

Characterization of Some Selected Salt Affected Soils at Bule Hora District, West Guji Zone

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Abstract – The study of soil physico-chemical properties was made on the soils of Surro Woreda located in West Guji Zone, Oromia Region. The objective of the study was to characterize and classify some selected salt affect soils then to determine the suitability for agriculture. The physico-chemical properties of the soils were also characterized in the laboratory through the analysis of soil samples collected on depth wise. The results of the study revealed that the soil texture, bulk density, porosity, permanent wilting point, field capacity, total available water, and chemical properties of soil such as soil pH, Electrical conductivity, Cation exchange capacity, exchangeable cations and exchangeable sodium percentage in the soil profile of different land use systems such as Rainfed field (Pedon1), irrigated field (Pedon2) and Fallow land (Pedon3). The bulk density values ranged from 1.07 g cm⁻³ to 1.23 g cm⁻³ in the all Pedon at the Surro study site. The textural class of the soil in all land use system throughout soil profile was the same (clay soil) at which clay fraction was the dominant soil separate throughout the soil profile. The average values of field capacity, permanent wilting point and total available water throughout soil horizon were 33.2, 24.4 and 8.8 recorded for Pedon1, 39.5, 28.7 and 10.80 recorded for Pedon2 and 46.2, 32 and 14.2 recorded for Pedon3, respectively. The Electrical conductivity value of the soils collected from the Pedon1, Pedon2 and Pedon3 were generally very less than the limit (4 dS/m), which indicates the non-saline soils. The highest and the lowest average values of CEC were recorded in Pedon2 and in both Pedon1 and Pedon3 with average values of 23 and 16, cmolc kg⁻¹, respectively. The highest and the lowest average values of exchangeable sodium percentage were observed on Pedon3 and on the Pedon2 with average values of 22.5 and 13.58%, respectively.

Keywords – Land use Systems; Salt Affected Soils; Soil Physicochemical Properties.

I. INTRODUCTION

In developing countries like Ethiopia, agricultural production is very low because of various natural hazards and poor agricultural practices have greatly reduced the productivity of soils. Worldwide, many soils have been changed into classes of problem soils, among which are saline and sodic soils which are caused by the accumulation of soluble salts and exchangeable Na of varying composition and amounts. Soil salinity and alkalinity problems are most pronounced in arid and semi-arid regions of the earth due to insufficient annual rainfall to leach accumulated salts from the root zone (US Salinity Laboratory Staff, 1954; Heluf, 1985). According to Brady and Weil (2002), the two major interactive worldwide problems are widespread hunger and malnutrition, and the deterioration of quality of the environment resulting from injudicious attempts made to alleviate hunger and

malnutrition. The quality, management and conservation of the world's soils are critical elements in the rectification of the sated problems. The evidence is clear that the soils' natural ability to supply sufficient nutrients has decreased with the higher plant productivity levels associated with increased human demand for food. Soil fertility is not just a problem of nutrient deficiency. It is a problem of soil physicochemical and biological degradation.

Agriculture is facing major problems worldwide with lack of adequate water resources and sever salinity problem. Salinity and drought stresses are responsible for greater reductions in crop productivity than any other biotic or abiotic factor in the arid and semiarid environments. Drought and salinity are already widespread in many regions, and are expected to cause serious salinization of more than 50% of all arable lands by the year 2050 (Vinocur and Altman, 2005). Agriculture is facing major problems worldwide with recurrent droughts and dependency of agriculture on rainfall, lack of adequate water resources, salinity problems, improper land management and lack of adequate information on soil and other land resources for their unsound management practices could be among other major problems responsible for the existing low food crop production in the country particularly West Guji Zone.

The major obstacles to crop production are lack of water and accumulation of salts to grow crops mainly from low and variable rainfall. Most semiarid and arid areas of the world will continue to depend on low and erratically distributed rainfall and salt affected soils. As a result, the study of arid lands and salt affected soils has been an important topic particularly for modern agricultural management and for countries such as Ethiopia where agriculture is the backbone of its economy.

The problems of salt affected soils are old but their magnitude and intensity have been increasing fast due to the establishment of large scale irrigation farms in recent decades. Reports indicate that in Ethiopia, about 200 ha of land of the limited areas of irrigated lands in the Rift Valley System are abandoned for agricultural crop production every year due to salinity, sodicity and associated problems (Heluf, 1995). However, the wide spread occurrences of salt affected soils in Ethiopia, the scientific information available so far is scanty, and most of it is from reconnaissance soil survey studies. This necessitated the need for characterizing of some selected of salt affected soils of the West Guji Zone. Therefore, the study was initiated with the following specific objectives

- ✓ To characterize the soil physicochemical properties and classify the soils of the irrigated areas of Surro Woreda to the standard classes of salt affected soils.

II. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted in West Guji Zone, Southern Oromia, which is located 467 km away from Addis Ababa to the South and 100 km North of Yabello, the capital of Borana Zone. Geographically, the Bule Hora district lies between latitudes 50 26' and 50 52' North and longitudes 370 56' and 380 31' East and an altitude between 1500 and 2400 meters above sea level (masl). The rainfall pattern is bimodal i.e have two distinct rain seasons. The highest mean annual average rainfall of the study area was 1250 mm whereas the lowest mean average was 600 mm recorded. The lowest mean average temperature was 15 0C whereas the highest was 22.8 0C recorded.

2.2. Soil Sampling

A field observation and general visual reconnaissance survey of the area was carried out to determine as to which specific areas should be selected as representative sites of the study area on the basis of land use. Accordingly, three representative soil profile study sites representing different cultivation histories were selected. These include non-irrigated field (Pedon1), irrigated farm (Pedon2) and fallow land (Pedon3). Pedon1 was opened on non-irrigated (rainfed) field as control for irrigation using Lake Habas for sources of water in the study area. On the other hand, Pedon3 represents the land areas that were not cultivated and can be considered as the control for the cultivated lands it is using irrigation or under rainfed conditions. Soil profiles were opened on each of the sites and soil samples were collected depth wise. From each sampling site (Pedon1, Pedon2 and Pedon3), five soil samples were taken at interval of 0-65, 65-85 and 85-120 cm depth of soil. Make one composite soil sample by well mixed five soil samples collected from each sampling site for characterization of their physicochemical properties of the study field. Soil samples was collected from three different cultivation histories for the determination of water content at field capacity (FC), permanent wilting point (PWP), soil texture, bulk density, soil pH, exchangeable cation and electrical conductivity (EC), cation exchange capacity (CEC), percent base saturation (PBS) and exchangeable sodium percentage (ESP)) in the National Soil Laboratory and Hawass University. The appearance of soil and plant in the study area was shown as the following figure.



Fig. 1. Rain feed Wheat field at surro area

The wheat field (Pedon1) is the highest upper plateau portion of the Surro study area. The site is known as fertile on which wheat is cultivated under rainfed conditions. As observed during the field survey, there are sparse stands of old trees in the wheat farm which is help for soil moisture conservation and as a results increasing crop yield.

The irrigated farm (Pedon2) is located at the most low-lying portion of the Surro, where water harvesting is simple and suitable for cultivation of vegetables under irrigation. The irrigated farm is represents the areas of the Surro that have been irrigated for a short period of time and cultivated with the shallow rooted vegetables crops such as cabbage, onion and tomato. But after short period of time the irrigation canal was not functional and cultivated of crop under irrigation conditions is interrupt. During study period, the land is cultivation of maize under rain feed.



Fig. 2. Maize field at Surro study area

The fallow land (Pedon3) represents the land areas which were abandoned for crop cultivation due to repeated crop failures that occurred since the establishment of the farmland. Accordingly, these areas have been left or banded out of production for a long year as fallow. As observed during the field survey, the area is currently colonized by some native grasses, bushes and acacias of naturally recovered vegetation as shown in this figure.



Fig. 3. Virgin land at Surro study area

III. RESULTS AND DISCUSSION

3.1. Soil Physical properties at Surrro Woreda Study Area

3.1.1. Bulk density and total porosity

The bulk density values of the surface horizons ranged from 1.07 g cm⁻³ to 1.08 g cm⁻³ at the 0-15 cm depth in all Pedon as shown in the Table 1. The bulk density of subsurface layers ranged between 1.08 and 1.23 g cm⁻³ in

all pedons. The bulk density of the soils studied showed variability with respect to soil depth. These values ranged from 1.07 to 1.21, 1.08 to 1.23 and 1.07 to 1.09 g cm⁻³ for Pedon1, 2 and 3, respectively. In the present study, the bulk density of the virgin land (Pedon3) soils was lowest of all other land use types (pedon1 and 2). This result is in agreement with Gebreyohannes (2001) who reported lower bulk density values in the soils of the virgin lands than on the cultivated lands. Relatively, the highest bulk density was recorded in the irrigated maize farm (Pedon2) at the Surro study site in the Table 1.

Table 1. Bulk density (cm/g) and Porosity (%) of the soils at Surro Woreda

| Depth (cm) | Pedon1 | | Pedon2 | | Pedon3 | |
|------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|
| | Bulk density (cm/g) | Porosity (%) | Bulk density (cm/g) | Porosity (%) | Bulk density (cm/g) | Porosity (%) |
| 0-15 | 1.07 | 60 | 1.08 | 59 | 1.07 | 60 |
| 15-40 | 1.13 | 57 | 1.2 | 55 | 1.08 | 59 |
| 40-65 | 1.21 | 54 | 1.22 | 54 | 1.03 | 61 |
| 65-90 | 1.09 | 59 | 1.21 | 54 | 1.09 | 59 |
| 90-120 | 1.18 | 56 | 1.23 | 54 | 1.02 | 62 |

General, there is a tendency to increase in bulk density values with depth for most of the soil in the rain fed wheat farm and irrigated maize farm from surface (0-15 cm) to subsurface (65-90 cm) but decreased from 65-90 to 90-120 cm soil depth. This may correspond to a decline in contents of organic matter and presence of hardened calcium carbonate in some of the bottom horizons. The acceptable range of bulk density is 1.3 to 1.4 gm cm⁻³ for inorganic agricultural soils (Bohn *et al.*, 2001). Therefore, in view of this, the bulk density values observed in most of the soils studied in the Pedon1, Pedon2 and Pedon3 were within the normal range of mineral soils worldwide, which may not limit root growth or root penetration, air circulation, water movement and availability of less mobile elements.

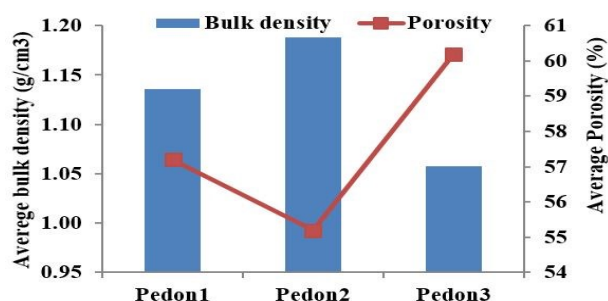


Fig. 4. Average value of bulk density and porosity

The total porosity of the soils ranged between 54 and 62% in the different land uses systems. The total porosity values of the surface horizons (0-15 cm) ranged from 59% at the Pedon2 to 60% at both the Pedon1 and Pedon3. The highest (62%) total porosity was observed in the Pedon3. As shown above figure, there is an inverse variation between total porosities and bulk densities. In all different land use systems, higher total porosity values were obtained in the virgin land, followed by Rain feed wheat land and relatively the lowest total porosity values was

obtained in the irrigated maize farm which is inverse relationship with bulk density as shown in the above figure 4. Total porosity decreased consistently with depth of soil profiles from surface layer (0-15 cm) to subsurface (40-65 cm) soil depth except in Pedons3. This is might be due to attributed to the low organic matter contents in the subsurface horizons, high bulk density in the subsurface, compaction overlying horizons and the filling up of pores paces by translocate clays in the study area. Wakene (2001) reported that the lower total porosity in the subsoil layers were a result of low organic matter contents and high bulk density that was imposed by the use of heavy machinery for tillage activity and intense grazing of the fallow land of Bako area.

3.1.2. Particle Size Distribution at Study Area

The textural class of the soils in the present study area was clayey soil for all land use system (Table 2). In line with the textural class, the sand fraction showed a low in the soil profile opened on the Rain feed wheat farm (Pedon1), irrigated maize farm (Pedon2) and virgin land (Pedon3) while the clay fraction showed a high in all soil profile opened on the all land use system. The relationship between particle size distribution such as sandy, silt and clay content and soil profile depth was not consistent as shown in the Table 2. The variations in respective particle size distribution observed in the different soil layers indicate the presence of distinct lithological discontinuity within the soil profile. Clay to silt ratios were generally high, which in all of the cases might be suggesting high weathering stages of the soils and reconfirms deposition of clay materials as well as transformation of sand size particles to silt size particles and silt size particles to clay.

Table 2. Particle size distribution and textural class of the soils in the study area

| Depth (cm) | Particle size distribution (%) | | | Textural class | Water content (%) | | |
|--------------------------------------|--------------------------------|------|------|----------------|-------------------|------|------|
| | Sand | Silt | Clay | | FC | PWP | TAW |
| Rainfed wheat field (Pedon1) | | | | | | | |
| 0-65 | 18.6 | 25.3 | 56.2 | Clay | 30.5 | 22.2 | 8.3 |
| 65-85 | 12.6 | 25.3 | 62.2 | Clay | 40 | 30.6 | 9.6 |
| 85-120 | 18.6 | 25.3 | 56.2 | Clay | 29 | 20.4 | 8.6 |
| Irrigated maize farm (Pedon2) | | | | | | | |
| 0-65 | 8.6 | 23.3 | 68.2 | Clay | 43.4 | 30.2 | 13.2 |
| 65-85 | 12.6 | 25.3 | 62.2 | Clay | 39.8 | 29.8 | 10 |
| 85-120 | 18.6 | 21.3 | 60.2 | Clay | 35.4 | 26.2 | 9.2 |
| Fallow Land (Pedon3) | | | | | | | |
| 0-65 | 12.6 | 21.3 | 66.2 | Clay | 42.5 | 30 | 12.5 |
| 65-85 | 4.6 | 23.3 | 72.2 | Clay | 48.9 | 33.3 | 15.6 |
| 85-120 | 8.6 | 21.3 | 70.2 | Clay | 47.2 | 32.6 | 14.4 |

3.1.3. Soil Moisture Content at Study Area

The water content at Field capacity (FC) ranged from 29 to 40 %, 35.4 to 43.4% and 42.5 to 48.9% for the Pedon1, 2 and 3, respectively. The higher water content at FC was recorded for the Pedon3, while the lowest water contents at FC were recorded for Pedon1. The water content at permanent wilting point (PWP) varied from 20.4 to 30.6, 26.2 to 30.2 and 30 to 33.3% for Pedon 1, 2 and 3, respectively. The total available water (TAW) content varied from 8.3 to 9.6 %, 9.2 to 13.2% and 12.5 to 15.6% for the Pedon 1, 2 and 3, respectively. General, the

average value of FC, PWP and TAW throughout soil horizon were 33.2, 24.4 and 8.8 recorded for Pedon1, 39.5, 28.7 and 10.80 recorded for Pedon2 and 46.2, 32 and 14.2 recorded for Pedon3, respectively. The highest average value of FC, PWP and TAW throughout soil horizon was recorded in the Pedon3 followed by the Pedon2 and then in the Pedon1 as shown in the figure 5.

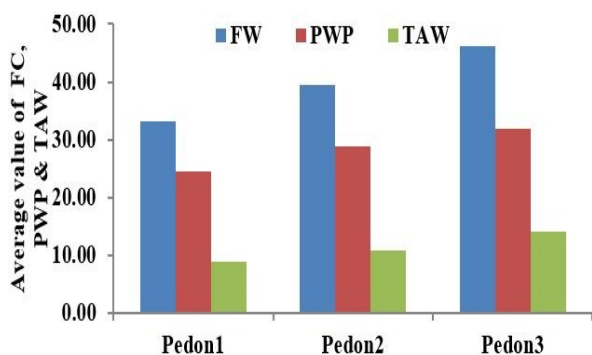


Fig. 5. Average value of FC, PWP and TAW

3.2. Characteristics of Chemical Properties of Soil

3.2.1. Soil Reaction (Ph) and Electrical Conductivity

The pH values increased consistently with depth in all of the profiles except in Irrigated maize farm (Pedons2), ranging from 5.43 in the surface layer (0-65 cm) of Pedon3 to 6.55 in the bottom layer (65-85 cm) of Pedon2. The pH value of the soil profile opened at the rainfed wheat production field (Pedon1) 6.04, 6.12 and 6.16 were recorded for the surface layer (0-65 cm), subsurface layer (65-85 cm) and bottom layer (85-120 cm) soil horizon, respectively. The pH values of the fallow land (Pedon3) ranged from 5.43 at the surface horizons (0-65 cm) to 5.54 at the extremely bottom horizon (85-120 cm). The pH values recorded in this Pedon3 were the lowest among the Pedon studied. In the present study, the highest pH value corresponded to high values of exchangeable sodium, calcium, magnesium, total exchangeable bases (TEB) and percent base saturation (PBS) at the irrigated maize fields. Thus, contents of TEB, PBS and ESP of the soils could be the source of variability of soil pH in the present study area. The highest average pH value (pH 6.46) throughout soil horizon was recorded for the Pedon2 followed by the Pedon1 (pH 6.11) and then Pedon3 (pH 5.48) as shown the figure above. According to the classification ranges suggested by Brady and Weil (2002), the soil reaction based on the pH values recorded in the soils of Pedon1 and Pedon2 studied qualify for slightly acidic reaction classes. Based on the pH values, the soils in the present studied area represented by Pedon3 was a moderately acidic reaction class (pH < 5.54) throughout the entire depths of their respective profile. The moderately acidic soil reaction particularly in the Pedons3 was indicators of possible toxicity of micronutrients and Al, and deficiency of basic cations and some other nutrients (Foth, 1990; Landon, 1991).

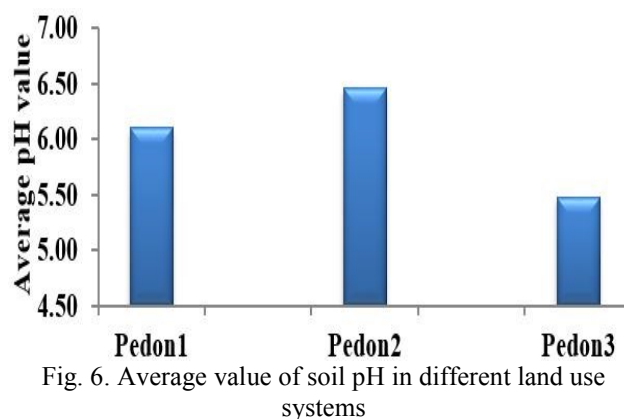


Fig. 6. Average value of soil pH in different land use systems

The electrical conductivity of the saturation extracts (ECe) decreased consistently with depth from 0.027 dS/m at the surface layer to 0.021 dS/m at the depth of 65 N-85 cm and then slightly decreased to 0.018 dS/m at the bottom 85-120 cm layer of the soil profile in Rainfed wheat field (Pedon1). The ECe of the soil profile opened at the field supporting good cabbage, onion, carrot and maize stand irrigated by Lake Habas waters in the previous year but the year of sampling supporting with the maize without of irrigation ranged from 0.041 at the 85-120 cm to 0.042 at the 0-65 cm. The ECe value of the soils collected from the Pedon1, Pedon2 and Pedon3 were generally very less than the limit (4 dS/m), which indicates the presence of lower soluble salt in the soil solution, which is a threshold used to define non saline soils (US Salinity Laboratory Staff, 1954).

3.2.2. Exchangeable Chemical Characteristics

3.2.2.1. Rainfed Wheat Field

The data on the exchangeable chemical characteristics of the Rainfed wheat field (Pedon1) are presented in Table 3. Exchangeable Ca and Mg were relatively predominant cations in the exchange sites of soil colloidal over the exchangeable K and Na in all soil profiles of the study area. In fact, soils of inherently high productivity usually have an exchange complex dominated by calcium and magnesium and contain only minor amounts of potassium and sodium (FAO, 1979). Exchangeable Ca and Mg low with depth 0- 65 cm, increased at the interval of 65-85 cm and it thereafter decreased at the 85-120 cm depth. On the other hand, exchangeable Na increased relatively lower concentration (1.24 cmol (+)/kg) from surface layer in the interval between 0-65 cm to relatively higher concentration (1.50 cmol (+)/kg) at the bottom layer (85-120 cm) depth. Exchangeable K decreased from relatively higher concentration (0.12 cmol (+)/kg) on the surface to relatively lower concentration (0.08 cmol (+)/kg) at the lower depth. The cation exchange capacity (CEC) increased from 16.51 at the surface (0-65 cm) horizon to 18.06 cmol (+)/kg in the subsurface (65-85 cm) horizon and decreased to 12.90 cmol (+)/kg in the bottom (85-120 cm) horizon. The CEC ranging from 16.38 cmol (+)/kg at the bottom horizon (85-120 cm) to 18.06 cmol (+)/kg at the subsurface (65-85 cm) horizon is generally controlled by the concentration of exchangeable Ca, Mg & TEB. According to the ratings of Landon (1991), soils with CEC

values of 15-25 or less and 5-15 are classified as medium CEC and low CEC, respectively. Report by Wakene (2001) also indicated that the highest CEC values were recorded on the surface layers of Bako area soil profiles compared to the respective subsoil layers. The lowest value of percent base saturation (PBS) of 47% was

observed in the surface (0-65 cm) horizon and increased linearly with depth to 67% at the bottom (85-120 cm) horizon of the profile. The PBS increased consistently with increasing depth from 47%, 51% and 67% in the 0-65 cm, 65-85 cm and 85-120 cm soil depth, respectively.

Table 3. Exchangeable chemical compositions and properties of the soil at the Pedon1

| Depth (cm) | Ph (H ₂ O) | ECe (dS/m) | Exchangeable cations (cmol(+)/kg) | | | | | CEC (cmol(+)/kg) | ESP (%) | PBS (%) |
|------------|-----------------------|------------|-----------------------------------|------|------|------|------|------------------|---------|---------|
| | | | Na | K | Mg | Ca | TEB | | | |
| 0-65 | 6.04 | 0.027 | 1.24 | 0.12 | 3.20 | 3.20 | 7.75 | 16.51 | 7.5 | 47 |
| 65-85 | 6.12 | 0.021 | 1.43 | 0.06 | 3.84 | 3.84 | 9.18 | 18.06 | 7.9 | 51 |
| 85-120 | 6.16 | 0.018 | 1.50 | 0.08 | 3.84 | 3.20 | 8.62 | 12.90 | 11.6 | 67 |

The PBS values showed a slightly increasing trend with depth of the profiles, suggesting the existence of movement of bases from surface to subsoil horizons. The exchangeable sodium percentage (ESP) increased with depth consistently from 7.5% in the surface horizon (0-65cm) to 11.6% at the bottom horizon (85-120 cm) depth. The ESP values observed in this Pedon1 followed the trend of concentrations of exchangeable Na as well as the pH values. According to the US Salinity Laboratory Staff (1954), the Pedon1 soils of the study area represented by all this profile are classified as non-saline-sodic soil because the ECe at 25 °C was less than 4 dS/m, the ESP was less than 15% and the pH was less than 8.5.

3.2.2.2. Soils of Irrigated Maize Fields

Table 4 presents the exchangeable chemical composition of the soil profile opened on field of irrigated

by Lake Habas water in the previous year but the year of sampling/study field supporting poor maize stand without irrigated (Pedon2). Among the exchangeable cations, exchangeable Ca was dominant while exchangeable K was the lowest throughout the profile in the soils of the previous year Irrigated. The order of abundance of the basic exchangeable cations were Ca > Mg > Na > K in all horizon at the Pedon2. Concentrations of exchangeable Ca, Mg, Na, TEB, ESP and PBS were increased slowly from the surface (0-65 cm) to subsurface (65-85 cm) and it thereafter decreased in the bottom layer (85-120 cm) depth of the profile. According to the ratings of FAO (2006a), the level of exchangeable Sodium, Potassium, and Magnesium was high whereas calcium was medium in Pedon2.

Table 4. Exchangeable chemical compositions and properties of the soil at the Pedon2

| Depth (cm) | Ph (H ₂ O) | ECe (dS/m) | Exchangeable cations (cmol(+)/kg) | | | | | CEC (cmol(+)/kg) | ESP (%) | PBS (%) |
|------------|-----------------------|------------|-----------------------------------|-------|------|------|-------|------------------|---------|---------|
| | | | Na | K | Mg | Ca | TEB | | | |
| 0-65 | 6.44 | 0.042 | 1.63 | 1.355 | 3.20 | 5.76 | 11.95 | 24.768 | 6.58 | 48 |
| 65-85 | 6.55 | 0.037 | 1.70 | 0.972 | 3.84 | 6.40 | 12.91 | 19.952 | 8.50 | 65 |
| 85-120 | 6.39 | 0.041 | 1.63 | 1.087 | 3.20 | 5.76 | 11.68 | 25.456 | 6.40 | 46 |

The exchangeable sodium percentage (ESP) values increased from 6.58% in the 0-65 cm to 8.50% in the 65-85 cm horizon and then decreased 6.40% in the 85-120 cm soil depth. The maximum values of exchangeable Ca, Na, Mg and the ESP attained at the subsoil (65-85 cm) layer in the soil profile observed in this particular Pedon2 were in agreement with the findings of similar studies reported by Mesfin (2001) for rainfed cultivated farmers field. According to the US Salinity Laboratory Staff (1954), soils with ESP, ECe and pH values were lower than 15%, 4 dS m⁻¹ and 8.5, respectively; the soils were classified as non-saline-sodic soil. Cation exchange capacity (CEC) is one of the most important chemical properties of soils and strongly affects nutrient availability for plant growth. The CEC decreased from 24.76 at the 0-65 cm to 36.79 cmol(+)/kg at the 65-85 cm depth and it thereafter increased to 25.45 cmol(+)/kg at the 85-120 cm depth.

3.2.2.3. Soils of the Fallow Land

Among the exchangeable cations, Na increased linearly with increasing soil depth from 1.35 cmol (+)/kg at surface horizon to 1.52 cmol (+)/kg soil at the bottom layer in the pedon3. On the other hand, exchangeable K varied

irregularly with depth while exchangeable Mg increased with depth from 1.92 cmol (+)/kg at the surface horizon to 2.56 cmol(+)/kg at the bottom horizon depth. Among the pedon considered in the present study, the highest exchangeable sodium percentage (ESP) values were observed in the pedon3. In line with the respective trends observed in Pedon 3, ESP and PBS also increased linearly with depth from 8.16 to 9.6% and from 38.00 to 44.00% respectively. Relatively the lowest concentrations of PBS values were recorded in the pedon3 compared to that of pedon1 and 2 could be due to attributed to the relatively lower pH value. The increase in ESP with depth is the reflection of the relative concentration exchangeable Na. According to the US Salinity Laboratory Staff (1954), Fallow land met the criteria to be classified as neither saline nor sodic soil because the ECe at 25 °C was less than 4 dS/m and pH was less than 8.5 and the ESP was less than 15%.

Table5. Exchangeable chemical compositions and properties of the soil at the Pedon3

| Depth (cm) | pH (H ₂ O) | ECe (dS/m) | Exchangeable cations (cmol(+)/kg) | | | | | CEC (cmol(+)/kg)(%) | ESP | PBS (%) |
|------------|-----------------------|------------|-----------------------------------|------|------|------|------|---------------------|------|---------|
| | | | Na | K | Mg | Ca | TEB | | | |
| 0-65 | 5.43 | 0.029 | 1.35 | 0.37 | 1.92 | 2.56 | 6.20 | 16.51 | 8.16 | 38 |
| 65-85 | 5.46 | 0.028 | 1.50 | 0.29 | 1.92 | 2.56 | 6.27 | 16.17 | 9.28 | 39 |
| 85-120 | 5.54 | 0.029 | 1.52 | 0.32 | 2.56 | 2.56 | 6.96 | 15.82 | 9.60 | 44 |

The Cation exchange capacity (CEC) value of Pedon3 was decreased consistently with depth from surface layer (16.51 cmol(+)/kg) to subsurface layer (16.17 cmol(+)/kg) to the bottom layer (15.82 cmol(+)/kg) as shown in the above table. According to the rating of soil characteristics, by Landon (1991), the CEC registered on the fallow land was medium (CEC 15-25 cmol(+) kg⁻¹) throughout the soil horizon.

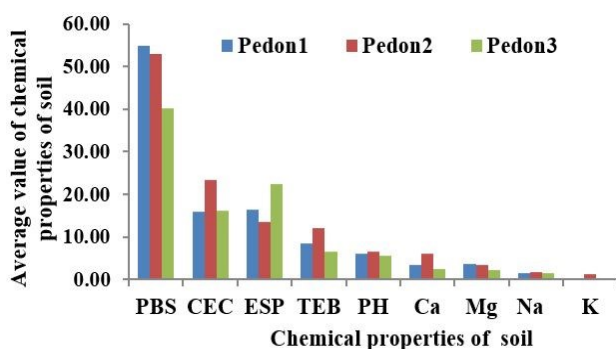


Fig. 7. Average value of chemical properties of soils at Surro site

IV. Conclusions

The bulk density values of the surface horizons ranged from 1.07 g cm⁻³ to 1.08 g cm⁻³ at the 0-15 cm depth in the all Pedon at the Surro study site. The textural class of the soil in all land use system throughout soil profile was the same (clay soil) at which clay fraction was the dominant soil separate throughout the soil profile. The average values of FC, PWP and TAW throughout soil horizon were 33.2, 24.4 and 8.8 recorded for Pedon1, 39.5, 28.7 and 10.80 recorded for Pedon2 and 46.2,32 and 14.2 recorded for Pedon3, respectively.

The highest average value of pH (6.46) was observed on the Pedon2 followed by 6.11 on the Pedon1 and then by 5.48 on the Pedon3 when the all soil horizons are considered. Considering the soil pH, the soils in the present study area represented by Pedon1 and Pedon2 were slightly acidic (6.0-6.6) and that of Pedon3 was moderate acid (5.3-5.9) as per the classification set by Tekalign (1991). The highest average value of exchangeable Ca (5.97 cmol (+) kg⁻¹), Na (1.65 kmol (+) kg⁻¹), K(1.14 cmol (+) kg⁻¹), CEC (23.39 cmol (+) kg⁻¹ and TEB (12.18 cmol (+) kg⁻¹) among the Pedon was obtained in the Pedon2. On other hand, the lowest average value of exchangeable Ca (2.56 cmol (+) kg⁻¹), Mg (2.13 cmol (+) kg⁻¹), TEB (6.48 cmol (+) kg⁻¹) and PBS (40.11%) was recorded in the Pedon3 as compared to other pedons described at the same site. According to the

rating of soil characteristics, by the FAO (2006a), Pedon2 were observed to contain high exchangeable Mg, K, Na and medium exchangeable Ca whereas Pedon1 were observed to contain high exchangeable Mg & Na and low & very low exchangeable Ca and K, respectively. Pedon3 contain low Exchangeable K and Ca and medium & high exchangeable Mg & Na, respectively. The highest and the lowest average values of exchangeable PBS were 54.86 and 40.11% for Pedon1 and3, respectively. The highest and the lowest average values of ESP were observed in Pedon3 and in the Pedon2 with average values of 22.5 and 13.58%, respectively. The highest and the lowest average values of CEC were recorded in Pedon2 and in both Pedon1 and Pedon3 with average values of 23 and 16, cmolc kg⁻¹, respectively as shown in the figure 7. From this observation, it could be said that the Pedon2 had high potential fertility from CEC status point of view as compared to the other Pedons.

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