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Characterization and Classification of Soils of Aba-Midan Sub Watershed in Bambasi Wereda, West Ethiopia

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Abstract- The research work was conducted on Aba-midan sub water shed, which is located in the Bambasi District of Assosa Zone in the Benishagul Gumuz Regional State to characterize and to classify the soils along toposequence. Three pedons along toposequence were studied. Aba-midan sub watershed is located between 09°49' 98.9'' and 09°49'89.3'' N latitude and between 34°42' 31.8'' and 34°42'50.3''E longitude, with altitude ranging from 1443 to 1491 m.a.s.l. The soils were generally dark reddish brown to dark red colour and shallow to moderate soil depth. Almost very friable consistency, with bulk density ranges (1.14 to 1.49 gm/cm3), prismatic to sub angular blocky structure, low total porosity indicated that the soil has poor physical condition for plant growth. a definite trend of clay increase down the profile and along the slope in all of the soil pedons. The soils pH along the profiles were slightly (pH: 5.2) to moderately acidic (pH: 6.4). All the micro and macro nutrients, cations and CEC have irregular trends in all the pedons along depth .While Organic carbon content of the soils decrease with soil depth. The available P and TN of the soils of the study area was qualifying for the low range. The surface horizons of all the pedon in the study area qualify for mollic epepedon. The middle and lower pedons had distinct clay increment in the B horizons, which met all the requirements of natic horizon. While the upper sub surface pedons with cambic horizons. Based on the morphological and chemical data obtained from the opened pedons, the soil of the study area was classified under Mollic Nitisol The deterioration in some chemical properties of lower slope as compared to other slopes were supposed to be due to continuous cultivation for longer period of time and that removed the soil organic matter and other plant nutrients. This study results concluded that increasing extent of continuous and intensive cultivation with minimum conservation practices and erosion due to slope effect can further deteriorate soil properties. The control of such damaging effects would require proper soil conservation strategies such as proper land leveling, afforestation, crop rotation, fallowing, terracing and inclusion of restorative crops in cropping systems on these lands.

Index Terms- Soil physico-chemical properties, pedons, Topography, Aba-midan sub water shed

I. Introduction

Agricultural development is crucial to the survival of mankind in as much as the provision of food, shelter and clothing is closely associated with it. Food, in particular is necessary for growth, energy production for good health and normal development of the population. All living things depend on their environment for survival to remain alive, thrive and reproduce their kinds. As it is known, nearly all green plants depend on soils which provide a conducive environment and supply all the essential materials that they need for their growth. Since animals, in turn, depend on plants, it becomes obvious that all agricultural activities directly or indirectly depend on the soil. It is from the soil that plants obtain their nutrients and water. It also contains air needed for respiration of the roots (Akinrinde, 2004).

Like other, countries in Ethiopia, agriculture is the predominant economic activity. Due to this, there is an increasing demand for information on soils as a means to produce food (Fasina *et al*., 2007). In addition as a result of agricultural development and increasing demand for experimental data, much work should be carried out on soil characterization. This provides the basic information necessary to create functional soil classification schemes, and assess soil fertility in order to unravel some unique soil problems in an ecosystem (Lekwa *et al*., 2004).

Characterization of soils is fundamental to all soil studies, as it is an important tool for soil classification, which is done based on soil properties. It also provides information for understanding of the physical, chemical, mineralogical and microbiological properties of the soils (Ogunkunle, 2005). In addition it can help to determine the types of vegetation and land use best suited to a location (Globe, 2005). Soil classification, on the other hand, helps to organize our knowledge, facilitates the transferring of experience and technology from one place to another and helps to compare soil properties. A soil characterization study therefore is a major building block for understanding the soil, classifying it and getting the best understanding of the environment (Esu, 2005).

Soils are being degraded worldwide through processes of erosion, overgrazing, salinization, compaction, organic matter depletion, and nutrient imbalance. The current activities which focus on ensuring sustainable ecosystems must be the protection and enhancement of soil quality. The concept of soil resource management for sustaining the productivity of plant systems was needed to ensure the reality of sustainable agriculture and environmental protection. Characterizing soil type can serve as an indicator of the soil's capacity to produce safe and nutritious food, enhance human and animal health, and overcome degradation processes (Schoenholtza *et al*., 2000).Therefore, the overall purpose of this new emphasis on soil characterization is to develop a more sensitive and dynamic way to document a soil's condition, how it responds to cultivation and its resilience to stresses imposed by cultural practices.

Information of soil and related properties obtained from the soil survey and soil classification can help in better delineation of soil and land suitability for irrigation and efficient irrigation water management. So, depending on the suitability of the mapped agro-ecological units for a set of crops, optimum cropping patterns have to be suggested taking into consideration the present cropping systems and the socioeconomic conditions of the farming community (Sehgal *et al*., 1989).

In Benishangul-Gumuz Region like Bambasi Wereda, there is a problem of lack of information on soil characterization and soil fertility status. Particularly in the study area the dominant soil type is not known. Consequently the agricultural experts do not know the available and deficient nutrients in the soil to supply the required amount of inorganic or organic fertilizers to the cultivated crop. This condition creates a conducive environment for the expansion of unwise land use practices and allocating lands without considering its capability and suitability classes for each and every crop that are grown in the Wereda. For that the soil becomes exposed for maximum degradation and loss of fertility potential. Due to this the farmers in the study area prefer to use extensive system of farmland expansion in cost of destructing the available natural forests and its ecosystem to maximize their crop yields rather than searching a solution for the degraded land. Therefore, the purpose of this study will be to characterize and classify soils of Bambasi sub watershed to generate baseline information, which was important for formulating the management alternatives for different soil types identified.

The research would help to know the major soil type and the fertility level of the soil in the Aba-Midan sub watershed of Bambasi Wereda; based on these it was become simple to infer and identify the crop type which was highly productive on the land. The outcome of the study was fill the knowledge gap on the soil minerals available in the soil and the minerals which are deficient and require application. Based on the research result it is possible to classify the total area of lands in the watershed into their suitability classes for the appropriate agricultural practices possible to do on the land. The result of the study can be a baseline data for the developmental projects that will be done in the Wereda; mainly in agricultural sector. Finally, this soil research also paves a way for further related research in the Bambasi Wereda specifically in Beneshangul-Gumuz Region generally. Therefore; the research was initiates with the following objectives:

- To characterize the physico-chemical properties of soils of the study area and
- To classify the soils according to USDA and World Reference Base Legend

II.

III. MATERIALS AND METHODS

3.1. Description of the Study Area

Bambasi Wereda is located in Assosa Zone of Benishangul-Gumuz National Regional State. The Wereda administrative town is known as Bambasi. It is 640kms away from the capital city of the country Addis Ababa and also 46 kms away from the regional and zonal administrative town Assosa to the eastern direction. Bambasi Wereda is bordered in the Northern direction by Oda Bildigilu Wereda of Benishangul Gumuz Region, in the Southern direction by Begi Wereda of Oromia Region and Mao-Komo Special Wereda of Benishangul Gumuz Region, in the Eastern direction by Menesibu Wereda of Oromia Region, in the Western direction by Assosa Wereda of Benishangul Gumuz Region (Bambasi Wereda Administration Office, 2014).

The Wereda is physiographically characterized by Lowland and Midland. The altitude range is lying between 1350-1470m above sea level. The Wereda has diversified land forms such as Plateaus, Hills, Plains and Valleys. It has 38 rural peasant associations and 2 urban dwellers associations which are totally 40 kebeles. The total area of the Wereda is 221,014 hectare (Bambasi Wereda Administration Office, 2014).

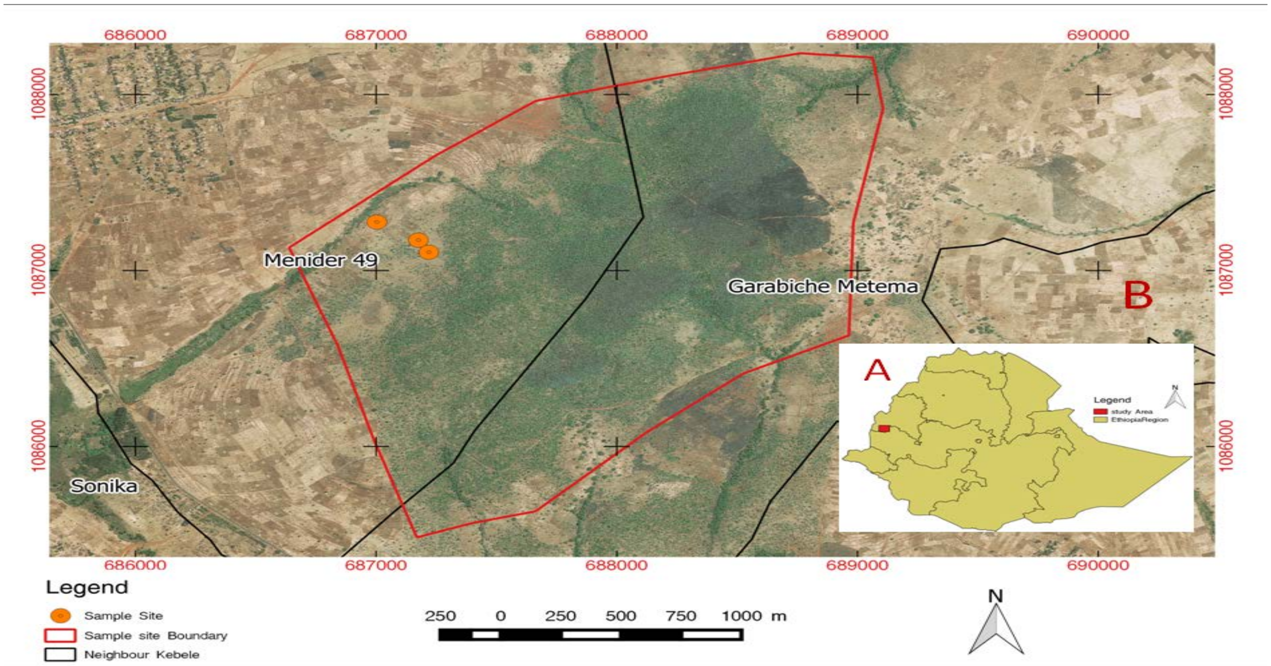

Figure 1: Map of the study area

3.1.2. Climate

The agro-ecological zone of the Wereda is categorized as 15% *Weynadega 5% Dega* and 80% *Kolla*. The annual Rainfall ranges between 900mm-1500mm and the average temperature is 28°C. The study area has a mono-modal rainfall distribution pattern. The rainy season, extends from May to October and the dry season extends from November to April. During the rainy season most of the crops in the Wereda are cultivated by using the moisture which is obtained from the rainfall. The rest of the crops are produced in the dry season by using the moisture which is obtained from wetlands found at the side of streams, rivers bank and irrigation water (Bambasi Wereda Agricultural Development Office, 2014).

3.1.3. The socio-economic conditions and population

Even though there is no equal share of land among the farming community of the Wereda, the average land holding size of a single rural household is 15 hectares of land. The livelihood of the people of the study area is mainly depend on crop production and livestock production. The crops mainly produced are maize, sorghum, finger millet, teff, haricot bean, noug, sesame etc. The domestic animals mainly being reared are cattle, sheep, goat, mule, donkey and poultry. The total human population of the Wereda is 62,693 out of this 31,539 are males and 31,154 are females. The urban dwellers of the wereda are 20% of the total population and the rural dwellers are 80% of the total human population in the Wereda (Bambasi Wereda Administration Office, 2014).

3.1.4. Soil type and geology

There are many soil types in the wereda. Most of them are conducive for agricultural production such as crop cultivation, livestock rearing and forest tree production. Because of high availability of rainfall and undulating nature of the land forms; the soil resources in the wereda are exposed for leaching which in turn exacerbate soil acidity problem. Even though the soil resources of Bambasi Wereda were depleted by inappropriate land use practices and geological factors; it has high capacity and possibility for restoration and rehabilitation. The rock types mainly found in the wereda are basalt, granite, limestone and the like (EARO, 1998).

3.1.5. The land use types

The land use types of the Wereda are dominated by private farm lands. It covers 65% of the total land out of which is 85,747 hectares of land are covered by annual crops and 2373 hectares are covered by perennial crops such as coffee and fruits. Grazing lands in the Wereda cover 18,021 hectares that is 10%, forest land covers 12,488 hectares which is 20% of the total area of the Wereda of which 3743 hectares are intact forest and 8745 hectares are scattered or riverine forests. The wetlands in the Wereda cover 720 hectares and the lands covered by the domestic purposes such as homesteads, roads, public institutions are 350 hectares. The degraded land which is left without any use in the Wereda cover 350 hectares and the future cultivable land or virgin land including savanna grass lands covers 82,270 hectares (Bambasi Wereda Rural Land Administration and Environmental Protection office, 2014).

3.2. Type and Sources of Data

The primary data was obtained by collecting soil samples. Soil profile or Pedons was excavated from the representative fields in the Aba-Midan sub watershed on which the research was carried out for the soil type characterization and for the soil fertility level analysis. Moreover the secondary data was collected from literatures (scientific reports, proceedings and statistical abstracts), Bambasi Wereda Agriculture Development Office, Bambasi Wereda Rural Land Administration and

Environmental protection office. The development agents and the peasant association manager assigned in the PAs where the sub watershed is found and provide the basic information concerning the micro catchment.

3.3. Method of Data Collection

3.3. 1. Sampling techniques for soil profile characterization

A semi-detailed soil survey was carried out in Aba-Mijan sub watershed of Bambasi Wereda. Field observations and analysis relating to morphological properties of the soils, topography by using clinometers, soil color with Munsell standard color chart, soil consistency analysis in three moisture level i.e. under wet, moist and dry condition was carried out to establish the soil boundaries. The sampling site was separated into three groups based on their topographic position or slope gradient difference upper slope, middle slope and bottom slope. Three soil profile pit with 1m width, 2m length and 1.5m depth was excavated in each identified soil sampling sites. The soil samples were taken from surface and subsurface horizons in each sampling site and a total of 12 soil samples were collected for laboratory analysis. The soil samples were collected from the four corners of the pit and they were mixed thoroughly in a plastic bag to form a composite soil sample. The soil profiles were characterized according to FAO (2006) Soil Taxonomy Guideline. The collection of bulked samples was made from each horizon for bulk density analysis in laboratory.

3.4. Method of Data Analysis

3.4.1. Analysis of Soil Physical and Chemical Properties

The soil physical and chemical properties will be analyzed at National Soil research Laboratory. Soil particle size distribution (texture) was be analyzed by the Bouyoucos hydrometer method following the procedure described by Bouyoucos (1962). Soil bulk density was determined on undisturbed soil samples using the core method and particle density of soil was determined by using the pycnometer method (Blake, 1965). Total soil porosity was calculated from the values of bulk density (ρ_b) and particle density (ρ_s) using the following relationship:

$$\text{Total porosity}(\%) = \left(1 - \frac{\rho_b}{\rho_s}\right) \times 100$$

Soil pH was measured potentiometrically using a pH meter with combined glass electrode in 1: 2.5 soils: The soil electrical conductivity (EC) was measured in 1:1 (weight ratio) dry soil to distilled water mixtures (Ryan *et al.*, 2001). The Walkley and Black (1934) wet digestion method was used to determine soil organic carbon content and percent soil OM was obtained by multiplying percent soil organic carbon by a factor of 1.724. Similarly total N was analyzed using the Kjeldahl digestion, distillation and titration method as described by Black (1965) by oxidizing the OM in concentrated sulfuric acid solution (0.1N H2SO4). Determination of available P was carried out by the Olsen method using sodium bicarbonate as extracting solution (Olsen *et al.*, 1954).

Cation exchange capacity (CEC) and exchangeable bases (Ca, Mg, K and Na) were determined after extracting the soil samples by ammonium acetate (1N NH4OAc) at pH 7.0. Exchangeable Ca and Mg in the extracts were measured by using atomic absorption spectrophotometer, while Na and K were read using flame photometer (Rowell, 1994). Cation exchange capacity was thereafter estimated titrimetrically by distillation of ammonium that will be displaced by sodium from Nacl solution (Chapman, 1965). Percentage base saturation (PBS) was calculated by dividing the sum of the charge equivalents of the base-forming cations (Ca, Mg, Na and K) by the CEC of the soil and multiplying by 100. Exchangeable acidity was determined by saturating the soil samples with potassium chloride solution and titrated with sodium hydroxide as described by Mclean (1965). Available micronutrients (Fe, Cu, Zn and Mn) were extracted by DTPA as described by Sahlemedhin and Taye (2000) and all these micronutrients were measured by atomic absorption spectrophotometer.

IV. RESULT AND DISCUSSION

4.1. Morphological and Physicochemical Properties of the Soils

4.1.1. Morphological properties of the soils

The depth of the investigated soils ranged from moderately shallow to deep with irregular A, B and C horizons (Table 4.1). Among the topographic positions, the upper pedons were relatively moderately shallow in depth. Generally the thickness of the soils increases down topographic positions. Soils on all the three topographic positions showed considerable similarity in the presence and sequence of master horizons where every pedon has B master horizon showing illuviation of silicate clays under A master horizon, affected by cultivation, pasturing and other kind of disturbance.

The upper slope pedon soils were very dusky red (10YR 2.5/2,) at the surface and changed to dark red (10YR 3/6) and dark grayish brown (10 YR 4/2); at the subsurface under moist condition with dark grayish brown (10YR 4/2) at surface to strong brown (7.5 YR 5/6) in the subsurface horizons under dry condition. The structure of the soils were generally moderate, medium sub angular blocky in the surface and change to weak, fine prismatic in the subsurface. An impermeable layer is reached on the upper slope at a depth of less than 90 cm. The dry, moist & wet soil consistence of the upper pedons range slight hard to very hard, firm to very firm and sticky to non sticky on surface and sub surface pedons respectively.

In the middle slope of the pedons soil color was very dark brown (7.5YR 2.5/3) at moist and reddish brown (2.5YR5/3) at dry condition while dominated almost by dark reddish brown (2.5 YR 3/3) at both condition on sub surface. The reddish colour indicates oxidation of Fe at both surface and sub surface soils. Similar finding was reported by Foth (1990) who stated that reddish color is due to the presence of iron compounds in various states of oxidation.

Structurally the soils were strong very course sub angular blocky at surface and moderate very course prismatic at sub surface. the dry soil consistence is almost hard on A, AB and slight hard on Bt1 and Bt2 horizons while the moist and wet soil consistence dominated by friable and sticky along the profile respectively.The structure of the soil of the lower slope position pedon was dominated by weak medium prismatic on sub surface and moderate large blocky on surface while their color almost dark reddish brown (2.5YR 3/3) under dry condition along the profile.

The variations in soil color observed within and among the pedons might be reflections of differences in chemical and mineralogical composition, topographic positions, soil organic matter, texture, parent materials and moisture regimes. Similar finding was reported by Dengiz et al, (2012) who stated the variation in soil color could be related to OM, water logging, CaCO3 accumulation and redox reaction in the soil.

Table 4.1: Morphological properties of the soils of Aba-midan sub water shed

Horizon	Depth (cm)	Colour		Structure	Consistency			Other features
		Dry	moist	Grade, size type	Dry	Moist	Wet	
Upper slope (pedon 1)								
A	0-20	10YR 4/2	10YR2.5/2	MO, ME SB	SlH	Fm	St	Holes or channels i.e. housing for termites
B	20-60	7.5YR 5/6	10YR 3/6	WE, F,Pr,	H	VFm	Sl St	Holes or channels i.e. housing for termites
C	60-90+	10YR6/6	10YR 4/2	WE, F,Pr	VH	VFm	Non St	Large fragments /stones/
Middle slope (pedon 2)								
A	0-15	2.5YR5/3	7.5YR 2.5/3	ST, VC, SB	H	Fr	St	Crack along the whole horizon
AB	15-38	2.5YR 4/4	2.5 YR 3/3	MO, VC, Pr	H	Fr	St	
Bt1	38-80	2.5 YR 4/6	2.5YR 3/6	WE, VC, Pr	SlH	Fr	St	
Bt2	80-130+	2.5YR 3/6	2.5 YR 2.5/4	WE, VC, SB	SlH	VFr	St	
Lower slope (pedon 3)								
Ap	0-15	2.5YR 3/3	5YR 3/1	MO, L,B	H	Fr	Sl St	
AB	15-35	2.5YR 3/4	7.5YR 3/2	WE, ME, Pr	H	V Fr	Sl St	
Bw	35-80	2.5YR/3/4	7.5YR 3/4	WE, ME, Pr	SlH	V Fr	St	
B	80-135+	2.5YR 4/4	7.5YR 3/4	WE, ME, Pr	SlH	V Fr	St	

Notes: *MO=moderate, ME=medium, SB=sub angular blocky, F= Fine, Pr= prismatic, ST= strong, VC=Very course, VL= very large, SlH=Slight hard, H=Hard, VH= very hard, S=soft, Fm= firm, VFm= very firm, Fr= friable, VFr =very friable, St= sticky, Sl slight, SlSt = slight sticky, Pl=plasticity*

4.1.2. Physical properties of the soils

Data in (Table 4.2) show a definite trend of clay increase down the profile and along the slope in all the soil pedons. The clay texture of the lower topography was heavy and could be associated with large accumulation due to the lateral movement of finer fractions from higher elevation as a result of erosion or clay translocation within the pedon.

In pedon 1 the clay increase down the profile ranges from 2 to 4%, which is not significant to characterize it as an argillic horizon having 15% increase in clay movement within 2.5 cm according to Soil Survey Staff (2003). In contrast, for pedons 2 and 3 the increase in clay ranges from 12 to 20 % and 14 to 16%, respectively. The texture of soil is sandy clay in pedon 1, and clay in pedon 2 and 3 respectively. Generally looking the data regarding particle size distribution, it was observed that the clay content showed an increasing trend as slope gradient lowers while sand content showed a decreasing trend down the slope gradient. Higher physiographic position and more leaching of fine particles at the lower physiographic positions

The bulk density of the soils was in the range of 1.14 gm/cm^3 in the Ap horizon of the lower pedon to 1.49 gm cm-3 in the C horizon of the upper pedon (Table 4.2). In all pedons the lowest bulk densities were found at the surface horizons, which have relatively higher OM content. Bulk densities values of the soils increased with soil depth in all pedons.

In all the topographic position an appreciable increase in particle density with depth of soil horizons. Brady (1987) reported that particle density values increase with soil depth. Similar results were also reported by Idoga *et al* (2006) in soils of Samaru area, Nigeria.

Porosity values of pedon 1 soil ranges from 43 to 50%, 46.83 to 49.60%, in pedon 2 and 53.43 to 55.81% in pedon 3. According to Brady and Weil (2002) ideal total pore space values, which are acceptable for crop production, are around 50%. Except C horizon in pedon 1 the other pedons soils have almost an acceptable range of total porosity values for crop production.

(Table 4.2) Selected physical characteristics of soils of Aba-midan sub water shed

Horizon	Depth (cm)	Particle size Sand	Silt	Clay	Textural class	BD	PD	TP (V %)
		%				gm /cm^3		
Upper slope(pedon 1)								
A	0-20	47	12	41	SC	1.17	2.35	50.21
B	20-60	45	12	43	SC	1.22	2.58	52.71
C	60-90+	45	10	45	SC	1.49	2.62	43.12
Middle slope(pedon 2)								
A	0-15	33	18	49	C	1.18	2.30	48.69
AB	15-35	31	8	61	C	1.22	2.33	47.63
Bt1	35-80	21	10	69	C	1.26	2.37	46.83
Bt2	80-130+	21	10	69	C	1.28	2.54	49.60
Lower slope (pedon 3)								
Ap	0-15	33	10	57	C	1.14	2.58	55.81
AB	13-35	17	10	73	C	1.22	2.62	53.43
Bw	35-80	21	8	71	C	1.23	2.65	53.58
B	80-135+	23	8	71	C	1.23	2.67	53.93

Note: SC=Sand clay, C= Clay, BD= Bulk density, PD= Particle density, TP=Total porosity

4.1.3. Chemical characteristics

4.1. 3.1. Soil pH and electrical conductivity

The pH-H2O values of soils varied from 5.2 to 6.4 (Table 4.3). The lowest (5.2) value was observed in the C (60 to 90 cm) horizon of upper slope position pedon, whereas the highest (6.4) was found at the middle slope position. According to Tekalign (1991) the pH range of the soils is slightly to moderately acidic, which is preferred range for most crops. The pH H2O values had shown a general tendency to increase with soil depth at the lower and middle slope positions compared to the upper slope position pedons. This could be attributed to down ward translocation of basic cation and leaching.

All pedons irrespective of topographic positions showed very low electrical conductivity (EC) which varied from 0.008 to 0.032dS/m. According to Havlin et al. (1999) this range is categorized as very low and implies that the soils are not salt affected.

4.1.3.2. Organic matter, Total nitrogen and available Phosphorus

Soil organic matter (SOM) content is one of the most important attribute of an arable land. Irrespective of landforms, SOM decreased with depth in all the pedons. Its concentration varied from 2.69 to 0.8%; 2.59 to 0.96%; 1.67 to 0.88% in pedons 1, 2 and 3, respectively (Table 4.3). Generally the lower slope(pedon 3) have relatively low SOM contents than the pedons 1 and 2 this may due to the continuous cultivation, burning of farm lands and removal of crop harvest.

The total nitrogen (TN) content of the soils ranged from 0.08 in the subsurface horizon of the lower pedon to 0.17% in the surface horizon of the upper pedon. According to London (1991), TN content of soils are categorized less than 0.1 very low, 0.1-0.2 as low, 0.2 - 0.5 as medium, 0.5-1 high and > 1 as high. Accordingly, the TN content of the soils is almost categorized under low category. This reveals that nitrogen is found the limiting plant nutrients in the study area due to low level of soil organic matter content and the limited use of nitrogen containing inputs like commercial fertilizer, plant residues and animal manure.

In general, OC and TN content decrease from the upper to the lower slope in all surface soil position. Intensive and continuous cultivation aggravated OC oxidation, resulted in reduction of total N as compared to virgin land. The results are in accordance with the findings of Wakene and Heluf (2003) and Tuma (2007) who reported that intensive and continuous cultivation forced oxidation of OC and thus resulted in reduction of TN.

The available phosphorus content of the soils ranged from 0.02(ppm) in the A horizon of the lower pedon to 1.02 (ppm) soil in the A horizon of the middle pedon (Table 4.3). According Olsen *et al.* (1954) (appendix table 3) rating for available phosphorus content of the study area is low. Phosphorus fixation tends to be more pronounced and ease of phosphorus release tends to be lowest in those soils with higher clay content (Brady and Weil, 2002).

(Table 4.3) Selected chemical characteristics of soils of Aba-midan sub water shed

Horizon	Depth (cm)	pH (1:2.5)	EC(dS/m)	OC	OM	TN	Avai P(ppm)	Ex.Acid	Ex.H	Ex Al
				(%)				meq/100g		
Upper slope(pedon 1)										
A	0-20	5.9	0.013	1.56	2.69	0.17	0.58	0.75	0.35	0.4
B	20-60	5.6	0.009	0.47	0.81	0.14	0.59	2.34	0.46	1.88
C	60-90+	5.2	0.032	0.46	0.80	0.11	0.43	2.17	0.73	1.44
Middle slope(pedon 2)										
A	0-15	6.0	0.014	1.5	2.59	0.15	1.02	0.3	0.16	0.14
AB	15-35	5.9	0.029	0.48	0.89	0.14	0.3	0.95	0.44	0.51
Bt1	35-80	6.4	0.008	0.48	0.88	0.10	0.96	0.39	0.23	0.16
Bt2	80-130+	6.3	0.009	0.49	0.86	0.09	0.86	0.36	0.3	0.06
Lower slope(pedon 3)										
Ap	0-15	5.7	0.023	0.97	1.67	0.14	0.02	1.32	0.63	0.69
AB	13-35	6.1	0.010	0.54	0.93	0.11	0.08	0.79	0.27	0.52
Bw	35-80	6.1	0.017	0.53	0.92	0.10	0.52	0.21	0.07	0.14
B	80-135+	6.2	0.020	0.51	0.88	0.08	0.53	0.1	0.08	0.02

4.1.3.3. Exchangeable bases, cation exchange capacity and percentage base saturation

The extent of exchangeable bases followed unsystematic pattern of distribution along the toposequence and along depths The cation exchange capacity (CEC) of the soils ranged from 12.1 to 20.5 cmol (+) kg-1 of soil (Table 4.4) and the values were generally higher in surface than in subsurface horizons except for the upper pedon, which had relatively higher CEC values in the sub surface horizons. Furthermore, the upper and middle pedons have relatively higher CEC than the lower slope pedons. Hazelton and Murphy, (2007), CEC values are rated < 6 as very low, 6 - 12 as low; 12 - 25 as medium, 25 - 40 as high and > 40 as very high. Accordingly the CEC of the soils in the study areas ranged from medium to high. In general, there was a decrease in CEC with depth, except in the middle pedon, which could be due to the strong association between organic carbon and CEC. According to Brady and Weil (2002), CEC depends on the nature and amount of colloidal particles.

The exchange complex of the soil was dominated by Ca followed by Mg, K and Na (Table 4.4). According to Havlin et al. (1999), the prevalence of Ca followed by Mg, K, and Na in the exchange site of soils is favorable for crop production. According Hazelton and Murphy, (2007) rating the exchangeable bases were low to moderate for Ca and K, moderate to high for Mg and very low to low for Na for all the pedons.

The exchangeable Na content of the soils is low and the exchangeable sodium percentage (ESP) of the soils was also less than 15%. This indicates that there is no sodicity problem in these soils. According to Brady and Weil (2002), ESP of 15% is considered as critical for most crops. The base saturation percentage of the soil was greater than 50 in all surfaces except in the upper pedons of B horizon.

(Table 4.4). Exchangeable cation CEC, Sum of bases, PBS and ESP of Aba-midan sub water shed

Horizon	Depth (cm)	Exchgeable cation (Cmolc(+)/kg of soil					Sum of Bases	PBS	ESP (%)
		Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	CEC			
Upper slope									
A	0-20	6.01	4.00	0.19	0.09	16.5	10.29	62.36	0.5
B	20-60	4.20	1.60	0.18	0.09	19.9	6.07	30.50	0.4
C	60-90+	4.60	2.61	0.49	0.17	15.1	7.87	52.11	1.12
Middle slope									
A	0-15	9.40	5.80	0.27	0.09	20.5	15.56	75.90	0.43
AB	15-35	7.80	3.41	0.20	0.09	18.5	11.5	62.16	0.48
Bt1	35-80	6.60	6.40	0.19	0.13	16.5	13.32	80.72	0.78
Bt2	80-130+	6.04	5.60	0.12	0.09	19.5	11.85	60.76	0.46
Lower slope									
Ap	0-15	7.01	3.63	0.28	0.13	17.7	11.05	62.42	0.43
AB	15-35	7.80	3.01	0.17	0.11	18.5	11.09	59.94	0.59
Bw	35-80	6.09	4.08	0.14	0.09	12.1	10.4	85.95	0.74
B	80-135+	6.08	4.02	0.17	0.19	14.5	1046	72.13	0.13

4.1.3.4. Micronutrients

The available micronutrient content (Fe, Mn, Zn, and Cu) in all pedons have irregular trends along soil depth and slope (Table 4.5). Very high concentration of available Fe and Mn were found in all the pedons as compare with Zn and Cu. The micro nutrient content of soils is influenced by several factors among which soil organic matter content, soil reaction and clay content are the major ones (Fisseha, 1992).

The amounts of Fe, Mn, Zn, and Cu in all the pedons ranged from 109.91mg/kg (in the B horizon of the lower pedon) to 149.78mg/kg in the AB horizon of the middle pedon, 106.8mg/kg (in Bt1 horizon of the middle pedon) to 133.4mg/kg (in the Bt2 horizon of middle pedon), 0.6ppm (in B horizon of the lower slope pedon) to 4.86ppm (in B horizon of the middle slope pedon) and 2.41mg/kg (in B horizon of the middle pedon) to 3.53mg/kg (in the B horizon of the upper pedon), respectively.

According to critical values of available micronutrients set by Havlin et al. (1999) the amounts of Fe, Zn, Mn and Cu in all the pedons have above sufficient and it might be affect particularly for sensitive crops. This is in agreement with various works which stated that particularly Fe and Mn contents usually at an adequate level in Ethiopian soils (Abayneh, 2005; Alemayehu, 2007).

(Table 4.5.) Available micronutrient of Aba-midan sub water shed

Horizon	Depth (cm)	Micro nutrients (mg/kg)			
		Cu	Zn	Mn	Fe
Upper slope					
A	0-20	3.28	2.90	124.18	145.91
B	20-60	3.53	2.07	131.18	110.88
C	60-90+	2.96	4.54	126.23	142.9
Middle slope					
A	0-15	2.92	3.19	131.31	130.42
AB	15-35	2.65	4.86	125.0	149.78
Bt1	35-80	2.41	2.91	106.80	121.5
Bt2	80-130+	3.17	2.29	133.4	128.07
Lower slope					
Ap	0-15	3.34	1.09	122.19	112.73
AB	15-35	2.86	1.23	125.83	111.57
Bw	35-80	2.73	1.73	123.67	129.48
B	80-135+	3.22	0.60	128.73	109.91

Classification According to USDA and WRB

The surface horizons of all the pedon in the study area qualify for mollic epepedon. In the subsurface horizons, all pedons had thick B horizons. The middle and lower pedons had distinct clay increment in the B horizons, which met all the requirements of Natic horizon. Although few to many distinct clay coatings exist in the upper slope pedons, due to slight clay increment in the profiles they did not meet the clay increase requirement of argillic horizon. Rather they showed evidence of color alteration in their B-horizons, and as a result they are recognized to have a cambic horizon.

The soil classification was done according to the procedure of World Reference Base for Soil Resources (WRB, 2006). Based on the morphological and chemical data obtained from the opened pedons, the soil of the study area was classified under Mollic Nitisol

V. CONCLUSIONS AND RECOMMENDATION

The results of this study are evidences of significant changes in the quality attributes of the soils in the study area following the removal or destruction of vegetative cover and frequent tillage that lead to soil erosion and thereby declining soil fertility. The direct causes of land degradation, including decline in the use of fallow, limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, deforestation, and overgrazing, are apparent and generally agreed. Underlying these direct causes include population pressure, poverty, high cost and limited access to agricultural inputs and credit, fragmented land holdings and insecure land tenure, and farmers' lack of information about alternative appropriate technologies. The process of prolonged use of lands for crop production with no or only little inputs has exacerbated soil quality decline leading to soil degradation, which may ultimately lead to complete loss of land values.

Topography had influence on the characteristics of the soils in the studied site. Hence, much of the soil properties varied along the toposequence. The soils are dark reddish brown to dark red colour and shallow to moderate soil depth .a definite trend of clay increase down the profile and along the slope in all the soil pedons. Almost very friable consistency, with bulk density ranges (1.14 to 1.49 gm/cm^3), prismatic to sub angular blocky structure, low total porosity indicated that the soils have poor physical condition for plant growth. The soils pH were slightly (pH: 5.2) to moderately acidic (pH: 6.4). All the micro and macro nutrients, cations and CEC have irregular trends in all the pedons along depth .While Organic carbon content of the soils decrease with soil depth. The available P and TN of the soils of the study area were categorized under the low category.

Available Fe, Zn, Mn and Cu contents of the soils were more than the requirement for crop production and may leads to toxicity especially for sensitive crops. Macro morphological observations have shown that clay translocation and accumulation has taken place in the soils. In the middle and lower pedons, there was a marked increase in clay content with depth and common to many distinct clay coatings were observed.

The surface horizons of all the pedon in the study area qualify for mollic epepedon. The middle and lower pedons had distinct clay increment in the B horizons, which met all the requirements of a natic horizon. While the upper sub surface pedons with cambic horizons.

In the study area a general decline trend in soil OM and TN contents in the middle and lower slope were observed. This may due to the continuous cultivation, burning farm lands, clearing of forests and grasslands for annual crop production invariably resulted in a loss of soil organic matter because of the removal of large quantities of biomass during land clearing, a reduction in the quantity and quality of organic inputs added to the soil. Furthermore as OM is the main supplier of soil N, S and P in low input farming systems, a continuous decline in the soil OM content of the soils is likely to affect the soil productivity and sustainability.

The sub water shed area was being degraded particularly on the lower slope, therefore; it will highly require intensive and grate conservation agriculture, develop proper soil fertility improvement strategies such as, use of organic and inorganic input such as crop rotation, conservation tillage, fallowing, terracing and inclusion of restorative crops in cropping systems on these lands and thereby utilizing optimum rate suitable types of fertilizers.

The sub water shed area was totally subjected to overgrazing and communal wood land, therefore; it requires intensive management regarding range land utilization and conserving biodiversity.

REFERENCES

[1] Abayneh E (2005). Characteristics, genesis and classification of reddish soils from Sidamo Ethiopia. Ph.D thesis, Universiti of Putra Malaysia. pp: 25-52.

[2] Alemayehu K (2007). Effect of Different Land Use Systems and Topography on Some Selected Soil Properties at Delbo Watershed Area, Wolaita SNNPRS. M.Sc. Thesis, Hawassa University, Awassa, Ethiopia. pp. 22-25.

[3] Akinrinde, E. A., 2004. Soils: Nature, Fertility Conservation and Management. Agronomy Department, University of Ibadan, Ibadan, Nigeria AMS Publishing, Inc.

[4] Bambasi Wereda Administration Office, 2014. January month unpublished report

[5] Bambasi Wereda Agricultural Development Office, 2014. January month unpublished report

[6] Black, G.R., 1965. Bulk density. In: C.A. Black (ed.).Methods of Analysis. Agronomy part I, No.9, American Society of Agronomy, Madison, Wisconsin. Pp.374-399.

[7] Bouyoucos, G.J., 1962. Hydrometer method improvement for making particle size analysis of soils. Agronomy Journal, 54: 464-4.

[8] Brady, N.C and Weil, R.R., 2002. The Nature and Properties of Soil, 13th Ed. Preason Education, Asia.

[9] Chapman, H.D, 1965. Cation Exchange Capacity. In: C.A. Black, et al. (Eds.), Methods of Soil Analysis. Agronomy 9, American Society of Agronomy. Inc., Madison, Wisconsin, pp. 891–901.

[10] Dengiz O,zaglam M Sarioglu FE, 2012. Morphological and physiochemical characteristics and classification of verti soils developed on deltaic plain. Open J soil Sci .2:20-27

[11] EARO (Ethiopian Agricultural Research Organization), 1998. Annual Report of Soil Department. Addis Ababa, Ethiopia.

[12] Escobedo J., 1990. Survey of soils and land classification Guide-line. Field Document.MoA, Addis Ababa. Ethiopia.

[13] Esu I.E., 2005. Soil characterization and mapping for food security. A Keynote Address at the 29th annual conf. of SSSN held at University of Nigeria, Abeokuta, from 6th to 10th Dec. 2004.

[14] Fasina, A.S., Omolayo, F.A., Ajayi, SO., and Falodun, A.A., 2007. Influence of Land Use on Soil Properties in Three Mapping Units in Southwestern Nigeria-Implications for Sustainable Soil Management.

[15] Fisseha I (1992). Macro and micronutrients distribution in Ethiopian Vertisols landscapes. Ph.D. Dissertation submitted to Institute fur

[16] Bondenkunde und Standortslehre, University of Hohenheim, Germany. p. 201.

[17] FAO (Food and Agriculture Organization), 2006. Guidelines for soil description. FAO, Rome. Italy.

[18] Foth, H.D., 1990. Fundamentals of Soil Science. (8th) ed. John Wiley and Sons, Inc; New York, USA.

[19] Havlin JL, Beaton JD, Tisdale SL, Nelson WL (1999). Soil fertility and fertilizers. Prentice Hall, New Jersely. pp. 345-355.

[20] Hazelton PA and Murphy BW. (2007). Interpreting Soil Test Results: What Do All the Numbers Mean? CSIRO Publishing, Collingwood.

[21] Idoga, S., Ibanga, I.J. and Malgwi, W.B. (2006). Variation in Soil morphological and physical properties and their management implications on a toposequence in Samaru area, Nigeria. pp. 19– 25. In Proceedings of the 31st Annual Conference of Soil Science Society of Nigeria. Ahmadu Bello University, Zaria, Nigeria. November 13–17

[22] Lekwa, M.U., Anene, B.O. and Lekwa, G., 2004. Chemical and Morphological Soil Characteristics in Drainage Toposequence in Southeastern Nigeria.

[23] Landon JR(1991).Booker tropical soil manual. A handbook for soil survey and agricultural land evaluation in the tropics and sub tropics.John Wiley and Sons, New York. pp. 94-95.

[24] McLean, E.O., 1965. Aluminum. pp. 978-998. In: C.A. Black (eds.). Methods of Soil Analysis. Agron. No.9. Part II. Am.Soc.Agron, Madison, Wisconsin. USA.

[25] Ogunkunle, A.O.; 2005. Soil Survey and Sustainable Land Management. Invited paper at the 29th annual conf. of SSSN held at University of Nigeria, Abeokuta, from 6th to 10th Dec. 2004.

[26] Olsen, S.R, C.V Cole, F.S. Watanabe and L.A. Dean, 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular 939. 1-19.

[27] Rowell, D.L., 1994. Soil science: Methods & Applications. Addison Wesley Longman Singapore Publishers (Pte) Ltd., England, UK. 350p.

[28] Ryan, J., G. Estefan and A. Rashid, 2001. Soil and Plant Analysis Laboratory Manual.ICARDA, Aleppo, Syria, 172 p.

[29] Sahlemedhin Sertsu and Taye Bekele (eds.), 2000. Procedures for soil and plant analysis. Technical paper 74. National Soil Research Center, Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia

[30] Schoenholtza S. H., Miegroetb, H. V. and Burger J.A., 2000. A review of chemical and physical properties as indicators of forest soil quality: challenges and opportunities. Department of Forestry, Mississippi State University, USA

[31] Tekalign Mamo and I. Haque, 1991. Phosphorus of some Ethiopian soils. 111. Evaluation of some soil test methods for available phosphorus. Tropial Agriculture. 68(1): 51-56.

[32] Walkley A and Black C.A., 1934.An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chromic acid titrati.3on method. Soil Science, 37:29-38.

[33] Wakene N, Heluf G (2003). Forms of phosphorus and status of available micronutrients under different land-use systems of Alfisols in Bako area of Ethiopia. J. Ethiopian Nat. Res., 5: 17-37.

[34] WRB (World Reference Base for Soil resources) (2006). World Soil Resources Report, FAO, Rome. p. 103.

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