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Characterization and Classification of Salt Affected Soils and Irrigation Water at Bule Hora District, West Guji Zone

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Abstract
The study of soil physico-chemical properties and irrigation suitability was made on the soils of Galesa Negeso small scale supplementary irrigation located in West Guji Zone, Oromia Region. The objective of the study was to characterize, classify the soils and irrigation Water 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, field capacity, permanent wilting point, total available water and chemical properties of soil such as soil pH, Electrical conductivity, cation exchange capacity, exchangeable catios and exchangeable sodium percentage in the soil profile of different land use systems such as Rainfeed field (Pedon1)**,** irrigated field (Pedon2) and Fallow land (Pedon3). The highest average value of bulk density (1.36 g cm-3) was observed on the irrigated sugarcane field followed by 1.31 g cm-3 on the Rainfeed maize land and the lowest bulk density (1.20 g cm-3) was observed on the fallow land. The soil texture classes the same throughout the depth to sandy loam and sandy clay loam in the Pedon1 and Pedon2, respectively. The average value of total available water holding capacity of the Pedon1, 2 and 3 were 9.0, 11.9 and 7.9 %, respectively. The highest average value of pH (6.9) was observed on the Pedon3 followed by 6.43 on the Pedon1 whereas the lowest average value of pH (6.42) was observed on the Pedon2. The highest average values of exchangeable sodium percentage (14.43%) were observed in the Pedon1 followed by 10.34% in the Pedon2 and then followed by 7.23% in the Pedon3. In all of the land use systems the electrical conductivity & exchangeable sodium percentage of the soils was found to be less than 4dS/m & 15%, respectively, indicating that there would not be any actual and potential salinity & sodicity hazard in the soils of the study area. The sodium adsorption ratio (SAR) ranged from 11 in the irrigation water sampled from the Alfat River to 12 for Lake Habas water for the sampling at mid-rainy and mid-dry season. During the mid-rainy and mid-dry season, the EC of the different water sources varied from 151µmhos/cm to 165µmhos/cm for Alfat River and Lake Habas, respectively.The sodium adsorption ratio (SAR), electrical conductivity (EC) and RSC value were 11, (151 µmhos/cm), 0.14meq/l for Alfat River water for the sampling at mid-rainy season, respectively. SAR, EC and RSC contents of the Alfat River and Lake Habas water fell under the same class, low salinity hazard class (C1), medium sodium hazard class (S2) and safe (class1), respectively which were used for irrigation purpose according to the classification set.
Keywords: Salt affected soils, soil physicochemical properties; water quality

1. INTRODUCTION

In Ethiopia, agricultural production is largely based on traditional rain fed system, which is lagging behind the food requirement of the fast growing population. Recent facts show annual growth rate of agricultural production to be much below the population growth rate (EAC, 2004), indicating presence of a widespread food scarcity in the country because of various natural hazards and poor agricultural practices have greatly reduced the productivity of soils. 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. Soil salinity may be resulted naturally or due to human activities such as poor drainage and/ or poor irrigation water. Dry land salinity is mainly a product of the limited rainfall for leaching. Up to 80% of plant's yield can be lost because of drought and salinity (FAO, 2005). This problem is particularly severe in developing countries, especially arid and semiarid regions, resulting in damage to the livelihoods of people in the short term, and with long term effects on food security of the country.

The greatest concentration of water bodies in Ethiopia, and thus there is a tendency to consider use of these waters for irrigation as a solution to alleviate the problem of the very unreliable rainfed agriculture and to the determinant for agricultural development and self-sufficiency with respect to food production (Zinabu, 2003). This in fact calls for the development of irrigation agriculture and sound soil information for a proper management of irrigated as well as rainfed crop cultivation systems. 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. Efforts to increase agricultural yield with the help of improved varieties, chemical fertilizers and improved management practices, on the other hand, will not be feasible unless the irrigated activities are supported by data of a research output on soil and water resources.

This necessitated the need for characterizing and classifying of the soils and irrigation water sources of the Bule Hora Woreda. 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 Bule Hora Woreda to the standard classes of salt affected soils
- ✓ To assess the chemical properties and evaluate the quality of waters used for irrigation and classify them to the standard suitability classes of irrigation water

3. MATERIALS AND METHODS

3.1. 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. Galesa Nageso, which is the specific site of the present study, is one of the high lands *Kebele* of Bule Hora Woreda. In this specific study area, Afalata small scale irrigation is situated in Galesa Nageso about 48 km away from the district town. 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.

3.2. Soil and Water 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 Afalata River 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 was 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. About 1kg of the composite samples was properly labeled, and taken to the laboratory for analysis. The appearance of soil and plant in the study area was shown as the following figure

The Pedon1 is the highest upper slope portion of the Galesa Negeso area. The site is known as infertile on which maize is cultivated under rainfed conditions as compared to the other land use systems. The area is unstable, that is it is affected by very high runoff water. Therefore, there is evidence of shinny sands, gravels, and stones observed frequently as a left over on the surface of the soil.

Figure 1. Rain feed Maize cultivation field

The irrigated farm (Pedon2) is located at the most low-lying portion of the Galessa Negesso that have been irrigated for a long period of time and cultivated with the perennial crops such as sugarcane, Papaya, Banana and sometimes cultivated maize. Better sugarcane with the a good internodes length is observed here and as a result there is an indication of litters and humic substances overlay on the surface soils and the eroded soil from the high topography area deposited in this place.

Figure2.Shows sugarcane irrigated field

The virgin land (Pedon3) represents the land areas which were fallow the land used for Livestock grazing. As observed during the field survey, the area is currently colonized by native grasses.

Figure 3.Shows virgin land in study area

3.2.1. Irrigation Water Sampling

Water samples were collected from the Afalata River which is used as irrigation water sources of the Bule Hora Woreda. Each of these irrigation water samples was prepared from samples collected at two sites that are from the sources and main irrigation canal but the irrigation canals not functional, so water samples only taken from the sources. A total of six samples of irrigation water so that representative water samples could be obtained. Each of these irrigation water samples was collected twice within one year in order to ensure that information obtained was not affected by sampling time. These was during the mid of the dry season and during the mid of the main rainy season. The collection and handling of the irrigation water samples was done in accordance with the procedures outlined by the US Salinity Laboratory Staff (1954)

3.3. Soil Physicochemical and Irrigation Water Analysis

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 cations of Ca^{2+}, Mg^{2+} , Na^{+} and K^{+} in the irrigation water was determined directly from the water samples .The electrical conductivity of the irrigation water (ECw) was determined using electric conductivity meter. Sodium adsorption ratios (SAR) of the irrigation water samples were calculated from the concentration of Ca^{2+}, Mg^{2+} and Na^{+} ions. Residual sodium carbonate (RSC) content of the irrigation water samples were calculated from the concentration of Ca^{2+}, Mg^{2+}, HCO_3^{-} and CO_3^{2-} ions .Classification of irrigation waters based on salinity (EC), sodicity (SAR) and residual sodium carbonate (RSC) were done in accordance with US Salinity Laboratory Staff (1954).

4. RESULTS AND DISCUSSION

4.1. Soil physical properties of study area

4.1.1. Bulk Density and Total Porosity

The result in table 1 indicated that the bulk densities in the surface soil were 1.12 g cm-3, 1.20 g cm-3 and 1.08 g cm-3 at the Maize field (Pedon1)**,** irrigated sugarcane field (Pedon2) and fallow land (Pedon3), respectively. The lowest value of bulk density in the surface soil of profile might be due to higher organic matter content. The Pedon1**,** Pedon2 and Pedon3 had the highest bulk density 1.51, 1.52 and 1.40 g cm-3 in the subsurface horizon (40-65 cm) depth followed by1.45, 1.44 and 1.22 g cm-3 at the bottom (90-120 cm) depth, respectively. In the present study, the bulk density of the fallow land (Pedon3) soil was lowest of all other land use types. This result is agreement with Gebreyohannes (2001) who reported lower bulk density values in the soils of the virgin lands than on the cultivated lands. The bulk density of the Pedon1**,** Pedon2 and Pedon3 increased consistently from 0-15cm in the surface layer to 40-65cm in the subsoil layer but decreases at the depth of 65-90 cm of the soil profile. Nega (2006) also reported that bulk density was significantly affected by soil depth and the values increased from surface to sub-surface soils. Thus, the bulk density values observed in all land use systems were within the normal range of mineral soils worldwide, which may not limit root growth, air circulation and availability of less mobile elements.

Table1. Bulk density (g/cm) and Porosity (%) of the soils

Pedon1			**Pedon2**		**Pedon3**	
Depth (cm)	Bulk density (g/cm)	Porosity (%)	Bulk density (g/cm)	Porosity (%)	Bulk density (g/cm)	Porosity (%)
0-15	1.12	58	1.20	55	1.08	59
15-40	1.31	51	1.25	53	1.13	57
l40-65	1.51	43	1.52	43	1.40	47
65-90	1.14	57	1.40	47	1.17	56
90-120	1.45	45	1.44	46	1.22	54

The total porosity of the soils in the study area was range between 43 and 59%. The total porosity of the land use systems showed variability with respect to soil depth and bulk density as showed on the above table1. The highest average value of bulk density (1.36 g cm-3) was observed on the Pedon2 followed by 1.31 g cm-3 on the Pedon1 and then by 1.20 g cm-3 Pedon3 when the all soil horizons are considered. The highest average value of total porosity (55%) was registered in the Pedon3 followed by 51% in the Pedon1 while the lowest average value of total porosity (49%) was registered in the Pedon2. Accordingly, total porosity increases as the bulk density decreases while it decreases as bulk density increases.

4.1.2. Particle Size Distribution

The result in table2 indicated that the particle size distribution of the maize field (Pedon1)**,** irrigated sugarcane field (Pedon2) and fallow land (Pedon3) were sandy loam, sandy loam and sandy clay loam in textural class, respectively. In all land use systems, the sand fraction dominated the particle size distributions in the soil profile depth. The soil texture changed markedly with depth to sandy loam (0-65 cm), sandy clay loam (65-85 cm) and sandy clay at the bottom (85-120 cm) horizon in the Pedon3. In line with the textural class, the sand and silt fraction decreased consistently with depth from the surface layer (0-65cm) to the bottom depth (85-120 cm) of the soil profile in Pedon3. The reason for more clay content in the 85-120cm soil depth than clay content in the 0-65 cm soil layer might be attributed to leaching of the clay particles from the 0-65cm layer and subsequent accumulation in the 85-120 cm layer at the study area of Pedon2 &3.

In generally, the content of the sand fraction decreased consistently with soil depth but the content of the clay fraction increased consistently with soil depth from the surface layer (0-65cm) to the bottom layer (85-120cm) in the pedon2 and pedon3. From textural classes of soil this, it could be concluded that the soils of the study area are not suitable for surface irrigation systems as the observed sandy loam to sandy clay loam could affect the water holding capacity and availability of a number of essential plant nutrients due to deep percolation of irrigation water

Table2. Particle size distribution and textural class of the soils in the study areas

Depth Cm	Particle size distribution (%)			Textural class	Soil Water content (%)		
	Sand	Silt	Clay		FC	PWP	TAW
	Rain feed Wheat Field (Pedon1)						
0-65	80	10	10	Sandy loam	25.8	16.6	9.2
65-85	84	6	10	Sandy loam	22.6	15.3	7.3
85-120	80	10	10	Sandy loam	30.9	20.4	10.5
	Irrigated Fruit Field (Pedon2)						
0-65	70	10	20	Sandy clay loam	28.6	18.3	10.3
65-85	66	6	28	Sandy clay loam	32.7	20.4	12.3
85-120	60	8	32	Sandy clay loam	36.6	23.4	13.2
	Fallow Land (Pedon3)						
0-65	58	24	18	Sandy loam	20.4	14.5	5.9
65-85	54	18	28	Sandy clay loam	25.6	18.4	7.2
85-120	48	12	40	Sandy clay	19.2	8.6	10.6

4.1.3. Soil Moisture Contents

The result in the figure4 indicated that the average values of water content at field capacity (FC), permanent wilting Point (PWP) and total available water content (TAW) for all the land use systems. The water content at FC ranged from 22.6 to 30.9 %, 26.6 to 36.6% and 19.2 to 25.6% for the Pedon1, 2 and 3, respectively. The water content at PWP ranged from 15.3 to 20.4 %, 18.3 to 23.4% and 8.6 to 18.4% for the Pedon1, 2 and 3, respectively. The average value of TAW of the Pedon1, 2 and 3 were 9.0, 11.9 and 7.9 %, respectively. The highest average value of TAW (11.9%) was observed on the Pedon2 followed by 9.0% on Pedon1 and then by 7.9% on the Pedon3 as shown in the figure 4.

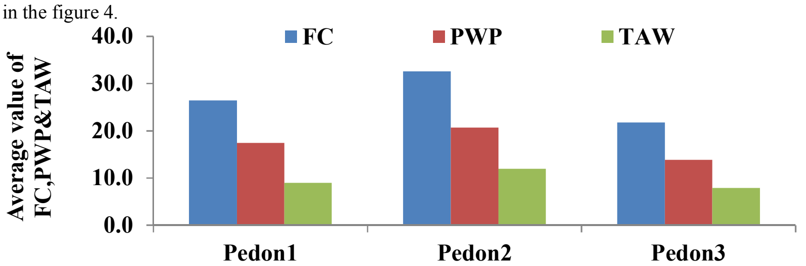

Figure4. Soil water content at FC, PWP and TAW as affected by land use

4.2. Characteristics of chemical properties of soil at study area

4.2.l. Soils under Rainfed Maize Production

The result in Table3 indicated that the pH of the rainfed maize production field was 6.19 on the surface soil (0-65cm) and increased almost consistently with depth 6.67 at the depth of 85-120 cm. Considering the soil pH, the soils in the present study area represented by Pedon1 was slightly acidic (6.19- 6.67) as per the classification set by Tekalign (1991). In line with the pH value, the electrical conductivity of the saturation extracts (ECe) also decreased from 0.058 dS/m at the surface layer to 0.029 dS/m at the depth of 65-85 cm and then slightly decreased to 0.048dS/m at the bottom 85-120cm layer of the soil profile to qualify for none saline salt affected soil class. Exchangeable Ca and Mg were relatively predominant cations in the exchange sites of soil colloidal over the exchangeable K and Na in the order Ca > Mg > Na > K in all soil profiles of the study area (Table3). According to the FAO (2006a) standard rating of exchangeable cations, exchangeable Na, K, Ca and Mg could be rated high, low, low and high were observed in pedon1, respectively. The possible reason for the relatively low concentrations of exchangeable K and Ca from the exchange sites in all the land units could be associated with intensive weathering due to continuous ploughing of the land without fallow where the exchangeable bases were exposed to rapid depletion from the soil exchange complexes by leaching and removal by crops without replenishment.

Table3. Exchangeable chemical compositions and properties of the soil at the Pedon1

Depth (cm)	pH (H_2O)	ECe (dS/m)	Exchangeable cations (cmol(+)/kg)					CEC (cmol(+)/kg)	ESP (%)	PBS (%)
			Na	K	Mg	Ca	TEB			
0-65	6.19	0.058	1.22	0.33	1.92	3.20	6.67	11.01	18.25	61
65-85	6.42	0.029	1.41	0.10	1.92	2.56	6.00	6.88	23.57	87
85-120	6.67	0.048	1.59	0.22	1.92	2.56	6.28	13.59	25.25	46

Cation exchange capacity (CEC) is one of the most important chemical properties of soils and strongly affects nutrient availability for plant growth. The highest and the lowest contents of CEC were observed in bottom horizon (85-120cm) and subsurface horizon (65-85cm) with values of 13.59 and 6.88 cmolc kg-1, respectively. In general the surface, subsurface and bottom layer of soils have low CEC contents with absolute values of 11.01, 6.88 and 13.59 cmolc kg-1 soil, respectively. The highest and the lowest values of percent of base saturation (PBS) were 87 and 46% in Maize cultivated field for sub surface and bottom soil depth, respectively. The PBS values showed a slightly increasing from soil surface to subsurface soil depth, suggesting the existence of movement of bases from surface to bottom layer. The exchangeable sodium percentage (ESP) values observed in Pedon1 was 11.06, 20.56 and 11.09 %, respectively in the surface (0-65cm), sub surface (65-85cm) and bottom (85-120 cm) depth (Table 3). In general, the pH in the different layers of the soil profile showed an indirect association with the concentrations of $Ca2^{+}$, K^{+}, CEC, PBS and ECe.

4.2.2. Soils of Alfat River Water Irrigated Sugar Cane Fields

The pH value was observed on the soils of the Pedon2 increased from (pH 5.87) at surface soil layer to (pH 6.9) at the bottom depth (Table4). The pH increased consistently with increasing soil depth with a maximum value of 6.9 in the bottom horizon. On the other hand, in all of the horizons of the studied pedon the electrical conductivity of the soils was found to be less than 4 dS/m, indicating that there would not be any actual and potential salinity hazard in the soils of the study area. Exchangeable calcium and magnesium are the dominant cations in the exchange sites, whereas the monovalent cations (K and Na) occupied a very small proportion of the exchange complex sites in the Pedon2 as shown in the table4 below.

Table4. Exchangeable chemical compositions and properties of the soil at the Pedon2

Depth (cm)	Ph (H2O)	ECe (dS/m)	Exchangeable cation (cmol(+)/kg)					CEC (cmol(+)/kg)	ESP (%)	PBS %
			Na	K	Mg	Ca	TEB			
0-65	5.87	0.069	1.391	0.281	2.56	3.20	7.43	14.10	9.86	53.00
65-85	6.5	0.042	1.36	0.75	1.60	2.90	6.60	12.00	11.33	55.00
85-120	6.9	0.047	1.57	0.95	2.24	2.88	7.60	16.00	9.81	47.00

The Cation exchange capacity (CEC) value of Pedon2 was increased from surface layer (14.10 cmol(+)/kg) to the bottom layer(16.00 cmol(+)/kg) . In line with the respective trends observed in Pedon2, CEC, ESP and PBS showed variation with the depth from 12.00 to 16.00 cmol(+)/kg, 9.81 to 11.33% and from 47 to 53% respectively. Hence the soil from which Pedon2 was opened neither saline nor sodic in characteristics based on the ESP > 15%) and the ECe > 4 dS m-1.

4.2.3. Soils of the Fallow Land

The pH values measured in H2O solution were greater than 5 throughout the profile, varying from 6.75 in the surface layer of 0-65 cm to 7.11 in the bottom horizon of 85-120 cm depth at the Pedon3. In the present study, the highest pH value corresponded to high values of exchangeable sodium, magnesium and potassium at the follow land. The ECe of the soil was low (ranging from 0.046 to 0.062 dS m-1) throughout the profile showing no significant accumulation of soluble salts to convert the soil to saline soil as per the criteria developed by the US Salinity laboratory Staff (1954). Among the exchangeable cations, Ca was dominant while Na was the lowest throughout the soil profile. Concentrations of exchangeable K and Mg were decreased slowly from the surface (0-65cm) to subsurface (65-85 cm) and it increased thereafter in bottom horizon (85-120cm) of the soil profile. The CEC decreased from 23.91 cmol(+)/kg in the surface horizon (0-65cm) to 17.03 cmol(+)/kg in the subsurface horizon (65-85 cm) and then increased to 18. 76 cmol(+)/kg in the bottom horizon (85-120 cm) depth as shown in the table5. The ESP values increased from 5.55 in the surface soil to 8.35 in the bottom horizon (85-120cm) soil is line to the observed general increment of Na from 1.33 at the surface to 1.56 cmol(+)/kg at the bottom horizon (85-120 cm). The ESP and the ECe of the soil were far below the lower limit (15%) and (4 dS m-1), respectively. Hence, these soils were a non-saline & sodic soil in the present study areas were below the critical values for almost all the soil depth.

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

Depth (cm)	Ph (H2O)	ECe (dS/m)	Exchangeable cations(cmol(+)/kg)					CEC (cmol(+)/kg)	ESP %	PBS %
			Na	K	Mg	Ca	TEB			
0-65	6.75	0.062	1.33	1.66	1.92	3.84	8.75	23.91	5.55	37.00
65-85	6.68	0.054	1.33	1.43	1.28	5.12	9.16	17.03	7.79	54.00
85-120	7.11	0.046	1.56	1.67	2.56	3.20	9.00	18.75	8.35	48.00

The highest average value of pH (6.9) was observed on the fallow land followed by 6.43 on the Rainfeed maize land and then by 6.42 irrigated sugarcane field when the all soil horizons are considered. The highest average value of PBS (64.66%) was obtained in the Pedon1 followed by 51.84% in the Pedon2 and then followed by 46.13% in the Pedon3. The highest exchangeable K (1.59 cmol(+) kg-1) contents was recorded in the Pedon2 followed by 0.66 cmol(+) kg-1 in the Pedon3 . The highest average values of ESP (14.43%) were observed in the

Pedon1 followed by 10.34% in the Pedon2 and then followed by 7.23% in the Pedon3 as shown in the Figure6. Considering the soil horizons across all soil profiles, the highest average value of CEC contents (12.39 cmol(+) kg-1) was recorded in the Pedon3 followed by 2.99 cmol(+) kg-1 in the Pedon2 and the lowest CEC was recorded in the Pedon1 of the same site as shown in the Figure6.

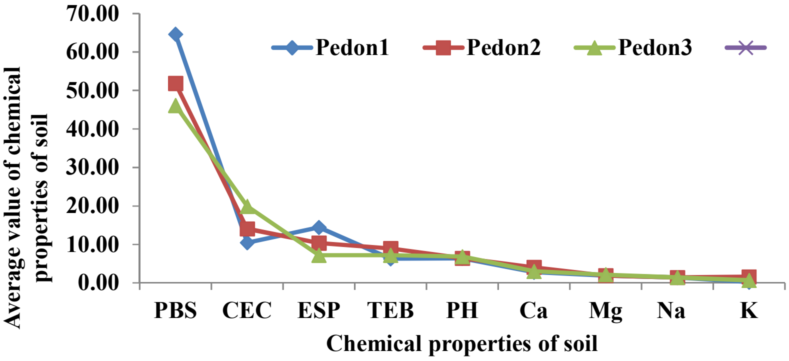

Figure4. The average value of chemical properties of soil at Gelessa Negesso

4.6. Chemical Composition of Irrigation Waters at Mid-Rainy and Mid- dry Season

The pH, RSC, salinity and sodicity related chemical properties of the irrigation waters were studied by sampling at the mid-rainy and mid-dry season with the objective of determining their quality and suitability for irrigation purposes. The pH of the irrigation water samples from the Alfat River at the mid-rainy and mid-dry season were 6.5 and 7.5, respectively (Table11). Unlike the pH values, relatively lower electrical conductivity (ECw) observed in the Alfat River were 151µmhos/cm and 160µmhos/cm at the mid-rainy and mid-dry season, respectively. The pH of the irrigation water samples from the Lake Habas at the mid-rainy and mid-dry season were 7.2 and 7.8, respectively (Table6 and 7). The electrical conductivity of water sources was 153µmhos/cm and 165µmhos/cm for Lake Habas, respectively during the mid-rainy and mid-dry season. Generally, during the mid-rainy and mid-dry season, the EC of the different water sources varied from 151µmhos/cm to 165µmhos/cm for Alfat River and Lake Habas, respectively. These indicate that all of the irrigation water sources studied in the area had low concentrations of dissolved salts that are not sufficient enough to change salt-free soils in to salt affected soils up on continued use of irrigation. Accordingly, based on the widely used diagram for classification of irrigation waters published by the US Salinity Laboratory Staff (1954), the irrigation water from the Alfat River and Lake Habas fell under low salinity hazard class (C1).

Table6. Chemical compositions of irrigation water sampled at Mid-Rain Season

Sampling area	EC (µmhos/cm)	pH	Cations (meq/l)				SAR	Anions(meq/l)		RSC (meq/l)
			Na^+	K^+	Ca^{2+}	Mg^{2+}		$CO_3 2-$	HCO_3^-	
Lake Habas	153	7.2	12.85	3.26	0.02	0.02	12	0.00	0.16	0.13
Alfat River	151	6.9	13.46	0.92	0.01	0.03	11	0.00	0.18	0.14

Table7. Chemical compositions of irrigation water sampled during dry season

Sampling area	EC (µmhos/cm)	pH	Cations (meq/l)				SAR	Anions(meq/l)		RSC (meq/l)
			Na^+	K^+	Ca^{2+}	Mg^{2+}		$CO_3 2-$	HCO_3^-	
Lake Habas	165	7.8	10.65	2.36	0.12	0.32	12.0	0.3	0.36	0.23
Alfat River	160	7.5	10.95	1.02	0.11	0.43	11.7	0.1	0.48	0.06

The sodium adsorption ratio recorded for Lake Habas water during mid-rainy and mid dry season was the same (12). Accordingly, the RSC contents of the Lake Habas during the mid-rainy and mid- dry season were 0.13meq/l and 0.23meq/l, respectively. The Alfat River water sources were found to have SAR values of 12.0 and 11.7, respectively during the mid-rainy and mid dry season. The RSC values revealed 0.14 and 0.06 meq/l during the mid-rainy and mid dry season, respectively. The sodium adsorption ratio (SAR) ranged from 11 in the irrigation water sampled from the Alfat River to 12 for Lake Habas water for the sampling at mid-rainy and mid-dry season. In reference to the diagram for classification of irrigation waters based on their SAR published by the US Salinity Laboratory Staff (1954) , all of the irrigation water sources studied fell under the same class, medium sodium (alkali) hazard class (S2), regardless of their sodicity hazard. Moreover, long duration of irrigation with medium

Na hazard waters may cause accumulation of sodium in soils to a level to convert a normal soil to a sodic salt affected soil in the future. Thus, the RSC contents of all these two water sources are within the range of < 1.25 meq/l which is the range considered to be safe (class1) to be used for irrigation purpose according to the classification set by the US Salinity Laboratory Staff (1954).

5. Conclusions

Sound information on soils and water characteristics provide a basis for decision making on proper utilization and management of natural resources. The conduction of soil and water studies at local and/or farm level is useful in the generation of basic information needed for determining the suitability of soils and water for specific uses as well as tackling local problems of agricultural production on the basis of sound land management methods. As a result, the small scale irrigated agriculture is being carried on in the study area soils in the absence of adequate information. Therefore, this calls for a need to conduct detailed study on soil characteristics, classification and land suitability for irrigated agriculture in the irrigation farms. Depth wise soil samples from three different land use systems (non-irrigated field (Pedon1)**,** irrigated farm (Pedon2) and fallow land (Pedon3) and tow irrigation water sources were analyzed. The highest average value of bulk density (1.36 g cm-3) was observed on the Pedon2 followed by 1.31 g cm-3 on the Pedon1 and then by 1.20 g cm-3 Pedon3. The highest average value of total porosity (55%) was registered in the Pedon3 followed by 51% in the Pedon1 while the lowest average value of total porosity (49%) was registered in the Pedon2. The surface soils of the Pedon1**,** Pedon2 and Pedon3 were sandy loam, sandy loam and sandy clay loam in textural class, respectively. In all land use systems, the sand fraction dominated the particle size distributions in the surface and the subsurface layers and showed a decreasing trend with profile depth except in the Pedon1. The average value of total available water holding capacity (TAW) of the Pedon1, 2 and 3 were 9.0, 11.9 and 7.9 %, respectively.

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