Asian Journal of Chemistry Vol. 19, No. 3 (2007), 2316-2324

Characteristics and Classification of Arid Region Soils: Salt Lake Specially Protected Area (Tuz Gölü-Turkey)

ORHAN DENGIZ
Department of Soil Science, Faculty of Agriculture, University of Ondokuz Mayis
55139, Kurupelit, Samsun, Turkey
Tel: (90)(362)3121919/1463; Fax: (90)(362)4576034
E-mail: odengiz@omu.edu.tr

Salt lake is a unique ecosystem for both agricultural activities and natural life in Turkey. This study was aimed to determine chemical and physical properties and classifying soils of salt lake (Tuz Gölü) specially protected area. The study revealed presence of 13 great groups in salt lake (Tuz Gölü) specially protected area. Soils determined were classified as entisol (26.7 %), aridisol (47.2 %), vertisol (0.6 %), histosol (0.3 %) according to soil taxonomy. Soil organic matter (SOM) for a depth of the upper horizons ranged from 0.64 to 4.49 % except for SOM-rich histic epipedon (67.8%). Bulk density of the soils varied between 0.12 to1.56 g cm^{-3}. High clay content of the soils ranging from 68.4 to 10.72% for the entire horizons causes poor drainage conditions in about 16.4% of the salt lake (Tuz Gölü) specially protected area. Sustainability of prime farmlands of the salt lake (Tuz Gölü) specially protected area can be ensured by best management practices such as reduce tillage, residue incorporation, surface and subsurface drainage, windbreaks, rotational cultivation, ecologically suitable crop selection, integrated pest management and intercropping.

Key Words: Salt lake, Soil classification, Soil taxonomy, Physical and chemical properties.

INTRODUCTION

Soil composed of mineral and organic materials and living forms in which plants grow are a dynamic natural body. The properties of soil vary spatially in a way not random. According to Jenny[1,2], the state of soils is a function of climate, organisms, parent material, relief and time. These soil forming factors determine soil properties by governing the type and intensity of the pedological processes involved. Information about soil properties and classification over tracts of land is vital for making decision about uses and management of natural resource, environmental protection, land use planning and precision agriculture[3].

Several soil studies in arid and semi-arid areas indicate that soils show wide spatial variability resulting from differences in parent material, age of land surface, topography, water distribution, amount and intensity of rainfall and plant heterogeneity[4,5]. The salt lake is surrounded by generally cereals, sugar beet and sun flower fields in the southern and eastern part of the study area. The most common land use type is dry farming (26.8 %) then, rangeland, irrigated land, pasture, settlement and other various lands (barren land, road, mine, swamp, *etc.*). There is no detailed inventory and survey of soils of the salt lake specially protected area. The present of this study was, therefore, to determine physical, chemical soil characteristics and soil classification of the salt lake specially protected area.

EXPERIMENTAL

Specially protected area of Salt lake of about 7414 km^2 is located geographical in latitude 39º 30' 00" to 38º 00' 00" and longitude 32º 30' 00" to 34º 30' 00" in Konya plain border and occupied a depression in the dry central plateau (Central Anatolia) of Turkey, 105 km northeast of Konya (Fig. 1).

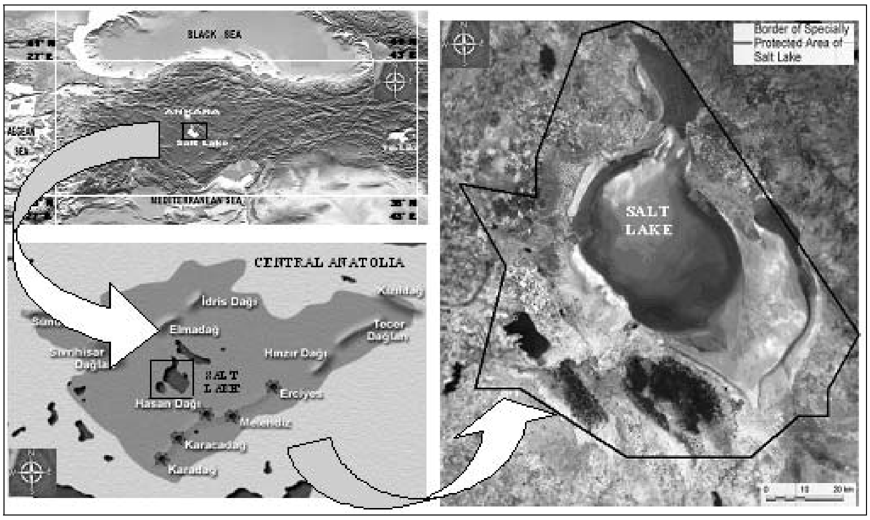

Fig. 1. Location of the study area

Salt lake has an area that covers 24.7 % of the total area (about 1831 km^2). Normally it is about 80 km north to south and 50 km east to west. It recedes each summer to leave a desolate expanse of encrusted salt. The lake has no outlet, but it has two major streams: Groundwater and surface water feed the lake. An unnaturally constant input is the wastewater, which reaches the lake through the 150 km long Konya main drain channel. Brackish marshes have formed where channels and streams enter the lake;

rainfall in the surrounding area is as low as 250 mm per year, average temperature and annually total evaporation are 11.8ºC and 1372.7 mm, respectively. Salt lake is the second largest lake in Turkey. Its extent varies greatly with a maximum of depth 1.5 m in spring and most of the lake dries up in summer (except some small areas, especially a 3500 ha area south of Sereflikochisar). The east west track at the bottleneck (reinforced with stones in the 16th century) is only passable in summer. The lake is surrounded by (only partially irrigated) cereal fields in the north, east and west; however, extensive seasonally flooded salt steppe occur, particularly to the south-west.

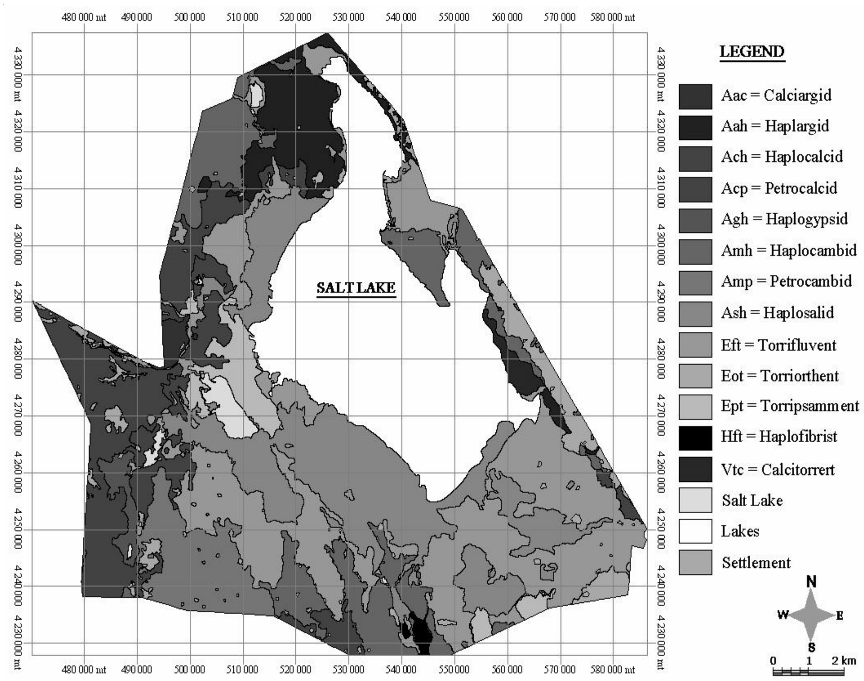

Fig. 2. Soil map of the study area

The salt lake and its vicinity are covered with oligocene formations having gypsum and salt strata. Although salinity level changes with seasonal fluctuations (on 24-30 April, on 1-9 July and on 18-26 August 2003), this lake water is extremely saline with a salt ratio of 32 %. The lake bottom is covered with 1 to 30 cm thick salt layer, which has given rise to a local salt industry providing 55% of all Turkish salt. On average 750,000 tons salt is produced annually at three (state owned) saline plots, covering 1200 ha. The Salt lake also includes a unique ecosystem with its natural attractive environments and habitats for biota.

Digital elevation model-DEM, Landsat-5 TM image, geological maps and meteorological data were used to prepare soil map (Fig. 2) and soil data-base of study region. All these data were analysed using of TNT mips 6.4v Micro Image GIS and RS programme[6]. Descriptions of soils in the salt lake (Tuz Gölü) specially protected area were accomplished according to soil survey manual[7]. Soil samples collected from all horizons were analyzed for total soluble salts[8], CEC[8] (cation exchange capacity), pH[8], texture[9], organic matter[10], $CaCO_3$[7] and bulk density[11]. Soil classification was accomplished using soil taxonomy[12] and FAO/UNESCO[13].

RESULTS AND DISCUSSION

Physico-chemical properties of the soil

The physical properties of the soils that have been taken into consideration in this study showed variability as a result of dynamic interactions among natural environmental factors such as climate, parent material, land cover-land use and topography[14]. The horizon orders of the profiles in the study area were defined to be A-B-C form except for especially IX, X, XI profiles which have A-C or A-R horizons. This means these soils have no diagnostic subsurface horizons and low pedogenetic development. Therefore, these soils can be defined as young soils. There are no significant differences in the values of pH 7.5-8.3 and a very high base saturation (Table-1).

Whereas profiles 7 and 8 have salic and gypsic horizons leading to high amount of soluble salt contents. All other soil have slightly soluble salt content. Soil CEC varied between 10.62 to 34.49 mol kg^{-1}. The soil with the highest CEC was Calcitorrert with high clay contents, while the lowest value was determined in Torripsamment soil. All soils have high $CaCO_3$, ranging from 8.21 to 78.60 %. In addition, profile II and III have a calcic horizon.

Soil organic matters contents depend on the complex interaction of several factors including the quantity and quality of litter fall, climatic factor, soil properties (especially the amount and type of clay) and erosion[15]. The soils of the salt lake specially protected area were determined commonly to be poor in soil organic matter (SOM) for the first two horizons ranging from 28-57 cm in depth. For all soils, the organic matter are highest in the surface horizon and decrease sharply to its lowest level in the subsoil. In the study area, the reasons of the low level organic matters are attributable to rapid decomposition and mineralization of organic matter (especially, due to intensive agricultural activities for right side), to overgrazing and to soil erosion (due to high slope for left side). Soil organic matter ranged from 0.64 to 4.49 % in upper horizons except for SOM-rich histic epipedon of profile XIII. Bulk density (BD) of the soils

TABLE-1
RESULTS OF PHYSICAL AND CHEMICAL

Profile No	Horizon	Depth (cm)	pH	Total salt (%)	CEC (mol kg^{-1})
		Haplargid/Haplic Luvisol			
I	Ap	0-23	7.5	0.042	22.98
	A2	23-39	7.5	0.031	22.98
	Bt	39-80	7.7	0.054	23.03
	C	80+	7.6	0.105	20.92
		Calciargid/Calcic Luvisol			
II	Ap	0-17	7.7	0.034	27.44
	A2	17-30	7.7	0.037	27.44
	Bt	30-50	7.7	0.058	27.37
	Bk	50-83	7.9	0.053	27.20
	C1	83-111	7.9	0.072	28.06
	C2k	111+	8.18	0.150	30.45
		Haplocalcid/Haplic Calcisol			
III	Ap	0-18	7.7	0.023	23.67
	A2	18-55	8.0	0.016	20.97
	Bk	55-143	7.8	0.045	16.48
	Ck	143+	8.2	0.020	11.26
		Petrocalcid/Petric Calcisol			
IV	A	0-10	7.7	0.012	15.88
	AC	10-27	7.8	0.015	13.03
	Cr	-	-	-	-
		Haplocambid/Eutric Cambisol			
V	A1	0-21	7.5	0.034	19.51
	A2	21-50	7.9	0.046	24.27
	Bw	50-87	8.1	0.036	19.95
	C	87+	8.0	0.122	23.58
		Petrocambid/Calcaric Cambisol			
VI	Ap	0-10	7.6	0.026	21.68
	Bw	10-38	7.8	0.024	21.77
	C	38+	-	-	-
		Haplogypsid/Gypsic Solonchak			
VII	A1	0-20	7.9	0.472	28.03
	A2	20-40	8.3	1.800	26.84
	Cy	40-80	8.2	2.017	23.51
	2Cy	80+	8.0	2.013	13.55
		Haplosalid/Haplic Solonchak			
VIII	A	0-21	7.7	2.42	20.80
	Cz	21-67	8.1	3.53	16.01
		Torripsamment/Eutric Regosol			
IX	Ap	0-19	7.7	0.008	10.62
	C1	19-71	7.8	0.160	18.46
	C2	71-111	7.9	0.025	17.63
	C3	111+	7.9	0.023	19.08
		Torrifluvent/Eutric Fluvisol			
X	Ap	0-28	7.7	0.059	34.07
	A2	28-57	7.9	0.346	34.49
	C	57+	7.9	0.204	32.09
		Torriorthent/Lithic Leptosol			
XI	A	0-24	7.61	0.029	22.47
	R	24+	-	-	-
		Calcitorrert/Calcic Vertisol			
XII	Ap	0-10	7.8	0.045	35.49
	Bss	10-57	8.2	0.040	35.49
	BC	57-102	8.2	0.045	28.16
	C	102+	8.3	0.021	11.64
		Haplofibris/Fibric Histosol			
XIII	Oi	0-34	7.8	0.032	22.8
	C	34+	8.1	0.043	25.4

ANALYSES OF SOILS OF THE STUDY AREA

$CaCO_3$ (%)	SOM (%)	BD (g cm^{-3})	Texture (%)			
			Sand	Silt	Clay	Class
			Haplargid/Haplic Luvisol			
13.69	2.09	1.20	32.72	25.44	41.24	C
13.69	1.20	1.30	37.36	24.42	38.22	C
12.32	0.90	1.27	34.72	17.64	47.64	C
12.32	0.81	1.30	38.72	19.64	41.64	C
			Calciargid/Calcic Luvisol			
13.02	1.52	1.09	31.28	28.00	40.72	C
14.67	1.32	1.18	31.28	24.00	44.72	C
20.49	0.91	0.97	19.28	26.00	54.72	C
26.23	0.68	0.96	19.28	32.00	48.72	C
20.56	0.35	1.06	17.28	34.00	48.72	C
23.30	0.25	1.15	21.28	30.00	48.72	C
			Haplocalcid/Haplic Calcisol			
8.21	1.41	1.22	50.72	17.64	31.64	SCL
10.27	0.30	1.24	52.72	11.64	35.64	SC
20.53	0.24	1.33	72.72	1.64	25.64	SCL
15.23	0.07	1.43	72.72	7.64	19.64	SL
			Petrocalcid/Petric Calcisol			
50.72	3.39	1.19	49.28	26.00	24.72	SCL
53.46	2.06	1.21	43.28	22.00	34.72	CL
-	-	-	-	-	-	-
			Haplocambid/Eutric Cambisol			
10.28	4.18	1.20	48.72	29.64	21.64	L
11.93	2.63	1.17	40.72	27.64	31.64	CL
13.02	0.18	1.37	36.72	29.64	33.64	CL
12.06	0.07	1.37	34.72	29.64	35.64	CL
			Petrocambid/Calcaric Cambisol			
26.26	1.47	1.29	35.8	33.00	31.72	CL
30.41	1.35	1.19	27.28	30.00	47.72	C
-	-	-	-	-	-	-
			Haplogypsid/Gypsic Solonchak			
17.68	2.11	1.15	21.28	67.00	11.72	SiL
19.19	1.45	1.29	4.28	65.00	30.72	SiCL
14.94	1.13	1.31	6.28	63.00	30.72	SiCL
32.90	0.82	1.20	2.28	71.00	26.72	SiL
			Haplosalid/Haplic Solonchak			
13.71	4.49	1.23	51.28	26.00	22.72	SCL
19.19	1.67	1.37	65.28	24.00	10.72	SL
			Torripsamment/Eutric Regosol			
9.32	0.64	1.56	72.72	9.28	18.00	SL
17.68	0.46	1.37	70.72	13.28	16.00	SL
28.10	0.19	1.35	72.72	16.28	11.00	SL
13.02	0.25	1.33	59.28	26.00	14.72	SL
			Torrifluvent/Eutric Fluvisol			
16.17	2.58	1.12	15.28	60.72	24.00	C
19.19	1.33	1.19	7.28	76.72	16.00	C
23.71	0.77	1.19	9.28	76.72	14.00	C
			Torriorthent/Lithic Leptosol			
15.02	1.44	1.27	35.28	34.00	30.72	CL
-	-	-	-	-	-	-
			Calcitorrert/Calcic Vertisol			
14.67	1.10	1.23	12.72	23.28	64.00	C
15.76	0.58	1.27	12.72	22.28	65.00	C
17.82	0.36	1.25	24.72	23.28	52.00	C
13.02	0.04	1.54	68.72	13.28	18.00	S
			Haplofibris t/ Fibric Histosol			
68.60	67.8	0.12	27.8	28.8	43.3	C
78.60	3.3	1.21	12.9	18.7	68.4	C

varied between 0.12 to1.56 gcm^{-3}. Profile XIII classified as fibric histosol has the lowest bulk density values ranging 0.12 to 1.21 g cm^{-3}. Soil texture of I, II, X, XII, and XIII was clayey in throughout the profiles. Among all the horizons, the maximum clay content (65 %) throughout the soils of the study area was determined in profile XII (calcitorrert), while the lowest content (11 %) was determined in profile IX classified as torripsamment. Furthermore, profile I, II and IX have argillic horizon and slickensides with high clay accumulation.

Soil classification

Four soil orders, ten suborders and thirteen great groups were identified in the study area. The soils were classified according to the criteria proposed by the soil taxonomy[12] and FAO/UNESCO[13] based on morphological, physical and chemical characteristics. According to the meteorological data, the study area has arid soil moisture regime and mesic temperature regime. Soils of the salt lake specially protected area were classified as entisols (26.7 %), aridisols (47.2 %), vertisols (0.6 %), histosols (0.3 %) and as luvisols, calcisols, cambisols, solonchak, fluvisols, regosols, leptosols, vertisols and histosols according to soil taxonomy[12] and FAO/UNESCO[13], respectively (Table-2). The majority of soils were aridisol and entisol in soil taxonomy while, according to FAO/UNESCO[13] fluvisol (20.6 %) is dominant soils in the study area.

TABLE-2
CLASSIFICATIONS OF SOILS OF SALT LAKE (TUZ GÖLÜ) SPECIALLY PROTECTED AREA ACCORDING TO SOIL TAXONOMY AND FAO/UNESCO

Orders	Suborders	Great groups	FAO/UNESCO	Area (ha)	Ratio (%)
Aridisol	Argid	Calciargid (Aac)	Calcic Luvisol	3470.1	0.15
		Haplargid (Aah)	Haplic Luvisol	35255.4	4.7
	Calcid	Haplocalcid (Ach)	Haplic Calcisol	66184.9	8.9
		Petrocalcid (Acp)	Petric Calcisol	23150.8	3.2
	Cambid	Haplocambid (Amh)	Eutric Cambisol	68377.9	9.2
		Petrocambid (Amp)	Calcaric Cambisol	31977.8	4.3
	Gypsid	Haplogypsid (Agh)	Gypsic Solonchak	6294.2	0.9
	Salid	Haplosalid (Ash)	Haplic Solonchak	115336.8	15.6
Entisol	Fluvent	Torrifluvent (Eft)	Eutric Fluvisol	152754.9	20.6
	Psamment	Torripsamment (Ept)	Eutric Regosol	19924.5	2.6
	Orthent	Torriorthent (Eot)	Lithic Leptosol	25061.1	3.4
Vertisol	Torrert	Calcitorrert (Vtc)	Calcic Vertisol	4528,9	0.6
Histosol	Fibrist	Haplofibrist (Hft)	Fibric Histosol	2045.1	0.3

Since the salt lake specially protected area has been developed on oligocene formations having gypsium and salt strata and sandstone, marl and limestone parent materials. In addition, some soils of the study area have been developed on young parent material, its soils do not have pronounced diagnostic subsurface horizons. Because of the heavy clay texture and high salt concentration of calcitorrert, haplogypsid and haplosalid soils pose some difficulties for agricultural activities such as cultivation, irrigation and drainage. Since majority of parent materials of the study area have high $CaCO_3$, most of the salt lake specially protected area soils have high $CaCO_3$.

It was determined that the some subsurface layers (Ap-plough layer) have higher bulk density (BD) than lower an overlaying layer without textural changes in most of the agricultural lands such as calciargid, haplargid, haplocalcid, torrifluvent and calcitorrert due to field machine traffic and tillage, which lead to reduced diffusion of water and gasses, poor drainage, restricted root growth and lowered crop yield. Therefore, poor timing of farming operations and excessive equipment size and power tend to increase soil compaction and have an important negative impact on productivity. This compaction also causes increasing erosion, especially on wet clay soil.

Sustainability of prime farmland of the salt lake specially protected area is threatened by mismanagement practices and ecologically incompatible land use. For example, salinization is emerging increasingly as a major problem in the soils of the salt lake specially protected area. It was found that 15.1 % of specially protected area of salt lake was not suitable for agricultural activities. However, these places are strongly connected to the wetlands ecologically and should be taken under protection because these places are habitat of the some endemic plants and animals (notably flamingos), both aesthetic values and as naturally attractive environments. In the same manner, some regions were found suitable for irrigated and rainfed agricultural practices by considering capacities of the soils.

In relation to environmental quality, it is clear that the intensification of agriculture will decrease biodiversity and increase the source pollution on soils and waters. As the salt lake basin is closed basin, it is the final recipient of all contamination. Therefore, the water quality of the fresh water has decreased owing to affection of domestic wastewater and agricultural pollution. In addition to that, water levels in the aquifer have decreased, due to the increase of fresh water consumption. It is estimated that there are roughly 10000 wells in the basin. However, most of these wells are not licensed that lead to the uncontrolled extraction of water from the aquifer and lead to lakes and wetland have diminished in surface area or have dried up. That's why, it should be taken under control and no more wells should be approved by authorities. Otherwise, most of the high and moderate quality lands can not be used in future due to acceleration of land and soil degradation in terms of salinization.

Best management practices including reduce tillage, residue incorporation, surface and subsurface drainage, windbreaks, rotational cultivation, ecologically suitable crop selection, integrated pest management and intercropping can increase levels of both agricultural productivity and environmental quality significantly[16].

ACKNOWLEDGEMENTS

This research was funded by the organization of authority from protection of special areas and general directory of rural services, Ankara Research Institute. This article has benefited from valuable contribution of Fatma Elbasi, Dilek Yatman during GIS process. I am thankful to both of them.

REFERENCES

1. H. Jenny, The Soil Resource-Origin and Behavior, Springer, New York (1980).
2. H. Jenny, Factors of Soils Formation, McGraw-Hill, New York (1941).
3. S. Kilc, N. Aca and M. Yalcin, *J. Agron.*, **3**, 291 (2004).
4. P.J. Wierenga, J.M.H. Hendrickx, M.H. Nash, J. Ludwing and L.A Daugherty, *J. Arid Environ.*, **13**, 53 (1987).
5. A. Shmida and T.L. Burgess, Plant Growth-From Strategies and Vegetation Types in Arid Environments, in ed.: M.J.A. Werger, Soil Reclamation Processes: Microbiological Analyses and Applications, Marcel Dekker, New York, pp. 83-106 (1988).
6. TNT (The New Thing), MIPS (MicroImage Processing System), Getting Started Geospatial Analysis, MicroImages, USA (1999).
7. Soil Survey Staff, Soil Survey Manual, USDA, Handbook No. 18 (1993).
8. Soil Survey Staff, Soil Surv. Invest. Rep. I. U.S. Gov. Print. Office, Washington D.C. USA (1992).
9. G.J. Bouyoucos, *Agron. J.*, **43**, 434 (1952).
10. D.W. Nelson and L.E. Sommers, Total Carbon, Organic Carbon and Organic Matter, in eds.: L.A. Page, R.H. Miller, D.R. Keeney and Methods of Soil Analysis, Part 2, Chemical and Microbiological Methods, American Society of Agronomy, Madison, WI, edn. 2, pp 539-579 (1982).
11. G.R. Blacke and K.H. Hartge, in ed.: A. Klute, Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, Agronomy 9, edn. 2, pp. 363-382 (1986).
12. Soil Survey Staff, Soil Taxonomy, A Basic of Soil Classification for Making and Interpreting Soil Survey, USDA Handbook No: 436, Washington D.C. USA (1999).
13. FAO/UNESCO, Soil Map of The World, Revised Legend, World Soil Resource Report, 60, Rome (1990).
14. O. Dengiz, C. Göl, S. Karaca and M. Yüksel, International Soil Meeting on Soil Sustaining Life on Earth, Sanliurfa, Turkey, Vol. 2, pp. 745-751, (2006).
15. R.H. Dahlgeren, J.L. Boettinger, G.L. Huntington and R.G. Amundson, *Geoderma*, **78**, 207 (1997).
16. F. Evrendilek and C. Ertekin, *Land Degrad Dev.*, **13**, 61 (2002).

(*Received*: 17 June 2006; *Accepted*: 4 November 2006) AJC-5249