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RESEARCH ARTICLE

Characterization and Classification of Soils of a Toposequence in a Derived Savannah Agroecological Zone of Nigeria

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Abstract:

Background:

Soil properties are anisotropic in nature, hence the need to study soil associations and regional landscapes for sustainable nutrient management and soil profile is an important tool which can be utilized for this purpose.

Objective:

The objectives of the study are to describe the morphology of the soils of the toposequence, determine their physical and chemical properties, classify them and make an appraisal of their agricultural potentials.

Methods:

Three slope classes were considered and a total of three profile pits, one on each slope were studied and described in the field morphologically at Eleyin Farms Omu-Aran, Kwara State, Nigeria, which was a newly opened up plantation. Samples of soil were collected from the horizons of the profile pits. The soil samples were analyzed for their physical and chemical properties.

Results:

All the three pedons showed appreciable differences in physical, chemical, and morphological characteristics of the soils and their classifications were determined as guided by their characteristics. The textural classes were defined mainly by the sand compositions which decreased from the upper and middle slopes down to the bottom slope, and the clay compositions which increased progressively from the uppermost slope through the middle slope to the bottom slope. Silt compositions did not exhibit any particular pattern.

Conclusion:

Thus, sand and clay compositions were more significant and relevant to the textural classification of the soils of the area than silt. The low nutrient status of the soils can be ameliorated by incorporation of organic or farm residues to increase the organic matter content of the soil, and also improve management practices and guided chemical fertilizer use. The soils of the area were classified as Typic Haplustalf (USDA), and Ferric Luvisol (FAO).

Keywords: Morphological characteristics, Physicochemical properties, Soil profile, Toposequence, Anisotropic, Agricultural potentials.

Article History	Received: January 10, 2019	Revised: February 13, 2019	Accepted: April 01, 2019

1. INTRODUCTION

Soils vary in their physical, chemical, morphological and mineralogical characteristics where topography happens to be a major factor which controls most surface processes taking place [1]. Adjacent soils that show differing profile characteristics reflecting the influence of local topography are called toposequence. Topography has an influence on soil chemical and physical properties and also on the pattern of soil distribution over landscape [2]. As the landscape is undulating, soil characteristics at different topographic positions differ. Toposequence refers to a succession of sites from crest to the valley bottom which contains a range of soil profiles that are representative of the landscape and soils [3]. Soil properties vary in vertical and lateral directions and such variations follow systematic changes as a function of the land scape position (slope), soil forming factors and/or soil management

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practices (land use).

Studies were conducted [4] on three pedons on a toposequence at Ijah-Gbagyi district in Niger State, Nigeria, and it was reported that surface soils were characterized by dark yellowish brown colour (10YR 3/4) and very dark greyish brown colour (10YR 3/2) and that sand dominated the mineral fraction and decreased down the slope, whereas silt content increased down the slope due to sorting by geological and pedogenic processes.

Amhakhian and Achimugu [5] worked on the characteristics of soil on toposequence in Egume, Dekina local Government area of Kogi State, Nigeria and observed colours range from black to reddish brown at the surface (A) and subsurface (B) horizons and a dominant sandy loam texture, and weak medium granular to subangular blocky structure. The soils were classified as Lithic Udorthents, Typic Kandiudalfs and Typic Psammaquent in the USDA soil classification system. Dessalegna *et al*. [6] worked on effects of topography and land use on soil characteristics and properties along the toposequence of Ele watershed in southern Ethiopia and observed that topography influenced the morphological and physicochemical properties of the soil. Sharu *et al*. [7] worked on characterization and classification of soils on an Agricul-tural landscape in Dingyadi District, Sokoto State, Nigeria, using a semi-detailed fixed grid soil survey to obtain compre-hensive soil data for characterization and classification. They identified three soil mapping units on the basis of land forms and surface texture. They also observed that the dominant ex-changeable bases were calcium and magnesium with the soils having high base saturation. They classified the soils as Typic Endoaqualfs, Typic Haplustepts and Lithic Ustorthents (US-DA) and Haplic Luvisols, Argic Lixisols and Ruptic Cambisols (WRB system of Classification).

Land use patterns are often highly correlated with biophysical variables, such as slope and elevation gradients [8, 9]. Inappropriate land use can aggravate the rate of soil degradation affecting soil biological and physico-chemical qualities [10]. Ezeaku and Iwuanyanwu [11], worked on degradation rates of soil fertility as influenced by topography in southeastern Nigeria and noted that lower slope soils require greater management requirements. The soils of the area have not been thoroughly studied previously. The objectives of this study were to describe the morphology of the soils of the toposequence, determine their physical and chemical properties, classify them and make an appraisal of their agricultural potential.

2. MATERIALS AND METHODS

2.1. Site Description

The study was carried out at Eleyin Farms in Omu Aran Kwara state Nigeria. The town is situated about 16 km North-East of Otun - Ekiti in Ekiti State and about 88 kilometers south of Ilorin, capital of Kwara State, Nigeria. It is located on Latitude 8.9 N and Longitude 5.6 E with an altitude of 560 m. The study area has a clearly identifiable toposequence with rolling landscape with various slopes at different directions depending on where you are standing. The vegetation of the study area is transitional between the southern forests and the northern savanna zone of Nigeria. The vegetation consists of scattered thick barked trees up to 12 meters high with tall grasses of about 1.5 to 4 m. The area has a tropical climate which is influenced by the movement of the Inter Tropical Discontinuity (ITD) comprising two wind systems (the moisture laden south west monsoon from the Atlantic Ocean and the dry, cold north east trade winds from the Sahara Desert) which give rise to a rainy season from April to October and a dry season from November to March in an average year. The annual rainfall in the area ranges between 1200 - 1300 mm, and the mean annual temperature is 32°C [12]

2.2. Field Study

Three profiles designated as EP1, EP2 and EP3 were dug at the study site representing the upper slope, middle slope and lower slopes, respectively. Each profile was dug to a maximum of about 2 m except where there was an impenetrable resistance (obstruction). Profile description followed Soil Survey Manual [13] and guidelines for soil profile description [14]. For each horizon, soil samples were collected in the three profile pits.

2.3. Laboratory Analysis

A total of 15 soil samples were collected from the study site for laboratory analysis. The samples of soil collected were spread for air-drying, crushed using a mortar and pestle, and latter sieved with a 2 mm-sieve. The samples that did not pass through the sieve were discarded to give fine soil separates. The soil samples were later analyzed for some physical and chemical properties following the procedures outlined by [15].

Particle-size analysis was done using the hydrometer method [16], with sodium hexametaphosphate as the dispersing agent. From information on percent sand, silt and clay, the soil textures were determined using the USDA textural triangle. Soil organic carbon was determined by Walkley and Black sulfuric acid-dichromate digestion followed by black titration with ferrous ammonium sulfate [17]. One (1) g of air-dried soil samples were weighed in duplicate on a filter paper and transferred into a 250 ml conical flask, 10 ml 0.167 M of $K_2Cr_2O_7$ was added. Then 20 ml of concentrated H_2SO_4 was added and the soil and reagent were immediately swirled gently for one minute until they were thoroughly mixed. Afterward, the reagents were swirled more rapidly for one minute and then allowed to stand for 30 minutes. 100 ml of distilled water was added after 30 minutes, 4 drops of ferroin indicator were added. Titration was done with 0.5 iron (II) sulphate. The colour of the soil reagents changed from sharply green to brownish red colouration. Then the titre value was taken for each sample beginning with the blank titre value. The blank value was to standardize dichromate. The calculation was done using the following formula:

$$\% \text{ Organic Carbon} = \frac{(B - S) \times N \times 0.003 \times 100}{\text{Weight of sample}}$$

Where B = blank titre value

S = sample titre value and

N = normality of ferrous sulphate

Total nitrogen was determined using the Kjeldhal distillation method described in a study [18] One (1) gram of 2 mm

Table 1. Site characteristics and land use of the pedons.

Pedon	Slope (%)	Drainage	Erosion		Land Use	Parent Material
			At Site	Surrounding		
EP1	16	WD	M	AE	Grassland	Undifferentiated basement complex
EP2	10	WD	M-S	M-S	Cultivated	Undifferentiated basement complex
EP3	3	MD	non	non	Grassland	Undifferentiated basement complex

EP1, EP2 and EP3 refers to Eleyin profile 1, 2 and 3 respectively; WD = Well Drained; MD = Moderately Drained; S = Slight; AE= Accelerated Erosion.

sieved air dry soil sample was weighed in duplicates, and then transferred into test tubes. One macro Kjeldahl tablet was added to each individual sample in a test tube. The test tubes were then placed in a standing machine for one hour as the digester was being prepared. The test tubes were then placed on the digester and the content was digested for one hour to a temperature of 420°C. Then the tubes were lifted from the digester and placed back on a stand to cool off for 30 minutes. Then distillation and titration were done, respectively.

Available P was determined by the Olsen method as described in a study [19]. The basic cations (K, Ca, Mg and Na) were extracted by leaching 5 g of soil sample with 50 mL ammonium acetate at pH 7 [20]. The exchangeable K in the extract was determined with a flame photometer, and exchangeable Na, Ca and Mg were determined using an absorption spectrophotometer. Effective CEC was the summation of NH_4OAc bases and KCl exchangeable Al and H. The base saturation was obtained by expressing Total Exchangeable Bases (TEB) as a percentage of ECEC. Soil pH was determined in 1:2 soil-water medium by weighing 10 g of 2 mm sieved soil samples into 50 ml beaker and 20 ml of water was added. The sample solution was stirred up occasionally using a glass rod. The samples were allowed to stand for 30 minutes after which the soil pH was taken using a digital electronic pH meter.

2.4. Statistical Analysis

Data collected from each experiment were expressed as means ± standard deviation of the various pedons. The data were subjected to one-way Analysis of Variance (ANOVA) to determine significant difference at 5% level of acceptance using SPSS version 21.

3. RESULTS AND DISCUSSIONS

The pedons in the lower slope were moderately drained, while the middle slope and the upper slopes were well drained. At the surroundings of the upper slope and middle slopes, evidence of little erosion was noticeable which is related to the susceptibility of the soils to water erosion. Erosion was not visible in pedon 3 and its surroundings. Parent materials and topography were observed to be the overriding factors influencing the characteristics (land use types, erosion and drainage) of the site. The parent material determines soil characteristics such as, pore size distribution and particle size (Table **1**).

3.1. Morphological Properties of the Soil

EP1 profile consisted of 3 generic soil horizons with an impenetrable layer at 36 cm making it very shallow, while EP2 and EP3 consisted of 6 horizons each. The surface (A) horizons are formed as a result of deposition and accumulation of humified organic matters from plant materials. The B horizons are created by weathering of the parent materials. EP1 site has fewer horizons, this can be adduced to active processes of soil erosion taken place on the site which might have caused soil instability. EP2 and EP3 sites have relative soil stability which was evidence in soil development in the soils of these sites. The horizons have also exhibited great differences in surface soil colour patterns. The colour varied from brownish black (7.5YR 2/2) to dark brown (7.5YR 3/3) to brown (7.5YR 4/3) in EP1, EP2 and EP3 surface (A) horizons, respectively Table **2**, indicating that soil colour patterns are influenced by topography through its effect on the rates of surface runoff, erosion and deposition. The profiles had also darker colour at the surface (A) as compared to the B horizon, which can be adduced to the relatively higher organic matter content in the A horizon. Generally, the value and chroma increased with soil depth and hue was redder. This can be attributed to an illuvial accumulation of Fe oxides (sesquioxides) into subsurface (B horizon) layer, which is often responsible for the apparent reddish soil coloration.

3.2. Physical Properties of the Experimental Soils

The soils of the pedons were dominated by sand (Table **3**) with the highest mean percentage in EP2 (84.12) followed by EP1 (82.03) then EP3 (68.78) pedons and this may be partly attributed to parent material rich in quartz mineral, an essential component in granite, and partly to geological processes involving sorting of soil materials by biological / agricultural activities, clay migration through eluviation and illuviation, or surface erosion by runoff or their combinations [21]. Accordingly, the soil texture varied from sand (EP1 and EP2) to loamy sand in EP3, with the surface horizons overlying sandy loam, loamy sand and sandy clay loam at the subsurface, respectively. The silt distribution was irregular within soil depth irrespective of landscape positions, probably because these soils were developed *in situ*. It was also observed that EP1 had the highest amount of silt with an average value of 14.28% [22]. The trend of silt content in the surface horizon was EP2 < EP3 = EP1. Clay fraction was next to sand in dominance in all the pedons. Clay was higher in the subsurface than surface horizons. Its distribution within the subsoil of the EP1 and EP2 pedons was irregular, characteristic of a cambic horizon. Results show that there was an increase with depth in clay content of the soil at the lower slope and this was attributed to vertical migration of clay down the profiles and/or high rates of clay formation in subsoil horizons. The increase in clay content of the subsoil (B) horizon can be adduced to the synthesis of secondary clay and the weathering of primary minerals [23, 24]. The mean silt/clay ratio was 2.14, 0.88

Table 2. Morphological properties of the soils in the pedons.

Pedon	Depth (cm)	Horizon	Boundary	Colour Moist	Textural Class (Feel Method)	Structure	Consistency		Roots
							Dry	Moist	
EP1	0-16	A1	SS	7.5Y2/2	Sandy Loam	CGr	VH	H	FI, VA
	16-25	A2	CS	7.5YR4/6	Loamy sand	CG	VH	H	FI-M, VA
	25-36	B	AW	5YR5/6	Sandy Clay Loam	MSAB	VH	H	FI-C, F
EP2	0-11	A1	SS	7.5YR3/3	Sandy loam	MSAB	VH	H	FI, VA
	11-24	A2	SW	7.5YR4/6	Loamy Sand	MSAB	VH	H	FI, VA
	24-37	B1	CW	7.5YR5/8	Sandy Clay Loam	MSAB	VH	H	VF, F
	37-65	B2	CW	5YR5/8	Clay Sand	FSAB	H	FM	Non
	65-128	C1	CS	2.5YR3/6	Sandy Clay	MSAB	MS	H	Non
	128-144	C2	CS	7.5YR6/8	Sandy clay	MSAB	MS	H	Non
EP3	0-10	A1	SS	7.5YR4/3	Clay loam	MMSAB	VH	H	FI, VA
	10-25	A2	CS	7.5YR5/6	Loamy clay	SAB	VH	H	FI, VA
	25-43	B1	CW	7.5YR4/6	Sandy clay loam	CSAB	VH	H	FI, M
	43-61	B2	AW	7.5YR6/6	Clay	SAB	H	FM	Non
	61-92	C1	CS	7.5YR5/6	Clay	AB	MS	H	Non
	91-150	C2	CS	7.5YR7/8	Clay	AB	VH	H	Non

SS = Sharp Smooth; CS = Clear Smooth; AW = Abrupt Wavy; CW = Clear Wavy; SM = Sharp Smooth; SW = Sharp Wavy; CGr = Grainy Coarse Granular; CG = Coarse Granular; MSAB = Medium Sub-Angular Blocky; FSAB = Fine Sub-Angular Blocky; MMSAB = Moderate Medium Sub-Angular Blocky; SAB = Sub-Angular Blocky; CSAB = Coarse Sub-Angular Blocky; AB = Angular Blocky; VH = Very Hard; MS = Moderately Strong; H hard; FM = Firm; FI = Fine; FI-M = Fine-Medium; FI-c = Fine-Coarse; VF = Very Fine; VA = Very Abundant; F = Few.

and 0.92, respectively for EP1, EP2 and EP3 which was an indica-tion that the soils of EP2, EP3 were relatively young. Silt/clay ratio of < 1.00 could mean that these soils had undergone ferralitic pedogenesis. As we move from the upper to lower slope position silt/clay ratio decreased with depth which can also be adduced to clay migration and this indicates the existence of a sheet erosion in top soil horizons.

Table 3. Physical properties of the soil in the pedons.

Pedon	Depth (cm)	Horizon	Particle Size Distribution (%)			Textural Class	Silt: Clay Ratio
			Sand	Silt	Clay		
EP1	0-16	A1	87.12	9.00	3.88	Sand	3.23
	16-25	A2	79.84	14.28	5.88	Loamy sand	2.44
	25-36	B	79.12	9.00	11.88	Sandy loam	0.76
	Mean		82.03a	10.76a	7.21c		2.14
	SD ±		4.43	3.05	4.16		1.26
EP2	0-11	A1	89.12	7.00	3.88	Sand	1.80
	11-24	A2	90.12	6.00	3.88	Sand	1.55
	24.37	B1	85.12	5.00	9.88	Loamy sand	0.51
	37-65	B2	78.12	5.00	16.88	Sandy loam	0.29
	65-128	C1	83.12	6.00	10.88	Loamy sand	0.55
	128-144	C2	79.12	8.00	12.88	Sandy loam	0.62
	Mean		84.12b	5.80b	9.71b		0.88
	SD ±		4.98	0.84	5.11		0.63
EP3	0-10	A1	84.12	12.00	3.88	Loamy sand	3.09
	10-25	A2	78.12	11.00	10.88	Sandy loam	1.01
	25-43	B1	70.12	9.00	20.88	Sandy clay loam	0.43
	43-61	B2	63.12	10.00	26.88	Sandy clay loam	0.37
	61-92	C1	59.12	10.00	30.88	Sandy clay loam	0.32
	92-150	C2	58.12	11.00	30.88	Sandy clay loam	0.35
	Mean		68.78c	10.50a	20.71a		0.92
	SD ±		10.61	1.04	11.18		1.09

EP1, EP2 and EP3 refer to Eleyin profile 1, 2 and 3, respectively. Means not followed by the same letter in a column are significantly different at 5% level of acceptance

3.3. Chemical Properties of the Experimental Soils

The soil reaction, especially for the surface horizons, was rated to be slightly acidic with mean pH values of 6.08, 6.06 and 5.84 for EP1, EP2 and EP3, respectively. The pH range of 5.5 - 7.0 as optimal for overall satisfactory availability of plant nutrients had earlier been reported [25]. The Cation Exchange Capacity (CEC) of the soils ranged from low to medium [26] *i.e* 4.00 to 7.03 cmol (+) kg^{-1} of soil (Table **4**) and showed variation with depth of the profiles. This variation indicates that the soils in the pedons vary in their clay mineral suite [27]. Higher values were generally obtained in the subsurface compared with the surface horizons. The exchange complex of the soils was dominated by Ca followed by Mg, K and Na (Table **4**). Calcium (Ca) and Mg are the dominant cations in the soils and they generally increased with soil depth on the exchange complex except for EP1 and this can be adduced to the leaching of the cations. The range of Ca: Mg ratio of the soils was 1.55 - 2.62 and the K: Mg ratio range between 0.08 - 0.42 was still a good option for crop production. The trend of distribution of Ca within the horizon was in the order of EP1 < EP3 < EP2 signifying the possibility of lateral movement of the nutrient element from upper to middle slope then the lower slope. On the other hand, Mg irrespective of soil depth and landscape position was rated to be moderate. Potassium was rated low in all the horizons. Sodium was also generally rated low in all the pedons showing that the experimental soils were not sodic. Base saturation was rated medium to high and was a reflection of basic cations in the exchange complex [28]. Results (Table **4**) show that organic C and total N decreased with depth. This was due to the presence of vegetative material and root activities on the surface soils as compared with the subsurface. The Organic Carbon (OC) content of the soils in the pedons ranged from 0.23 - 0.26% and was low in accordance with the rating as described in a study [26] and Soil Science correlation committee. Organic C content of less than 1.16% for tropical soils has been reported to be an indication of soil degradation and a high risk of soil erosion [29]. High intensity agricultural activities deplete soil organic matter content [30]. The total nitrogen content of the soils ranged from 0.02 to 1.11% and was also low. Although pedon EP3 has the advantage of receiving soluble nutrients from the upper slopes, its lower N content may be linked to the higher watertable which might be contributing immensely to leaching of N especially the nitrate form. The difference in organic C and total N between EP1 and EP3 could be adduced to the movement of organic material by water and clay contents variation [31]. The C: N ratio of the soils varied with depth and was within the range of 0.21 - 9.58. The ratio is not within the range to provide nitrogen in excess of microbial needs [32] indicating low microbial activities for humification and mineralization of organic residues. Available P contents of the pedons ranged from 4.93 mg kg^{-1} in the C horizon of EP2 to 97.23 mg kg^{-1} in the A1 horizon of EP3. It was rated medium in EP1 and EP2 to high in EP3. High level of available P in EP3 may be due to its low solubility/mobility in soil. Also, the high availability of P content in the sub soil of the three pedons could be due to deposition of P in the sub- soils [33].

Table 4. Chemical properties of the soils in the pedons.

Pedon	Soil Depth	pH (H_2O)	OC ($g\ kg^{-1}$)	TN ($g\ kg^{-1}$)	Av.P ($mg\ kg^{-1}$)	Exchangeable Bases ($cmol\ kg^{-1}$)				Exch. Acidity ($cmol\ kg^{-1}$)	CEC	BS (%)	C: N
						Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}				
EP1	0-16	6.66	0.26	0.13	13.7	2.56	1.20	0.15	0.02	1.28	5.21	75.43	2.06
	16-25	6.04	0.24	0.15	79.4	2.50	1.31	0.14	0.06	1.76	5.77	69.49	1.59
	25-36	5.54	0.23	0.10	6.34	1.70	1.10	0.12	0.04	1.04	4.00	74.00	2.30
	Mean	6.08a	0.24a	0.13a	33.1b	2.25c	1.20b	0.13c	0.04a	1.36a	4.99c	72.9c	1.98c
	SD ±	0.56	0.02	0.02	40.2	0.48	0.11	0.02	0.02	0.36	0.90	3.10	0.36
EP2	0-11	6.34	0.24	0.20	11.6	3.40	1.58	0.19	0.04	1.04	6.25	99.36	1.21
	11-24	6.40	0.24	0.13	8.63	3.48	1.60	0.18	0.07	0.80	6.13	86.95	1.86
	24-37	6.21	0.23	0.11	90.0	3.66	1.72	0.18	0.04	1.28	6.88	81.39	2.09
	37-65	5.84	0.23	0.11	5.28	3.80	1.77	0.14	0.04	1.28	7.03	81.79	2.13
	65-128	6.07	0.23	0.11	4.93	3.78	1.77	0.14	0.03	0.96	6.68	85.63	0.21
	128-144	5.51	0.23	0.02	9.51	3.75	1.78	0.14	0.03	0.96	6.66	85.59	9.58
	Mean	6.06a	0.23b	0.11b	21.6c	3.64a	1.70a	0.16b	0.04a	1.05c	6.60a	86.76a	2.84a
	SD ±	0.34	0.05	0.04	33.5	0.17	0.09	0.02	0.01	0.19	0.35	6.55	3.37
EP3	0-10	6.49	0.23	0.17	97.2	2.88	1.10	0.46	0.04	1.36	5.80	75.34	1.35
	10-25	6.00	0.24	0.11	8.46	2.90	1.11	0.18	0.04	1.28	5.50	76.77	2.50
	25-43	5.07	0.25	0.09	80.8	2.98	1.15	0.21	0.07	1.12	5.53	79.74	2.78
	43-61	4.98	0.23	0.09	79.0	3.10	1.48	0.18	0.04	1.36	6.16	77.92	2.56
	61-92	6.34	0.24	0.09	74.3	3.10	1.41	0.17	0.04	0.96	5.68	83.09	2.73
	92-150	6.14	0.23	0.06	10.2	3.12	1.41	0.16	0.03	1.12	5.84	80.82	3.65
	Mean	5.84b	0.23b	0.10c	58.3a	3.01b	1.28b	0.23a	0.04a	1.20b	5.57b	78.94b	2.59c
	SD ±	0.65	0.01	0.04	38.7	0.10	0.17	0.11	0.01	0.16	0.24	2.83	0.74

EP1, EP2 and EP3 refers to Eleyin profile 1, 2 and 3 respectively; OC = organic carbon; TN = total nitrogen; CEC = cation exchange capacity; BS = base saturation. Means not followed by the same letter in a column are significantly different at 5% level of acceptance

Soils of the middle and lower slope positions are classified as Alfisol at Order level because of the presence of an argillic horizon. It is Ustalfs at the Suborder level because of the ustic soil moisture regime, Plinthustalfs at Great Group level and Typic Plinthustalfs at the Sub- group level. Soil of the upper slope position is classified as Inceptisol at Order level because it has cambic horizon (an altered horizon in which the parent material has been changed into soil by formation of structured - clay), Ochrepts at the suborder level, Ustochrepts at the Great Group level and Typic Ustochrept at the Sub - group level. According to the World Reference Base (WRB) EP2 and EP3 are classified as Luvisols at the Reference Soil Groups (RSGs) for having an argic horizon overlain by loamy sand. At the lower level, they are classified as Haplic Luvisols for having a texture of loamy sand. EP1 is classified as Cambisols because of a cambic horizon.

CONCLUSION

As a result of landscape features, the soils of the experimental site show variations in characteristics and the main landscape feature affecting the soil characteristics and development was topography. Some soil quality indicators, such as structure, organic carbon, total nitrogen, C: N ratio, available P and CEC show variability on the pedons located at EP1, EP2 and EP3 along the toposequence. As we move down the slope, soil depth, rootability and profile development improved while drainage conditions deteriorated. The pedogenic processes along the toposequence dictate the soil quality and characteristics as evidenced by differences in transport and deposition of soil materials. The low fertility status of the soils of Eleyin farms can be brought to better use for agriculture by increasing the organic matter level through incorporation of organic residues, such as farmyard manure, plant residues, and household refuse, and also guided inorganic fertilizer use and improved management practices.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used for studies that are the basis of this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

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