffic within the teaching and research farm. According to Hillel (2004), bulk density values exceeding 1.5 g/cm<sup>3</sup> can restrict root penetration and reduce soil aeration.

**Table 4:** Bulk density of the profile site

Soil Profile 0-15cm	Bulk Density g/cm <sup>3</sup>
Profile 1	1.48
Profile 2	1.49
Profile 3	1.51
Profile 4	1.47
Profile 5	1.47
Profile 6	1.48
Profile 7	1.51
Profile 8	1.53

## CONCLUSION

Physically, the soils are predominantly sandy loam (SL) textures, reflecting coarse parent materials, with high sand percentages ranging from 66.8% to 89.2%. The sandy loam texture provides good aeration and ease of tillage but increases vulnerability to erosion and nutrient loss (Brady and Weil, 2017). Slight compaction identified in three profiles suggests anthropogenic disturbance, likely from foot traffic, cropping activities, or machinery use. This high sand content also promotes rapid drainage. but also increases susceptibility to drought stress during low-rainfall periods and accelerates nutrient leaching.

Surface horizons (0–40 cm) are notably darker in color and feature very fine, fine, and granular structures (vf, f, gr), supporting good tilth, root penetration, and ease of cultivation. In contrast, subsurface layers often show lighter colors and structures that transition to medium to coarse subangular blocky (me, co, sab), with harder or very hard consistence, which could impede deep rooting and necessitate mechanical intervention. Colour transitions reflect typical savanna soils experiencing organic matter loss and leaching (Schaeztl and Thompson, 2015). Structural differences indicate moderately well-developed horizons but also increasing compaction with depth an early sign of degradation.

The presence of clay accumulation in deeper horizons, forming sandy clay loam (SCL) textures (up to 24.8% clay), suggests active illuviation processes that form Bt horizons. Most of the soils fall within the non- to slightly degraded range regarding bulk density, with values generally below  $1.5\text{g/cm}^3$ . However, profiles 3, 7, and 8 have slightly higher bulk densities ( $1.51\text{--}1.53\text{g/cm}^3$ ), indicating a threshold of moderate degradation and minor compaction risks that could restrict root penetration.

Restricted rooting in some pedons aligns with increasing bulk density and reduced porosity (Hillel, 2004). Although overall degradation is mild, continuous disturbance without soil conservation may worsen physical decline.

This study provides baseline morphological and physical data for the LAUTECH Iseyin Campus, contributing valuable information for sustainable land-use planning and soil conservation in similar savanna environments.

## RECOMMENDATION

Soil management practices such as organic matter incorporation, reduced tillage, controlled machinery use, and contour farming should be

adopted to minimize compaction and erosion. Periodic monitoring of soil physical properties is recommended to detect early degradation and guide sustainable land management decisions.

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