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EVALUATING SOIL AND GROUNDWATER SALINITY IN TALUKA TANDO BAGO, SINDH

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ABSTRACT

A research survey on the current status of soil and groundwater salinity problem in taluka Tando Bago, district Badin, Sindh is reported in this paper. Ten different salt-affected sites were selected in the study area. At each site, a pit of approximately 1m x 1m and 1m deep was opened for detailed examination and sampling. Bulk soil sample was taken from each marked layer of the opened profile. Groundwater sampling was done by boring the centre of each profile. The results of analysis indicated that the soils were slightly alkaline in reaction, variable in texture, poor in organic matter and calcareous in nature. The surface and top layers contained more salts than sub-surface and deeper layers. The groundwater level in the area was very shallow and salty in nature. Compared to the other ions, the presence of higher concentration of Na^+ and Cl^- in groundwater and in surface and subsurface layers indicate upward/capillary rise of salty groundwater to the surface.

Keywords: Capillary rise, profile salinity, salts, Na^+, Cl^-

INTRODUCTION

Soil salinization has been reported as a major problem in several countries of the world, including India, Australia, China, USA and Pakistan (Sial, 1985a; Ghassemi, 1995; Rajpar and Sial, 1997; Ghafoor *et al.*, 2004). Soil salinity in arid and semi-arid regions occurs as a result of several factors, including high temperature, low rainfall (Ghafoor *et al.*, 2004), rise in salty water-table (Samdani, 1995), flooding by seawater (Rowell, 1994). Capillary rise in groundwater, seawater intrusion and flooding have been shown much more responsible for developing salinity problem in coastline of Sindh province of Pakistan (Samdani, 1995). Tidal lakes in coastline sometimes remain under seawater (Soil Survey of Pakistan, 1970). Drying up of old tidal lakes leaves large quantity of salts with thick crust on the surface. In 1999, extensive seawater

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flood due to cyclone occurred in various parts of Badin and Thatta districts brought large quantity of sea salts in the soil. This paper presents the evaluation of extent of soil and groundwater salinity problem in taluka Tando Bago, District Badin, Sindh. The survey area has an arid and semi-arid marine climate with low, uncertain and erratic rainfall (Soil Survey of Pakistan, 1970). The evaporation in the area is very high due to high temperature and continuous sea wind.

MATERIALS AND METHODS

A soil and groundwater survey was conducted to investigate the soil and groundwater salinity problem in taluka Tando Bagho, district Badin. Ten different salt-affected locations were selected for survey. At each location, a pit (profile) of approximately 1x1m and 1m deep was opened for description and sampling. Bulk soil sample was taken from each marked layer of every profile. Groundwater was sampled by making a bore hole at the centre of profile and obtaining a sample from the standing water (Timpson *et al.*, 1986). Soil samples were initially prepared by air-drying and passing through 2 mm sieve for detailed analysis of physico-chemical properties. Soil samples were processed to determine texture by Bouyoucos hydrometer method (Kanwar and Chopra, 1959), $CaCO_3$% through acid neutralization method and organic matter content % with the Walkley-Black titration method (Jackson, 1958). Both soil and groundwater samples were analyzed for: pH with a glass electrode pH meter (SP-34 Suntex), EC with digital conductivity meter (HI-8333), soluble Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^- and Cl^- by titration methods (USSL, 1954). Concentration of Na^+ was determined by flame photometry (USSL, 1954). Sodium adsorption ratio (SAR), residual sodium carbonate (RSC in water samples only) and exchangeable sodium percentage in soil samples were estimated by calculations (Rowell, 1994; Qureshi and Barret-Lennard, 1998; USSL, 1954).

RESULTS AND DISCUSSION

Soil salinity problem

Particle size distributions (Table 1) show that most of the soil profiles had layers with clay, silty clay loam, loam and clay loam textures. Only one soil profile (Profile 10) had two bottom layers with sandy loam texture. The main reasons for this particle size distribution pattern in the study area was possibly due to the nature of the parent material, the eluviation, illuviation and also may be some faunal activities (de-Villiers, 1965; Lewaka and Whiteside, 1986). It is evident from the report of Ghafoor *et al.* (2004) that the soils of lower Indus Plain contain more clay. Rajpar and Sial (1997) have also observed similar trend of soil texture in salt-affected soils of Hyderabad district, the area adjacent to Badin district (study site). At all depths, soil was slightly alkaline in reaction and showed pH range of 7.3 to 8.5. The alkaline pH was possibly due to the presence of high $CaCO_3$, as soils of the survey area were calcareous in nature (Table 1), though,

the general pattern of $CaCO_3$ distribution in all profiles was irregular. The organic matter content was found to be < 1% in all opened pits, however, the upper layers contained more organic matter than the bottom most layers (Table 1). Low organic matter content observed in these soils was possibly due to the lack of vegetation, except availability of some halophyte species such as *Sueda fruticosa, Alhaji mororum*, etc. In general ~2% organic matter is considered necessary for productive soils but in the arid lands, it always remains <2% (Ghafoor *et al*., 2004). Several other research workers including Sial (1985); Rajpar and Sial (1997); Akhter *et al.* (2001); Jawaid *et al.* (2001); Aslam *et al.* (2002) have observed similar properties of salt-affected soils of Sindh province.

The data regarding accumulation of salts in different layers of soil profiles are presented in Table 2. Compared to sub-soil and bottom layers, all soil profiles had high salinity problem in top most layers and showed efflorescence of salts at surface. Surface efflorescence indicates the accumulation of soluble salts possibly brought by salty groundwater to the surface. Capillary rise of salty groundwater to the surface and accumulation of salts on surface has long been reported in arid soils (Samdani, 1995). The Profile 3 was found deeply saline and showed high ECe values throughout the layers; but the other profiles had high salinity in top layers only. Perhaps in the Profile 3 salts were sourced from both surface irrigation and groundwater. Although, the concentrations of Na^+ and Cl^- remained high in top layers, both Na^+ and Cl^- followed by SO_4^{2-} and HCO_3^- were found to be the dominant ions in almost all layers. Carbonates (CO_3^{2-}) generally remained absent in almost all soil samples, except only in those soil samples taken from bottom layers of Profile 2. The distribution of HCO_3^- generally remained uneven and irregular throughout the soil profiles.

Groundwater quality

The results related to groundwater quality of the study area are presented in Table 3. The data showed that the pH of the groundwater ranged from 7.5 to 7.9, EC ranged from 12.5 to 45.94 dS m^{-1}. Concentrations of Na^+ and Cl^- remained dominant in all groundwater samples. Carbonates remained absent in water samples taken from Profile 1, 3, 6, 7, 8, and 9. The HCO_3^- were found in traces (i.e. < 10 $meqL^{-1}$). The study suggested that the quality of groundwater in the study area was quite variable. Groundwater sampled from Profile 5, 7, 8 and 9 showed very high salinity, which may be considered as unfit for irrigation use. Hence, the groundwater of the area covered by these 5, 7, 8 and 9 profiles must be restricted for crop use. Although, it depends upon type of soil, salt-tolerance of plant and climatic conditions, blending of such high salinity water with canal water may be allowed for irrigation. Irrigating crops with marginal quality waters up to certain degree is not necessarily adverse to all soils and / or harmful to all plant species (Gupta, 1990).

Table 1. Some physico-chemical properties of various soil profiles.

Depths (cm)	Mechanical Analysis			Textural Class	pH (H_2O)	% $CaCO_3$	% OM
	% Sand	% Silt	% Clay				
Profile: 1							
0-15	15.5	38.0	46.5	Clay	7.7	7.2	0.92
15-30	13.5	18.5	68.0	Clay	7.9	8.5	0.85
30-50	16.0	42.0	42.0	Clay	8.0	9.4	0.72
50-65	12.0	25.0	63.0	Clay	8.1	10.5	0.41
65-80	07.5	56.5	36.0	Silty clay loam	8.2	10.2	0.40
80-100	04.5	61.5	36.0	Silty clay loam	7.9	11.5	0.30
Profile: 2							
0-12	24.3	28.2	47.5	Clay	7.8	5.5	0.85
12-30	07.5	51.0	41.5	Silty clay	7.8	7.6	0.73
30-49	28.8	31.5	39.7	Clay loam	7.9	8.1	0.60
49-65	33.1	42.2	24.7	Loam	8.1	8.5	0.53
65-85	15.0	60.3	24.7	Silty loam	8.6	10.5	0.52
85-100	45.8	34.0	20.5	Loam	8.8	10.6	0.32
Profile: 3							
0-17	05.5	37.0	57.5	Clay	7.9	10.5	0.91
17-34	04.0	19.7	79.0	Clay	7.6	10.3	0.80
34-50	14.0	43.0	43.0	Silty clay	7.7	10.9	0.80
50-68	06.8	32.2	60.0	Clay	8.0	11.5	0.65
68-83	31.8	25.7	42.5	Clay	8.1	8.5	045
83-100	28.8	33.2	38.0	Clay laom	8.3	8.3	0.20
Profile: 4							
0-4	02.0	21.7	79.0	Clay	8.0	7.7	0.80
4-20	16.0	41.8	42.2	Silty clay	7.8	8.2	0.45
20-35	4.0	37.5	58.5	Clay	7.6	9.5	0.41
35-55	10.0	25.0	65.0	Clay	8.2	9.5	0.30
55-75	12.0	24.0	64.0	Clay	8.3	11.5	0.31
75-100	4.5	63.5	34.0	Silty clay loam	8.3	11.5	0.30
Profile: 5							
0-20	15.1	39.2	45.7	Clay	7.8	8.9	0.90
20-40	10.9	22.2	66.9	Clay	7.8	9.5	0.75
30-50	10.7	22.4	66.9	Clay	7.6	10.6	0.50
40-60	9.6	18.2	72.2	Clay	7.7	10.5	0.40
60-82	11.6	49.2	38.2	Silty clay	7.4	11.9	0.35
82-100	4.8	34.2	61.4	Clay	7.5	12.1	0.30
Profile: 6							
0-22	15.3	20.7	64.0	Clay	7.8	8.2	0.72
22-43	20.1	14.9	65.0	Clay	7.6	8.1	0.60
43-62	24.6	17.3	58.1	Clay	7.7	7.0	0.50
62-80	17.2	16.3	66.5	Clay	7.4	6.0	0.40
80-100	27.6	7.4	65.0	Clay	7.5	4.1	0.40
Profile: 7							
0-7	7.1	53.1	39.8	Silty clay loam	7.7	7.2	0.98
7-24	6.6	37.9	55.5	Clay	7.8	8.5	0.72
24-50	3.0	35.5	61.5	Clay	7.9	8.6	0.72
50-70	7.1	60.6	32.3	Silty clay loam	7.8	9.0	0.60
70-84	8.2	35.3	56.5	Clay	7.9	9.5	0.40
84-100	9.2	34.6	56.0	Clay	8.0	10.5	0.30

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Profile: 8							
0-20	10.0	29.5	60.5	Clay	7.6	8.2	0.71
20-42	4.0	19.7	76.3	Clay	7.6	9.5	0.70
42-62	7.8	32.2	59.0	Clay	7.8	10.5	0.62
62-79	30.6	26.8	42.6	Clay	7.9	10.5	0.42
79-100	28.0	33.0	39.0	Clay loam	7.8	11.7	0.30
Profile: 9							
0-18	42.0	37.5	20.5	Loam	7.6	6.2	0.65
18-40	15.2	20.8	64.0	Clay	7.8	8.0	0.60
40-58	20.1	14.9	65.0	Clay	7.9	8.1	0.55
58-76	20.7	14.3	65.0	Clay	8.1	10.5	0.30
76-100	16.1	16.4	67.5	Clay	7.9	10.9	0.31
Profile: 10							
0-26	35.0	33.5	31.5	Clay loam	7.7	7.9	0.72
26-45	33.5	35.2	31.3	Clay loam	7.9	9.5	0.41
45-64	31.0	38.0	31.0	Clay loam	8.1	10.0	0.45
64-87	64.0	21.0	15.0	Sandy loam	8.2	11.2	0.35
87-100	63.5	20.0	16.5	Sandy loam	8.2	12.1	0.30

Table 2. Soil salinity problem in taluka Tando Bagho, district Badin Sindh, Pakistan.

Depth (cm)	EC_e (dS m^{-1})	Soluble cations and anions ($meqL^{-1}$ in saturated extract)									
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cations	CO_3^{2-}	HCO_3^{-}	SO_4^{2-}	Cl^{-}	Anions
Profile: 1											
0-15	14.7	16.0	15.6	112.9	3.12	147.6	-	5.0	31.62	111.0	147.62
15-30	8.4	9.0	8.5	65.7	1.56	84.7	-	4.0	18.26	62.5	84.76
30-50	4.3	7.0	6.5	25.6	1.25	40.3	-	3.0	8.85	28.5	40.35
50-65	2.7	4.8	3.8	18.3	1.00	27.8	-	3.0	6.39	18.5	27.89
65-80	2.2	4.0	3.9	14.3	0.50	22.6	-	4.0	5.19	13.5	22.69
80-100	2.2	4.5	4.3	13.5	0.26	22.5	-	6.0	6.55	10.0	22.55
Profile: 2											
0-12	30.50	40.8	35.6	226.02	3.50	305.92	-	2.0	73.42	230.5	305.92
12-30	13.10	20.0	15.0	94.06	2.33	131.39	-	3.0	31.99	96.4	131.39
30-49	05.20	08.4	06.6	25.12	2.22	52.34	-	3.0	12.34	37	52.34
49-65	03.10	06.0	05.0	18.32	2.15	31.47	-	4.0	7.17	20.3	31.47
65-85	02.20	04.6	03.4	12.12	1.62	21.74	2	2.0	4.74	13	21.74
85-100	02.00	03.4	03.4	11.17	1.25	19.22	2	3.0	3.72	10.5	19.22
Profile: 3											
0-17	24.20	68.8	31.0	141.17	2.35	243.32	-	5.0	98.32	140	243.32
17-34	09.90	30.0	16.4	53.70	1.03	101.13	-	3.0	49.63	48.5	101.13
34-50	04.80	14.0	12.0	21.70	1.36	49.06	-	3.0	27.06	19	49.06
50-68	06.00	14.5	10.0	34.78	1.35	60.63	-	4.0	25.13	31.5	60.63
68-83	04.30	06.0	09.5	26.34	1.25	43.09	-	4.5	15.59	23	43.09
83-100	04.10	05.5	08.0	25.61	1.20	40.31	-	5.5	14.31	20.5	40.31
Profile: 4											
0-14	15.9	45.0	17.8	94.8	2.21	159.81	-	5.0	45.31	109.5	159.81
14-20	08.9	21.0	10.4	55.7	2.10	89.20	-	5.0	25.2	59	89.2
20-35	07.3	15.0	5.8	49.8	1.79	72.39	-	4.0	20.89	47.5	72.39
35-55	04.3	04.2	3.0	40.2	1.35	48.78	-	4.0	13.78	31	48.78
55-75	03.1	07.0	3.2	21.5	0.65	32.35	-	4.0	10.35	18	32.35
75-100	02.7	04.0	3.2	18.5	0.63	26.93	-	4.0	9.43	13.5	26.93

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Profile: 5											
0-15	11.3	21.0	17.0	72.95	2.36	113.31	-	5.0	31.81	76.5	113.31
30-50	4.5	8.0	6.6	29.16	1.43	45.19	-	2.0	14.19	29	45.19
41-60	3.4	7.0	5.0	21.78	1.05	34.83	-	2.0	10.33	22.5	34.83
65-82	3.0	7.0	2.8	19.46	1.00	30.26	-	1.0	9.26	20	30.26
82-100	6.2	6.0	11.6	43.40	0.78	61.78	-	2.5	19.78	39.5	61.78
Profile: 6											
0-22	29.0	48.0	23.5	57.80	1.46	131.36	-	2.0	54.86	74.50	131.36
22-43	4.2	10.0	10.4	20.59	1.23	42.22	-	2.5	17.72	22.00	42.22
43-62	3.7	8.0	8.0	20.59	1.12	37.71	-	2.0	15.71	20.71	37.71
62-80	2.8	6.0	4.4	17.43	1.00	28.83	-	1.0	12.33	15.50	28.83
80-100	2.5	2.0	6.4	15.83	0.85	25.08	-	2.0	11.08	12.00	25.08
Profile: 7											
0-7	12.1	10.5	11.5	95.60	3.39	120.99	-	2.0	30.49	88.50	120.99
7-24	6.1	6.0	14.0	38.50	2.28	60.78	-	3.0	17.78	40.00	60.78
24-50	3.0	6.0	4.0	18.25	2.12	30.37	-	3.0	7.37	20.00	30.37
50-70	3.2	3.0	7.0	20.86	1.14	32.00	-	2.0	10.00	20.00	32.00
70-84	2.7	5.0	5.0	16.28	0.87	27.15	-	2.0	8.15	17.00	27.15
84-100	2.4	4.5	3.9	16.28	0.28	24.96	-	3.0	8.46	13.50	24.96
Profile: 8											
0-20	5.5	15.2	3.2	34.90	2.04	55.34	-	3.0	14.34	38.00	55.34
20-42	3.1	6.3	7.3	16.42	1.14	31.16	-	2.0	12.16	17.00	31.16
42-62	2.7	6.0	4.0	16.28	1.00	27.32	-	2.0	9.32	16.00	27.32
62-79	3.0	3.6	3.2	21.74	0.96	29.00	-	5.0	9.00	15.50	29.50
79-100	3.1	5.0	3.0	21.98	0.93	30.91	-	5.0	9.91	16.00	30.91
Profile: 9											
0-18	8.4	17.0	13.4	51.34	3.17	84.91	-	2.5	24.91	57.50	84.91
18-40	3.4	6.0	4.8	21.18	2.31	34.29	-	2.0	10.03	22.26	34.29
40-58	2.6	4.0	3.0	17.92	2.00	26.92	-	2.0	8.42	16.50	26.92
58-76	2.2	3.0	1.8	15.26	1.42	21.48	-	1.0	7.48	13.00	21.48
76-100	2.5	4.0	5.4	15.20	0.87	25.47	-	3.0	8.47	14.00	25.47
Profile: 10											
0-26	10.2	30.0	11.8	58.52	2.12	102.4	-	2.0	45.24	55.20	102.44
26-45	4.7	7.6	4.6	33.60	2.03	47.83	-	2.0	15.33	30.50	47.83
45-64	4.2	6.0	3.5	30.30	2.01	41.81	-	3.0	10.56	28.25	41.81
64-87	4.2	6.1	4.1	29.28	1.78	41.26	-	2.0	12.26	27.00	41.26
87-100	4.1	6.0	4.6	28.72	1.51	40.83	-	3.0	11.33	26.50	40.83

Table 3. Groundwater quality in taluka Tando Bagho, district Badin, Sindh, Pakistan.

Pro-file #.	Depth (ft)	pH	EC (dS m^{-1})	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	CO_3^{2-}	HCO_3^{-}	SO_4^{2-}
				Meq L^{-1}							
1	2.90	7.7	21.30	20.0	58.0	130.8	4.89	124.0	--	07.00	82.69
2	3.70	7.8	12.50	14.0	10.0	86.92	2.56	88.48	2.0	05.00	18.00
3	4.30	7.6	19.90	32.5	43.6	121.72	2.56	118.5	--	10.00	71.88
4	3.96	7.9	12.80	13.0	18.6	86.94	2.30	85.00	4.3	11.00	20.54
5	3.36	7.9	36.26	27.0	68.0	260.86	6.90	253.50	4.0	11.00	94.26
6	5.00	7.5	27.33	27.0	55.0	191.30	3.06	212.56	--	12.00	51.80
7	2.90	7.8	34.30	83.0	17.0	234.78	9.23	236.00	--	12.00	96.00
8	3.60	7.8	45.94	75.0	25.0	351.28	8.20	353.00	--	08.01	98.28
9	2.80	7.9	33.31	45.0	55.0	226.00	5.12	232.00	--	08.02	91.10
10	3.60	8.0	19.50	27.0	27.0	139.12	2.56	145.00	4.0	06.00	40.54

CONCLUSION

From the results of the study, it is evident that, the soils of the study area are salt-affected in nature with salty groundwater requiring serious attention for reclamation and rehabilitation.

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