Asian Journal of Chemistry Vol. 20, No. 5 (2008), 4009-4020

Soil Degradation in Salty Areas of Mid-Anatolia Region, Turkey¶

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The chemical, physical and morphological properties of six typical quaternary soil in the Kizilirmak plain of Çankiri and in the closed Lake Basin of Kayseri in the Mid-Anatolia region were investigated to determine salinity problem. The most important pedogenic prosses is salt translocation and accumulation in these soils. The salty underground water have influenced the chemistry and morphology of soils. The extensive salt crystals were observed in the A horizons of soils. A salic horizon were developed in the surface as a result of salt accumulation. The soluble salt contents of soils change between 0.46 and 3.05 %. Existence of extensive salt crystals in the soils in study area may be attributed to salty underground water and minerals. The high Na^+ and Cl^- content in the A horizon are related with salt accumulation. Exchangeable Ca^{2+} and Mg^{2+} account for > 95 % of the exchangeable complex as a result of dissolution of carbonates and possible weathering of feldspar.

Key Words: Salty soil, Salinization, Soil degradation, Quaternary soils.

INTRODUCTION

Salt problems are of great concern in arid and semiarid regions, where soil salt content is naturally high and precipitation is insufficient for leaching. The increasing urban development in western states, turf is increasingly grown on soils where salinity problems already exist, or may develop subsequently from the use of saline irrigation water[1]. Agricultural productivity in many arid and semiarid regions of the world is threatened by the occurrence of salt-affected soils. Thus, improved management practices are needed to maintain or increase the productivity of saline-sodic soils[2]. Facilitation among the plants occurs in natural ecosystems as well as in agroecosystems takes place when plants ameliorate their neighbours by

¶This work was presented at 4th International Conference on Precision Agriculture, Minnesota, USA (1998).

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increasing growth or survival. Facilitative root interactions are likely to be important in nutrient-poor saline-sodic soils due to the critical inter specific competition for plant growth factors[3].

The salinization of soils and waters places an increasing constraint on crop production in the arid and semiarid regions of the world[4]. Since the basic ideas regarding solonetzic soils were putforth by early Russian pedologists. The researchers have developed a framework for studying their genesis, consisting of four idealized processes: salination, desalination, solonization and solodization[5]. The key to the generation and maintenance of saline conditions is a hydrological regime that favours net evaporative losses of water from the soil surface, as in arid and semiarid environments[6,7]. Subsequent changes in the local hydrology, favouring desalination, permit solonization and solodization to occur[5].

Some researchers indicated that soils developed from sedimentary materials must be assessed in terms of the characteristics of sedimentary layers before valid theories of pedogenesis can be advanced. Early works showed that the effects of sedimentary layers on the chemical and physical properties of solonetsic soils can be significant[8,9], especially in shallow-bedded lacustrine deposits[10].

An important portion of Turkey's land is in arid and semiarid regions. Though quaternary soils occupy a small portion, they have an important effect in agricultural production. The objectives of this study were to: (i) determine physical, chemical and morphological characteristics of some Quaternary soils in Mid-Anatolia region of Turkey, (ii) examine the salinity problems of these soils, (iii) classify the some Quaternary soils according to Soil Taxonomy[11].

EXPERIMENTAL

Six pedons from Çankiri-Kizilirmak plain and around Kayseri city in the Mid- Anatolia region of Turkey were studied. The studied soil pedons were developed on alluvium parent materials and lacustrine deposits. The study area is characterized by arid climate, lies between 38º45' and 41º10' N latitudes and 35º29' and 34º14' E longitudes with altitude 751 m above MSL. The average annual rainfall is 366 mm and potential evapotranspiration is 1268 mm. The annual mean air temperature is 10.8 ºC, that of soil at a depth of 50 cm is about 14.2 ºC. Summers have high temperatures (24.6 ºC mean temperature) and winters have very low temperature (2.1 ºC mean temperature). The vegetation of study area are grasses, cereal and leguminous crops.

Profiles PL1, PL2 and PL3 were described on the alluvium material from Kizilirmak Plain and Profiles PL4, PL5 and PL6 were described on the lacustrine deposits from closed lake basin in Kayseri city. Pedons were described in the field according to Soil Survey Staff[11]. Soils samples were collected from each horizon and air dried to pass a 2 mm siever and analyzed for particle size analysis with Hydrometer method[12]. $CaCO_3$ content measured by Sheibler Calciometer method[13], pH, major anions and electrical conductivity saturation extracts using electrodes and cation exchange capacity[14], exchangeable cations[15], organic C by modified Walkley-Black procedure[16]. Soils were classified according to Soil Taxonomy[11] and were classified into the World References Base for Soil Resources[17].

RESULTS AND DISCUSSION

Three soil pedons were described on the alluvium material in Kizilirmak Plain in Cankiri city. Profiles of PL1, PL2 and PL3 have developed on alluvium parent material deposited by the Kizilirmak River during the Holocene. The most important pedogenic prosses is salt translocation in the profiles PL1, PL2 and PL3. Two sources exist to the salt present the Kizilirmak Plain Soils. The underground water and minerals weathering in the till. The salty underground water have influenced the morphology and chemistry of soils. The extensive salt crystals were observed in the profile PL1. A salic horizon were developed in the surface as a result of salt accumulation. Most significant is the increase in the proportion of exchangeable Na^+, Cl^- and Mg^{2+} in the A horizon of these profiles, compared with salt accumulation on the surface. The exchangeable Na^+, SO_4^{2-} and Cl^- contents in the A horizon of profile PL1 are considerably higher than subsoil horizons(Table-2). This increase in the A horizon of profile PL1 are related with the salt accumulation in the surface horizon. The EC values, proportion of exchangeable Na^+ and Cl^- are high in the C_2 horizon but proportion of SO_4^{2-} is high in the 2 C_2 horizon. This difference in both horizon may be attributed to the lithological discontinuity. The higher content of exchangeable Na^+, Cl^- and SO_4^{2-} in the A_1 horizon of profile PL1 than the A_1 horizon of profile PL2 suggest that PL1 has probably received more salts. Silty clay loamy was the dominant texture in the A_1 horizon, whereas silty loamy was the dominant texture in subsurface. Soil colour is 10 YR 4/2 in the A_1 horizon and 5 YR 4/3 in the $2C_2$ horizon and $3C_3$ horizon (Table-1).

The morphology of profile PL2 is generally similar to profile PL1. The extensive salt crystals were also observed in the all horizons of profile PL2 as a result of salt accumulation. However, EC values of the surface horizon of this profile are much lower than EC values of profile PL1. Proportion of exchangeable Na^+, SO_4^{2-} and Cl^- in the A horizon of profile PL2 are higher than subsoil horizons (Table-2). Lowering of salt accumulation in the profile PL2 than profile PL1, may be attributed to its greater distance from the river than profile PL1. Silty loam is the dominant texture in the

TABLE-1
SELECTED MORPHOLOGICAL AND PHYSICAL CHARACTERISTICS OF SALTY SOILS

Horizon	Depth (cm)	Drainage	Colours (Moist)	Text.†	Struc.‡	Sand	Silt (%)	Clay	EC* (dS m^{-1})	Special features
				Profile PL1 (Aquic Torrifluvent)						
A_1	0-15	Imperfectly drained with slow permeability	10 YR 4/2	SiCL	2mgr	14.56	52.00	33.44	25.26	Salt crys.
A_2	15-28		10 YR 5/2	SiL	1fgr	12.28	63.00	24.72	9.30	Salt crys.
C_1	28-50		10 YR 5/2	SiL	1fgr	12.22	69.08	18.70	7.21	Salt crys.
C_2	50-74		10 YR 4/4	SiL	1fgr	19.26	54.03	26.71	13.41	Salt crys.
$2C_2$	74-98		5 YR 4/3	SiCL	ma	10.70	49.38	39.92	7.25	Salt crys.
$3C_3$	98-145		5 YR 4/3	SiC	ma	8.74	50.36	40.90	10.65	–
				Profile PL2 (Typic Torrifluvent)						
A_1	0-10	Imperfectly drained with slow permeability	5 YR 4/6	SiL	2mgr	22.00	56.00	22.00	6.24	Salt crys.
A_2	10-35		5 YR 4/6	SiL	1fgr	22.00	62.00	16.00	2.56	Salt crys.
A_3	35-46		5 YR 4/6	SiL	1fgr	33.30	52.00	14.70	8.47	Salt crys.
C_1	46-74		7.4 YR 6/2	SL	ma	59.30	30.00	10.70	2.12	Salt crys.
C_2	74-105		7.4 YR 6/2	LS	ma	76.00	18.40	5.60	0.99	–
				Profile PL3 (Aquic Torrifluvent)						
A_1	0-25	Imperfectly drained slow permeability	10 YR 3/4	C	1mabk	24.40	33.20	42.40	28.64	Salt crys.
A_2	25-42		7.5 YR 4/4	CL	2mabk	28.20	37.40	34.40	12.21	Salt crys.
C_1	42-55		7.5 YR 4/4	L	2msbk	40.20	39.20	20.60	18.26	Salt crys.
C_2	55-78		7.5 YR 4/4	L	ma	42.60	36.00	21.40	7.31	–
C_3	78-110		7.5 YR 4/4	L	ma	38.60	48.60	12.80	8.43	–

Horizon	Depth (cm)	Drainage	Colours (Moist)	Text.†	Struc.‡	Sand	Silt (%)	Clay	EC* (dS m^{-1})	Special features
Profile PL4 (Typic Aquicambid)										
A_1	0-15	Imperfectly drained rapid permeability	7.5 YR 5/3	SL	2msbk	41.60	43.00	15.40	30.60	Salt crys.
A_2	15-30		10 YR 6/3	SL	1msbk	43.45	42.10	14.45	5.39	Salt crys.
Bw	30-50		10 YR 7/3	SL	2msbk	55.60	30.20	14.20	6.36	Sulfur spots
Cg	50-75		5 Y 6/2	LS	ma	67.40	19.60	16.00	2.95	
Profile PL5 (Typic Aquicambid)										
A_1	0-17	Imperfectly drained	10 YR 5/3	SL	2msbk	49.60	34.00	16.40	56.10	Salt crys.
Bg	17-38		2.5 Y6/2	LS	1msbk	73.50	14.00	12.50	12.60	Sulfur spots
Cg	38-55		5 Y 6/2	LS	ma	69.80	18.00	12.20	5.70	
Profile PL6 (Typic Aquicambid)										
A_1	0-12	Imperfectly drained	10 YR 5/3	SL	1 fgr	39.60	43.90	16.50	37.10	Salt crys.
A_2	12-25		10 YR 5/3	SL	1 fgr	49.40	34.50	16.10	17.30	Salt crys.
C_1g	25-56		10 YR 6/3	LS	ma	69.10	18.60	12.30	6.90	Sulfur spots
C_2g	56-82		10 YR 6/3	LS	ma	63.20	24.00	12.80	3.50	

†Texture c: clay, cl: clay loam, l: loam, scl: sandy clay loam, sl: sandy loam, sicl: silt clay loam, sil: silt loam, ls: loamy sand
‡Structure 1: weak, 2: moderate, 3: strong, f: fine, m: medium, gr: granular, abk: angular blocky, sbk: subangular blocky, ma: massive, 0: structureless; *EC: Electrical conductivity.

TABLE-2
SELECTED CHEMICAL PROPERTIES OF THE SALTY SOILS

Horizon	Depth (cm)	pH (1:1)	Total salt (%)	CEC* (cmol kg^{-1})	Exchangeable cations (cmol kg^{-1})			$CaCO_3$ (%)	Org. C (g kg^{-1})	Exchangeable anions (cmol kg^{-1})	
					Ca + Mg +	K+	Na+			Cl^-	SO_4^{2-}
Profile PL1 (Aquic Torrifluvent)											
A_1	0-15	8.12	2.750	38.04	34.64	0.60	2.80	10.60	0.64	1.86	8.4
A_2	15-28	8.13	1.200	23.92	20.72	0.80	2.40	17.80	1.18	1.41	6.0
C_1	28-50	8.10	1.200	28.26	26.66	0.40	1.20	14.40	1.09	0.95	5.1
C_2	50-74	8.22	1.200	22.62	20.12	0.60	2.90	17.10	0.72	1.13	6.2
$2C_2$	74-98	8.50	1.000	40.21	37.41	1.00	1.80	12.10	0.82	0.82	6.6
$3C_3$	98-145	8.30	0.145	42.39	40.99	0.60	0.80	11.40	0.92	0.10	3.1
Profile PL2 (Typic Torrifluvent)											
A_1	0-10	8.12	1.300	20.65	18.89	0.64	1.20	13.60	1.14	0.96	5.1
A_2	10-35	8.20	1.300	22.83	20.18	0.41	2.24	15.20	0.95	0.92	5.6
A_3	35-46	8.20	1.200	21.73	19.83	0.26	1.64	14.00	1.25	0.11	1.2
C_1	46-74	8.10	1.100	10.56	8.85	0.75	0.96	14.80	0.67	0.63	1.0
C_2	74-105	7.70	0.650	8.86	7.46	1.18	0.36	13.60	0.28	0.80	1.3
Profile PL3 (Aquic Torrifluvent)											
A_1	0-25	8.80	3.050	34.20	30.40	0.60	3.20	10.12	0.61	2.61	9.2
A_2	25-42	8.44	1.460	30.23	29.17	0.20	0.86	11.34	0.34	2.05	9.0
C_1	42-55	8.10	1.120	18.64	17.40	0.20	1.04	14.22	0.14	1.81	6.3
C_2	55-78	8.36	0.460	19.26	18.02	0.30	0.90	10.64	0.14	1.98	2.1
C_3	78-110	7.70	0.650	15.40	15.40	0.66	0.34	9.76	0.11	1.16	1.1
Profile PL4 (Typic Aquicambid)											
A_1	0-15	8.80	2.400	41.30	40.62	0.19	0.49	19.20	1.45	1.52	6.3
A_2	15-30	8.70	0.900	32.01	31.74	0.22	0.65	22.80	1.42	1.05	6.0
Bw	30-50	8.52	0.700	27.17	25.73	0.45	0.99	23.10	1.35	1.13	2.1
Cg	50-75	8.38	0.215	19.02	12.17	2.67	4.18	17.10	1.41	0.92	6.3
Profile PL5 (Typic Aquicambid)											
A_1	0-17	8.05	2.400	21.74	19.74	0.93	1.07	15.20	1.38	1.02	4.6
Bg	17-38	8.00	1.350	28.26	21.69	2.66	3.19	15.50	1.40	0.86	12.3
Cg	38-55	7.98	0.350	26.63	20.04	2.41	4.18	16.70	1.44	1.21	10.9
Profile PL6 (Typic Aquicambid)											
A_1	0-12	8.10	2.420	20.11	18.04	0.87	1.20	15.20	1.30	1.63	4.5
A_2	12-25	8.05	2.400	34.78	33.20	0.71	0.87	15.90	1.21	1.05	6.3
C_1g	25-56	8.14	0.350	26.63	20.17	1.51	4.95	17.80	1.45	1.16	8.0
C_2g	56-82	8.11	0.450	25.00	21.12	1.60	2.28	19.00	1.33	0.53	6.8

CEC* = Cation exchange capacity.

surface horizons, whereas sandy loam is the C_1 horizon and loamy sand in C_2 horizon. Soil colour is 5 YR 4/6 in the surface horizons and 7.5 YR 6/2 in the C_1 and C_2 horizons.

The morphology of profile PL3 is generally similar to the profiles PL1. However, the salt content in the A horizon of profile PL3 was found higher than profile PL1. The salt content of profile PL3 is considerably high and change between 3.05 % and 0.460 % (Table-2). In addition to high salt content in the A horizon of profile PL3, also, EC values, the proportion of exchangeable Na, Cl^- and SO_4^{2-} are higher than the A horizons of the profiles PL1. The extensive salt crystals were observed in the profile PL3. A saline horizon were developed in the surface as a result of salt accumulation. The source of these salts in the surface horizon of profile PL3 is salty groundwater. The high values of exchangeable anions and cations in the surface of profile PL3 are related with the salt accumulation in the surface. Soil colour is 10 YR 3/4 in the A_1 horizon and 7.5 YR 4/4 in the other horizons. Clay is the dominant texture in the A_1 horizon, whereas clay loam is the A2 horizon and loam in the C_1, C_2 and C_3 horizons.

Three soil pedons were described on the lacustrine deposits in the closed lake basin in Kayseri city. Profile PL4 developed on lacustrine deposits of closed lake basin is comparatively older than the other soil pedons and soil formation process is at a further level. Apart from an Ochric A epipedon in the surface; due to structure formation and biological activity, a Cambic B diagnostic horizon developed in the subsurface. Cambic horizon in non-carbonated soil is described by the formation of structural elements of peds and in case oxidation is present, by a colour change from reddish to reddish brown[18,19]. Therefore, the Cambic B horizon in the studied soil is generally described by biological activity and the presence of structural elements. The extensive salt crystals were also observed in the all horizons of profile PL4 as a result of salt accumulation. The extensive salt crystals were observed in the profile PL1. A salic horizon were developed in the surface as a result of salt accumulation. Gleyic horizon has also developed in the C horizon as result of sulfide material. Sulfur spots were the indicators of sulfide material in the Cg horizon, begin at 50 cm of depth in the Profile PL4. Soil colour is 7.5 YR 5/3 in the A_1 horizon and 5 Y 6/2 in the Cg horizon. Sandy loam is the dominant texture in the all horizons except for Cg horizon.

Profiles PL5 and PL6 have developed on the lacustrine deposits in the closed lake basin around Kayseri city. The most important pedogenic process in the profile PL6 is salt translocation and accumulation. Salt crystals were observed intensively in all profiles, indicating salt accumulation. A salic horizon were developed in the surface as a result of salt accumulation. There are two sources for the salts in the closed lake basin around Kayseri city. The underground aquifer and minerals weathering in the till of Erciyes volcane. The relatively shallow lacustrine deposits and the high artesian pressure of the aquifer may facilitate surfacing of aquifer waters. Gleyic B horizon has also developed in these profiles as result of sulfide material. Sulfur spots were observed in the subsoil of PL5 and PL6. Sulfur spots which indicators of sulfide material in the Bg horizon begin at 17 cm of depth in the profile PL5. Also Sulfur spots begin at 56 cm of depth in the profile PL6. Land salinization has been attributed to the surfacing of aquifer waters elsewhere in the closed lake basin[1,7,20].

Soil colour is 10 YR 5/3 in the A_1 horizon in the profile PL5, 2.5 Y 6/2 in the Bg horizon and 5 Y 6/2 in the C_2 horizon. Also, soil colour is 10 YR 5/3 in the surface soil and 10 YR 6/3 in the subsurface soil in the profile PL6. Soil texture in the surface is sandy loam and loamy sand in the sub-surface of profiles PL5 and PL6.

The EC values and proportion of exchangeable Cl^- are high in the surface horizon and the proportion of exchangeable Na^+ and SO_4^{2-} are high in the Cg horizon of profiles PL5 and C_1g horizon of profile PL6.

Physical and chemical properties: Some morphological and physical characteristics soils have been presented in Table-1 and chemical properties of soils have been presented in Table-2. According to the results of laboratory analyses, the soils generally have loamy textures. The clay contents of all profiles were generally decreasing with depth, especially in the C horizons (Table-1).

The clay content of profile PL1 change between 18.70 % (in the C_1 horizon) and 40.90 % (in the $3C_3$ horizon). The organic C content of the soils was very low and decreases gradually with depth. The organic C content of profile PL change between 0.64 and 1.18 g kg^{-1}. The low content of organic C can be attributed to long arid periods and poor vegetation. Soil organic matter plays a major role in soil fertility by affecting physical and chemical properties and also controls soil microbial activity by serving as a source of mineralizable C and N[21]. Changes in land use and soil management can have a marked effect on the soil organic matters stock as a result of the interactions between detrital input and mineralization mediated by soil microorganisms[22]. The cation exchange capacity values, depending on the type of clay, organic matter and clay content in the soil profile, change between 22.62 and 42.39 cmol kg^{-1}. Some researchers reported[23,24] that high clay content have increased cation exchange capacity of soils in arid regions.

The soluble salt content, especially in the A1 horizons of profile PL1 was calculated very high and change between 2.750 and 0.145 %. The source of these salts is the salty underground water. Exchangeable Na^+ change between 0.80 and 2.90 cmol kg^{-1}. Exchangeable Cl^- change between 1.0

and 18.6 cmol kg^{-1}. The high Na^+ and Cl^- content in the A_1 horizon are related with salt accumulation in the surface. Exchangeable SO_4^{2-} change between 3.1 and 8.4 cmol kg^{-1}. $CaCO_3$ content changes between 11.40 % and 17.80. pH values are high and change between 8.10 and 8.50. The high pH values of profile PL1 may be attributed to high concentration of Na.

The clay content of profile PL2 are low and change between 5.60 % (in the C_2 horizon) and 22.00 % (in the A_1 horizon). The organic C content of the soils is very low changes between 0.28 and 1.25 g kg^{-1}. The low content of organic C can be attributed to long arid periods and poor vegetation. The cation exchange capacity values, depending on the type of clay, organic matter and clay content in the soil profile, change between 8.86 and 22.83 cmol kg^{-1}. The soluble salt content changes between 0.650 and 1.300 %. The source of these salts is the salty underground water. Exchangeable Na^+ change between 0.36 and 2.24 cmol kg^{-1}. Exchangeable Cl^- change between 0.8 and 9.6 cmol kg^{-1}. The high Na^+ and Cl^- content in the A_1 horizon are related with salt accumulation in the surface. Exchangeable SO_4^{2-} change between 1.0 and 5.6 cmol kg^{-1}. $CaCO_3$ content changes between 13.60 % and 15.20. pH values are high and change between 7.70 and 8.20. The high pH values of profile PL2 may be attributed to high concentration of Na.

The clay content of profile PL3 changes between 12.80 % (in the C_3 horizon) and 42.40 % (in the A_1 horizon). The organic C content of the soils is very low and changes between 0.14 and 0.61 g kg^{-1}. The low content of organic C can be attributed to long arid periods and poor vegetation. The cation exchange capacity values change between 18.64 and 34.20 cmol kg^{-1}. The soluble salt content is very high especially in the A_1 horizon, changes between 0.460 and 3.050 %. The source of these salts is the salty underground water. Exchangeable Na^+ change between 0.86 and 3.20 cmol kg^{-1}. Exchangeable Cl^- values are very high and change between 18.1 and 26.1 cmol kg^{-1}. The high Na^+ and Cl^- content in the A_1 horizon are related with salt accumulation in the surface. Exchangeable SO_4^{2-} change between 2.1 and 9.2 cmol kg^{-1}. $CaCO_3$ content changes between 10.12 % and 14.22. pH values are high and change between 8.10 and 8.80. The high pH values of profile PL3 may be attributed to high concentration of Na.

The clay content of profile PL 4 is relatively low and changes between 14.45 and 16.00 %. The organic C content of the soils is low and changes between 1.35 and 1.45 g kg^{-1}. The low content of organic C can be attributed to long arid periods and poor vegetation. The cation exchange capacity values change between 19.02 and 41.30 cmol kg^{-1}. The soluble salt content is very high especially in the A_1 horizon, changes between 0.215 and 2.400 %. The source of these salts is due to the salty underground water. Exchangeable Na^+ change between 0.49 and 4.18 cmol kg^{-1}. Exchangeable Cl^- values change between 9.2 and 15.2 cmol kg^{-1}. Exchangeable SO_4^{2-} change between 2.1 and 6.3 cmol kg^{-1}. Increasing of exchangeable SO_4^{2-} in the Gleyic B horizon associated with sulfudic material. $CaCO_3$ content changes between 17.10 and 23.10 %. pH values are high and change between 8.38 and 8.80. The high pH values of profile PL4 may be attributed to high concentration of Na^+.

The clay content of profile PL 5 is low and changes between 12.20 and 16.40 %. The organic C content changes between 1.38 and 1.44 g kg^{-1}. The low content of organic C can be attributed to long arid periods and poor vegetation. The cation exchange capacity values change between 21.74 and 28.26 cmol kg^{-1}. The soluble salt content is very high especially in the A_1 horizon, changes between 0.350 and 2.400 %. The source of these salts is due to the salty underground water. Exchangeable Na^+ change between 1.07 and 4.18 cmol kg^{-1}. Exchangeable Cl^- values change between 8.6 and 12.1 cmol kg^{-1}. Exchangeable SO_4^{2-} change between 4.6 and 12.3 cmol kg^{-1}. Increasing of Exchangeable SO_4^{2-} in the Gleyic B horizon associated with sulfudic material. $CaCO_3$ content changes between 15.20 and 16.70 %. pH values are high and change between 7.98 and 8.05. The high pH values of profile PL5 may be attributed to high concentration of Na.

The clay content of profile PL 6 is low and changes between 12.3 0 and 16.50 %. The organic C content changes between 1.21 and 1.45 g kg^{-1}. The low content of organic C can be attributed to long arid periods and poor vegetation. The cation exchange capacity values change between 20.11 and 34.78 cmol kg^{-1}. The soluble salt content is very high especially in the A_1 horizon, changes between 0.350 and 2.420 %. The source of these salts is the salty underground water. Exchangeable Na^+ change between 0.87 and 4.95 cmol kg^{-1}. Exchangeable Na^+ content of soil is increasing in the Gleyic horizon. Exchangeable Cl^- values are very high and change between 5.3 and 16.3 cmol kg^{-1}. Exchangeable SO_4^{2-} changes between 4.5 and 8.0 cmol kg^{-1}. Increasing of exchangeable SO_4^{2-} in the Gleyic horizon associated with sulfudic material. $CaCO_3$ content changes between 15.20 and 19.00 %. pH values are high and change between 8.05 and 8.14. The high pH values of profile PL5 may be attributed to high concentration of Na. It has been that high Na^+ content have affected to pH values[1,3].

Classification of soils: Soils have been classified as Entisol and Aridisols according to Key to Soil Taxonomy[11]. Profiles PL1 and PL3 were classifed as Aquic Torrifluvents since they have aquic conditions for some time in normal years and contain no diagnostic horizon but an Ochric epipedon and developed on alluvium parent material.

Profile PL2 was classifed as Typic Torrifluvents as they have an aridic moisture regime, contain no diagnostic horizon but an Ochric epipedon and developed on alluvium parent material. Profiles PL4, PL5 and PL6 were classified as Typic Aquicambid since they have aquic conditions for some time in normal years and as they have a Gleyic B diagnostic horizon.

Profiles PL 1, PL 2 and PL 3 were classified into the World References Base For Soil Resources[17] as Sodic Solonchaks since they have intensive salt cristals, have an Ochric A horizon in the surface. Profiles PL4, PL5 and PL6 were classified as Gleyic Solonchaks since they contain a Gleyic horizon and they have intensive salt crystals[17].

Conclusion

Drilling drainage channels to lower the level of base water is the first process to be carried out for the improvement of saline and alkaline soils. For a successful improvement process, the level of base water should be 180 cm deep in arid regions and 75-120 cm in humid regions[20,25]. In the second stage of an improvement process, the soluble salts should be leached from the soil profile. Salt content of the leaching water should be kept at minimum.

In order to obtain urgent and effective results from an improvement process, addition of some chemical substances such as gyps ($CaSO_4{\cdot}3K_2O$), H_2SO_4, sulfur (S) and $Fe_2(SO_4)_3$ should be added to the leaching water to remove Na^+ from the colloids[20]. Type and amount of the chemical substances to be used for the improvement of saline and alkaline soils change depending on the economy and soil characteristics such as $CaCO_3$ content, pH and gyps content. Because of its high reaction speed, H_2SO_4 is a suitable substance for the improvement of saline and alkaline soils. But due to the high cost involved, care-requiring usage and need of special equipment have limited its wide use for the improvement of large areas[20].

Gyps, the most commonly used and a moderately economical substance, is the best alternative for soil improvement in Turkey. Exchangeable Na^+ in the colloids is substituted by Ca^{2+} when gyps is used as a soil improvement agent. Na_2SO_4 forming as a result of this reaction dissolves in the water and removed from the soil with the leaching water.

It is known that the improvement of saline and alkaline soils is very costly and time-consuming task. In the field of study, the soil profiles PL1, PL3, PL4, PL5 and PL6 having salinity problem were close to the river prevented lowering the level of base water. Therefore, by letting the drainage channel flow into nature and keeping the drainage channels in operation, the study area with severe salinity problem that is close to the river should be used as a meadow. Allocating the cost of improvement process on the irrigation, fertilization etc of the cultivable agricultural fields of profile PL2 would be much more economical and feasible.

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(*Received*: 14 November 2007; *Accepted*: 9 February 2008) AJC-6342