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Soil Genesis as Influenced by Topography of Pinkyo Area, Western Ethiopia

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Abstract The influence of topography on soil genesis was investigated. Initially five slope categories (flat, level to nearly level, very gently sloping, gently sloping and sloping) were created using digital elevation model (DEM). Representative pits were opened in the five adjacent slope categories and the soils were described in situ following FAO soil description guideline. Pedon1 was deeped with weak horizon differentiation due to weak pedogenesis and classified as Eutric Fluvisols (Loamic) in WRB system of classification. Pedon 2 and 3 were deeped and classified as Haplic Vertisols (Hypereutric). Pedon 4 and 5 had shallow depth with thin (8-10 cm) surface horizons and coarse fragments in C horizon and classified as Eutric Cambisols. The soil genesis and soil type of the study area was greatly influenced by the topography of the area. This information would help for an appropriate land use planning, especially for land suitability for irrigation, since the study area is situated adjacent to Baro River, which supposed to have high potential for irrigation.

Key words: Cambisols, Fluvisols, morphology, pedon, slope, Vertisols

Introduction

Soil genesis includes all processes operative within the soil, whether they act to promote horizonation, preserve it, or even destroy it (Schaetzle and Anderson, 2005). Topography, one of the five soil forming factors, influence soil genesis and in turn land suitability for irrigation. Soil genesis is highly dependent on landforms as they control the erosion processes and the soil physical and chemical properties. Soil features are largely controlled by the landforms on which they are developed. Morphological, physical and chemical features of soils can be related to various topographic positions or specific landforms associated with accumulation, erosion and runoff processes during soil formation, due to the effects of adding water and energy, and taking them away from the soil (Senol *et al.*, 2016). This change also has an effect on the structural development of soils along the transverse section.

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The term topography refers to the configuration of the land's surface. The topography of an area incorporates its relief (relative differences in elevation), its aspect (position with respect to compass coordinates), and the general shape and connectivity of land surfaces (Graham, 2006). These attributes mediate how external factors, such as solar radiation, precipitation and wind, impinge upon a site. Topographic relief imparts potential energy, by virtue of gravity, that functions to move water and regolith from higher landscape positions to lower ones. The movement of materials, including water and soil materials, on a landscape is influenced by the slope gradient and shape and the degree of connectivity of drainage networks. Thus, from a pedologic perspective, topography is important because it exerts a strong control on the balance between soil organic matter additions and decomposition, erosion and deposition, leaching and accumulation, and even oxidation and reduction. Generally, topography is a major factor controlling both hydrological and soil processes (Seibert *et al.*, 2007).

Topography is one of the most obvious causes of variation found in crop production (Kumhalova *et al*., 2008). Topographical data in combination with soil information are useful for explaining land suitability for agricultural production. Topographical information can be especially helpful for planning an appropriate land use and site-specific management. In view of this fact, the study was conducted to examine the influence of topography on soil genesis.

Materials and Methods

Description of the study area

The study area, Pinkyo, which is situated about 776 km from Addis Ababa in the western region of the country, covers an area of 24,698 ha. The area is found adjacent to Baro River in the western part of Gambella town. The physiography of the area rang from flat (0-0.2%) to sloping (5-7%).

The climate of the area is formed under the influence of the tropical monsoon from the Indian Ocean, which are characterized with high rainfall in the wet period from May to October and little rainfall during the dry period from November to April (Yeshibir, 2003). The mean minimum annual temperature varies from 18.2 to 21.6 ^{0}C and the mean maximum annual temperature ranges from 30.5 to 40.0 ^{0}C. The mean annual rainfall is about 960 mm.

The major crops grown by farmers include maize (*Zea mays* L.), sorghum (Sorghum bicolor), groundnut (*Arachis hypogae*), sesame (*Sesamum astivum*) and in some extent cotton (*Gossypium sp*.) and rice (*Oryza sativa L*.).

The majority of the land is covered with forest as compared to the cultivated land.

Soil description and classification

Initially, slope categories: flat (0-0.2%), level to nearly level (0.2-1.0%), very gently sloping (1.0- 2.0%), gently sloping (2-5%) and sloping (5-7%) were created using digital elevation model (DEM) (Figure 1). Representative pedons, 1.5 x 2 m, were opened in the five adjacent slope categories and the soils were described *in situ* following FAO soil description guideline (FAO, 2006a). General site information and soil description were recorded and samples were collected from every identified horizon. Based on the morphological properties and the laboratory analysis, the soils of the study area were classified according to WRB (IUSS Working Group, 2014) and Soil Taxonomy (Soil Survey Staff, 2014).

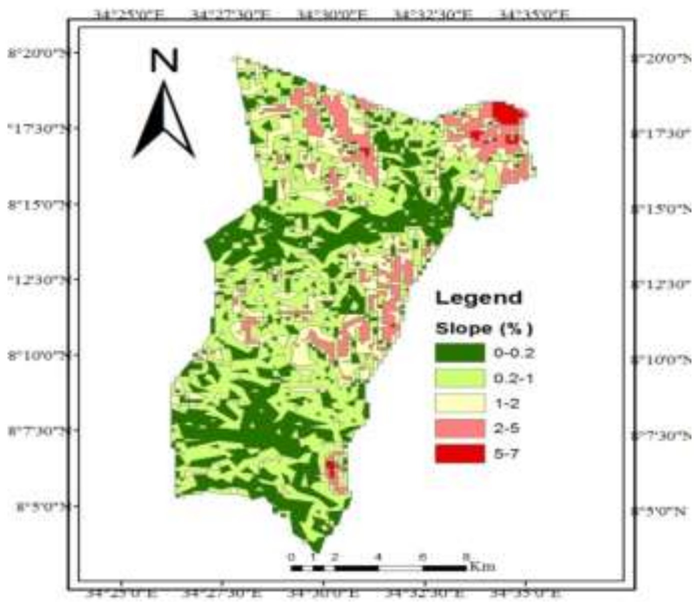

Figure 1. Slope category of Pinkyo area

Soil sample preparation and analysis

The soil samples were air-dried and ground to pass through 2 mm sieve. For the determinations of total N and organic carbon (OC), a 0.5 mm sieve was used. Analyses of the soil physicochemical properties considered in the study area were carried out following standard laboratory procedures. Particle size distribution was determined by the hydrometer methods (Bouyoucos, 1962). Soil pH and electric conductivity (EC) were measured in a 1:2.5 soil to water ratio suspension (Van Reeuwijk, 2002), whereas OC was determined by the wet digestion method (Sahlemedhin and Bekele, 2000). Total N was determined by the micro-Kjeldahl wet digestion and distillation method (Bremner and Mulvaney, 1982) while available P was extracted by the modified Olsen method (Olsen and Somers, 1982) and finally quantified by spectrophotometer. The cation exchange capacity (CEC) and exchangeable bases were extracted by 1M ammonium acetate (pH 7) method (Van Reeuwijk, 2002). In the extract, exchangeable Ca and Mg were determined by atomic absorption spectrophotometer (AAS) and exchangeable K and Na by flame photometer, whereas CEC was determined from the displaced ammonium through distillation followed by titration. Calcium carbonate and gypsum contents were determined following acid neutralization method (Jacson, 1970) and Nelson procedure (Nelson, 1982), respectively.

Data interpretation and mapping

The laboratory results of selected physical and chemical properties of the study area were interpreted using ratings established by different authors ((Tekalign, 1991; Jones, 2003; FAO, 2006b; Hazelton and Murphy, 2007; Scianna et al., 2007). The slope category map of the study area was made using ArcGIS10.3.1.

Results

Soil genesis, morphological properties and classification

The selected morphological properties of the pedons are presented in Table 1. Pedon1 that represents the flat (0-0.2%) land was deep with weak horizon differentiation due to weak pedogenesis. The area is found in the river plan and flooded every rainy season that leads to periodical fluvial deposit. The soil color of the pedon ranges from yellowish brown (10YR5/6) to dark brown (10YR3/3). It had moderate fine and medium granular structure and slightly hard, friable, slightly sticky and slightly plastic consistency of surface horizon. The pedon had fluvic diagnostic material with base saturation (by 1M NH_4OAc) of 50 percent or more throughout between 20 and 100 cm from the soil surface. As a result, the pedon is classified as Eutric Fluvisols (Loamic) and Oxyaquic Ustifluvents in WRB and Soil Taxonomy system of classification, respectively.

Pedon 2 and 3, which were opened in level to nearly level (0.2-1.0%) and very gently sloping (1.0- 2.0%) were deep. In response to the fine-textured swelling soil, infiltration is slow and in the rainy season water may stand on the surface for extended periods. The soil color of the pedons ranges from brown (10YR5/3) to black (10YR2/1). These pedons had moderate medium granular structure and hard, friable, sticky and plastic consistency of surface horizons. This profile had slickenside and shiny pressure faces in the subsurface horizons, indicating the shrink-swell properties of the soil (Dengiz, 2010). The pedon had thick (≥ 25 cm) subsurface horizons that had greater than 30% clay, which qualify it for vertic diagnostic horizons and also had base saturation (by 1M NH_4OAc) of 50 percent or more throughout between 20 and 100 cm from the soil surface and 80 percent or more in some layer between 20 and 100 cm of the soil surface, that qualify hypereutric with haplic principal qualifier. Thus, the pedons are classified as Haplic Vertisols (Hypereutric) and Typic Haplusterts in WRB classification and Soil Taxonomy system of classification, respectively.

Pedon 4 and 5 that represent gently sloping (2-5%) and sloping (5-10%) had shallow depth with thin (8-10 cm) surface horizons and coarse fragments in C horizon. The soil color of the pedons ranges from dark yellowish brown (10YR4/4) to very dark grayish brown. These pedons had moderate fine to medium granular structure and slightly hard, friable, sticky and plastic consistency of surface horizons. They had cambic subsurface diagnostic horizons with base saturation (by 1M NH_4OAc) of 50 percent or more. Consequently, the pedons are classified as Eutric Cambisols and Oxaquic Haplustepts in WRB and Soil Txonomy system of classification, respectively.

Soil physical and chemical properties

The selected soil physical and chemical properties of the study area are presented in Table 2 and 3. The particle size distribution of the soils varies across the pedons. Relatively high (53 – 60%) proportion of clay was observed in pedon 2 and 3 of level to nearly level (0.2 – 1.0%) slope, whereas relatively high (44 – 58) proportion of silt was observed in pedon 1 of the flat (0 -0.2%) land. With regard to sand, relatively high (14 – 33) proportion was recorded in pedon 5 of sloping (5 – 10%) land.

The bulk density of the pedons varied from 1.25 to 1.39 gm cm^{-3} in the surface horizons and 1.31 to 1.49 gm cm^{-3} in the sub-surface horizons. The bulk density of the sub-surface horizons were higher than that of surface horizons and increased with depth, which might be due to compaction caused by the overlaying horizons.

Table 1. Selected morphological properties of the pedons

Pedon	Horizon[1]	Depth (cm)	Boundary[2]	Color		Texture (Feel method)	Structure[3]	Consistency[4]	Coarse fragment (%)
				Dry	Moist				
1	Ap	0-28	GS	10YR4/4	10YR3/3	Clay loam	MO,FM,GR	SHA,FR,SST,SPL	-
	B1	28-70	GS	10YR4/5	10YR4/4	Silty clay	MO,ME,AB	SHA,FR,SST,SPL	-
	B2	70-90	DS	10YR5/6	10YR4/6	Silty clay	MO,ME,AB	SHA,FR,SST,SPL	-
	B3	90-140	DS	10YR5/6	10YR4/6	Silty clay	MO,ME,AB	SHA,FR,SST,SPL	-
	B4	140-200^{+}	-	10YR5/6	10YR4/6	Silty clay	MO,ME,AB	SHA,FR,SST,SPL	-
2	Ap	0-23	GS	10YR3/2	10YR2/1	Clay	MO,ME,GR	HR,FR,ST,PL	-
	Bi1	23-55	DS	10YR3/3	10YR3/1	Clay	ST,ME,AB	HA,FI,ST,PL	-
	Bi2	55-80	DS	10YR3/3	10YR3/2	Clay	ST,CO,AB	HA,FI,ST,PL	-
	Bi3	80-110	DS	10YR4/2	10YR4/1	Clay	ST,CO,AB	HA,FI,ST,PL	-
	Bi4	110-155^{+}	-	10YR5/3	10YR5/2	Clay	ST,CO,AB	VHA,EFI,VST,VPL	-
3	Ap	0-20	GS	10YR3/2	10YR2/1	Clay	MO,ME,GR	HR,FR,ST,PL	-
	Bi1	20-55	DS	10YR3/3	10YR3/1	Clay	ST,ME,AB	HA,FI,ST,PL	-
	Bi2	55-80	DS	10YR3/3	10YR3/1	Clay	ST,CO,AB	HA,FI,ST,PL	-
	Bi3	80-110	DS	10YR4/2	10YR4/1	Clay	ST,CO,AB	HA,FI,ST,PL	-
	Bi4	110-155^{+}	-	10YR5/3	10YR5/1	Clay	ST,CO,AB	HA,FI,ST,PL	-
4	Ap	0-10	CS	10YR3/3	10YR3/2	Clay	MO,FM,GR	SHA,FR,ST,PL	-
	Bw	10-35	CS	10YR3/4	10YR3/3	Clay	ST,ME,AB	HA,FI,ST,PL	-
	C	35-80	-	10YR4/3	10YR3/2	Clay loam	ST,CO,AB	SHA,FR,ST,PL	37
5	Ap	0-8	CS	10YR3/4	10YR3/3	Clay	MO,FM,GR	SHA,FR,ST,PL	-
	Bw	8-28	GS	10YR4/4	10YR4/2	Clay	ST,CO,AB	HA,FI,ST,PL	-
	C	28-48	-	10YR4/4	10YR4/2	Clay loam	ST,CO,AB	SHA,FR,ST,PL	39

[1]i = Slickenside; [2]CS = Clear and smooth; GS = Gradual and smooth; DS = Diffuse and smooth ; [3]ST= Strong; MO= Moderate; VST= Very strong; FI= Fine; FM= Fine and medium; ME= Medium; CO = Coarse; VC= Very coarse; GR= Granular; AB= Angular blocky; [4]SHA= Slightly hard; HA= Hard; VHA= Very hard; FR=Friable; FI=Firm; EFI=Extremely firm; ST= Sticky; SST= Slightly sticky; VST = Very sticky; PL= Plastic; SPL= Slightly plastic; VPL= Very plastic

The pH values of the pedons ranged from 6.4 to 7.3 and found to be increasing with depth in pedon 2 and 3. Electrical conductivity (EC) values of the pedons varied from 0.04 to 0.09 dS m^{-2}. Similarly, the calcium carbonate ($CaCO_3$) content within the pedons varied from 0.14 to 0.39%, whereas the gypsum ($CaSO_4 \cdot 2H_2O$) content was trace throughout the soil profiles.

The organic matter (OM) content ranged from 2.08 to 2.98% in the surface layers of all pedons. The values decreased with increasing depth in all pedons. Relatively higher OM (2.98%) for surface layers was recorded in grass land (Pedon 5), while the lowest (2.08%) was recorded in cultivated land (Pedon 3). The total N content of the surface soils ranged 0.12 to 0.17%. Similar to OM, total N content decreased with depth in all pedons. The available phosphorus content of surface horizons of the pedons ranged from 2.4 to 36.5 mg kg^{-1}.

Table 2. Selected physical properties of the pedons

Pedon	Horizon	Depth (cm)	Particle Size Distribution (%)			Textural Class[1]	Bulk Density (gm cm^{-3})
			Clay	Silt	Sand		
1	Ap	0-28	31	47	22	Cl	1.32
	B1	28-70	30	58	12	SCl	1.39
	B2	70-90	32	53	15	SCl	1.41
	B3	90-140	34	44	32	Cl	1.45
	B4	140-200$^+$	27	46	27	L	-
2	Ap	0-23	57	15	28	C	1.29
	Bi1	23-55	58	18	24	C	1.35
	Bi2	55-80	59	17	24	C	1.42
	Bi3	80-110	60	13	27	C	1.44
	Bi4	110-155$^+$	56	15	29	C	-
3	Ap	0-20	55	16	29	C	1.25
	Bi1	20-55	58	15	27	C	1.31
	Bi2	55-80	60	13	26	C	1.40
	Bi3	80-110	56	14	30	C	1.42
	Bi4	110-155$^+$	53	15	32	C	1.49
4	Ap	0-10	45	34	21	C	1.39
	Bw	10-35	48	36	16	C	1.47
	C	35-80	31	37	32	Cl	-
5	Ap	0-8	50	36	14	C	1.33
	Bw	8-28	51	29	20	C	1.43
	C	28-48	29	48	33	Cl	-

[1]Cl = Clay loam; C = Clay; SCl = Silt clay loam; L = Loam

Table 3. Selected chemical properties of the pedons

Pedon	Horizon	pH H_2O	EC (dSm^{-1})	$CaCO_3$ (%)	$CaSO4.2H_2O$ (%)	OM (%)	TN (%)	Av.P (mg/kg)	Exchangeable bases ($cmol_c$ kg^{-1})					CEC ($cmol_c$ kg^{-1})	ESP (%)	PBS
									Ca	Mg	K	Na	TEB			
1	Ap	6.7	0.04	0.14	Trace	2.36	0.13	36.5	16.6	18.7	0.15	0.17	35.62	38.02	0.48	94
	B1	6.5	0.07	0.17	Trace	1.96	0.11	20.7	20.8	6.6	0.15	0.32	27.87	32.43	1.15	86
	B2	6.8	0.05	0.15	Trace	1.21	0.05	15.6	14.4	5.2	0.14	0.30	20.04	22.35	1.50	90
	B3	6.6	0.06	0.16	Trace	0.96	0.06	7.9	15.8	4.7	0.14	0.28	20.92	26.57	1.34	79
	B4	6.9	0.09	0.15	Trace	0.75	0.03	9.8	17.4	3.8	0.13	0.27	21.6	25.54	1.25	85
2	Ap	6.6	0.07	0.15	Trace	2.12	0.12	2.4	31.8	15.7	0.36	0.47	48.33	52.97	0.97	91
	Bi1	6.8	0.06	0.14	Trace	1.40	0.06	2.36	28.8	13.1	0.22	0.80	42.92	44.82	1.86	96
	Bi2	6.5	0.08	0.21	Trace	0.48	0.03	0.29	27.5	15.4	0.34	1.33	44.57	49.85	2.98	89
	Bi3	6.9	0.07	0.33	Trace	0.28	0.02	1.34	36.2	18.7	0.36	1.61	56.87	59.61	2.83	95
	Bi4	6.9	0.06	0.29	Trace	0.22	0.01	0.98	35.9	16.9	0.34	1.74	54.88	58.52	3.17	94
3	Ap	6.8	0.05	0.18	Trace	2.08	0.12	5.6	26.5	14.4	0.38	0.57	44.85	51.74	1.27	87
	Bi1	7.1	0.05	0.20	Trace	1.94	0.12	4.5	27.7	12.9	0.24	0.76	41.6	46.94	1.83	89
	Bi2	7.3	0.08	0.30	Trace	1.28	0.07	2.1	26.3	14.1	0.39	1.43	42.22	48.71	3.39	87
	Bi3	6.9	0.07	0.31	Trace	0.76	0.05	1.4	33.4	16.5	0.33	1.52	51.75	59.92	2.94	86
	Bi4	7.0	0.09	0.39	Trace	0.44	0.03	0.75	36.2	14.8	0.37	1.69	53.06	59.34	3.19	89
4	Ap	6.7	0.04	0.36	Trace	2.65	0.14	9.7	23.4	11.9	0.11	0.05	35.3	46.83	0.14	75
	Bw	6.5	0.06	0.36	Trace	1.43	0.08	4.7	21.6	9.7	0.13	0.07	31.5	46.04	0.22	68
	C	6.8	0.05	0.25	Trace	0.45	0.03	5.7	24.7	8.9	0.15	0.05	33.8	44.15	0.15	77
5	Ap	6.9	0.06	0.24	Trace	2.98	0.17	12.8	25.5	10.9	0.13	0.07	36.6	47.89	0.19	76
	Bw	6.6	0.06	0.18	Trace	1.76	0.08	8.2	22.3	9.2	0.16	0.05	31.71	46.22	0.16	69
	C	6.4	0.08	0.21	Trace	0.78	0.03	7.4	19.8	8.9	0.14	0.07	28.91	43.90	0.24	66

EC = Electrical conductivity; OM = Organic matter; TN = Total nitrogen; Av.P = Available phosphorus; TEB = Total exchangeable bases; ESP = Exchangeable sodium; PBS = Percent base saturation

The status of exchangeable Ca and Mg varied from14.4 to 36.2 and 3.8 to 18.7 cmolc kg-1, respectively, whereas the exchangeable K varied from 0.11 to 0.39 cmolc kg^{-1}. The exchange complex was found to be dominated by Ca followed by Mg, K, and Na. The cation exchange capacity (CEC) of the soils ranged from 22.35 to 59.92 cmolc kg^{-1} and relatively high in Vertisols as compared to Fluvisols and Cambisols. The Na content throughout the profiles of all pedons was low (0.14 to 3.19%), indicating the absence of sodicity problem. The percent base saturation of the pedons ranged from 66 to 96%.

Discussion

The soil formation, morphological properties and soil types of the study area varied due to the influence of topography. The soils with flat (0-0.2%) to very gently sloping (1.0- 2.0%) were deep. The main reasons could be deposition of soil particles that had been eroded from the adjacent sloping watershed and accumulation of water, which is one of the prerequisite for intense weathering. The flat land has subjected to periodic deposition following the rainy seasons of the study area. In this situation, there would be evidence of stratification and weak horizon differentiation (IUSS Working Group, 2014), as a result Fluvisols had developed.

In the case of level to nearly level (0.2-1.0%) and very gently sloping (1.0- 2.0%), the sediments contain a high proportion of swelling clays that had been formed upon post-depositional weathering, as a result Vertisols had developed in this slope category. Vertisols are often found in lower landscape positions such as dry lake bottoms, river basins, lower river terraces, and other lowlands that are periodically wet in their natural state (IUSS Working Group, 2014). The distinct wet and dry seasons of the study area favored the formation and development of Vertisols. The average annual rain fall (960 mm) of the area is with the range that favorable for Vertisols development. Most Vertisols occur in the semi-arid tropics with an average annual rainfall of 500 – 1 000 mm (IUSS Working Group, 2014).

The gently sloping (2-5%) and sloping (5-10%) category had shallow soil depth with an incipient subsurface soil formation and beginning of horizon differentiation, consequently Cambisols had developed. Cambisols are characterized by slight or moderate weathering of parent material and by absence of appreciable quantities of illuviated clay, organic matter, Al and/or Fe compounds (IUSS Working Group, 2014). They are also common in areas with active geologic erosion, where they may occur in association with mature tropical soils.

The selected soil physical and chemical properties of the study area varied across the slope categories. Relatively high (44 – 58) proportion of silt was observed in pedon 1 of the flat (0 -0.2%) land. Alluvial deposits in land depressions have low sand contents and most of the non-clay materials are of silt size (Ahmad, 1983). However, generalities cannot be made about the particle-size distribution of Fluvisols overall (Grossman, 1983).

Relatively high (53 – 60%) proportion of clay was observed in pedon 2 and 3 of level to nearly level (0.2 – 1.0%) slope. In this slope category, the sediments contain a high proportion of swelling clays that had been formed upon post-depositional weathering. In the other hand, relatively high (14 – 33) proportion of sand was recorded in pedon 5 of sloping (5 – 10%) land. The possible reason could be selective erosion of clay and silt to the down slopes.

The textural class of the soils varied from clay loam to clay. This textural variation might be due to differences in topography, in-situ weathering and illuviation process. In most of the pedon, sub-surface horizons exhibited higher clay content as compared to surface horizons due to the illuviation process occurring during soil development.

Following the general relationship of soil bulk density to root growth, the root-restricting bulk densities for clay are greater than 1.47 g cm^{-3} (USDA, 2008) and for clay loam greater than 1.75 g cm^{-3} (USDA, 1999). Thus, the soils of the study area were not compacted to the extent of restricting root growth.

Generally, the soils of the study area were rated as slightly acidic (6.4) to neutral (7.3) in soil reaction (Tekalign, 1991). The area had no high rainfall that causes leaching of exchangeable bases and there was no fertilizer application history that leads to soil acidity. The electrical conductivity values of the soils were less than 0.1 dS m^{-2}, which was non-saline (Scianna *et al*., 2007). The calcium carbonate and gypsum values of the pedons were low and trace, respectively. The possible reason could be due to the parent materials of the study area.

The organic matter and total nitrogen content of the soils were categorized under low to medium (Tekalign, 1991). The low content of the soils in OM and total N were attributed to the warmer climate of the area, which enhances rapid rate of mineralization. This situation would be more pronounced in cultivated land, since cultivation practices favor decomposition and mineralization of organic matter (Dengiz, 2010). The available P values of the pedons were rated as low to high (Jones, 2003) and its values decreased with increasing depth which could be attributed to decrease in soil OM, as was also asserted by their positive significant correlation in previous studies (Mulugeta and Sheleme, 2010; Teshome *et al*., 2016; Ogbu *et al*., 2017).

The Ca and Mg content of the soils were rated as high to very high (FAO, 2006b), which could be considered as an appropriate for plant growth. Cations in productive agricultural soils are present in the order Ca^{2+} > $Mg2^{+}$ > K^{+} > Na^{+} and deviations from this order can create ion-imbalance problems for plants (Bohn *et al*., 2001). The CEC values of the pedons were rated as medium to very high (Hazelton and Murphy, 2007) and relatively high in Vertisols, which could be due to the high clay content predominantly of montmorillonite mineralogy with high permanent charge (Ahmad, 1983). Genesis of montmorillonite in a soil environment requires the accumulation in the solum of basic cations such as Ca and Mg. In every case where Vertisols develop from in-situ weathering of basic igneous and metamorphic rocks, environmental conditions such as nearly flat topography, restricted annual rainfall and/or seasonal distribution of precipitation would ensure accumulation of bases and therefore the genesis of 2:l minerals (Ahmad, 1983).

Conclusion

The study showed that Pedon1 that represents the flat (0-0.2%) land was deep due to periodic alluvial deposition with weak horizon differentiation. Pedon 2 and 3, which were opened in level to nearly level (0.2-1.0%) and very gently sloping (1.0- 2.0%) were deep and imperfectly drained. Pedon 4 and 5 that represent gently sloping (2-5%) and sloping (5-7%) had shallow depth with thin (8-10 cm) surface horizons. This information would help for an appropriate land use planning, especially for land suitability for irrigation, since the study area is situated adjacent to Baro River, which supposed to have high potential for irrigation.

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