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Effect of Salts on Bulk Density, Particle Density and Porosity of Different Soil Series

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Abstract : Soil columns of three different soil series were collected from the field and were applied with varying levels of salt solutions until steady states were achieved. Then samples were taken from those soil columns and their bulk density, particular density and porosity were determined. It was found that bulk density increases with increase in TSS and ESP but ESP effect is more. Particle density and porosity both decrease with increase in TSS and ESP and decrease is more due to ESP. However, in sandy loam soil TSS has no effect on any of the parameter studied.

Key words: Salts, bulk density, particle density and Porosity

Introduction

The bulk density of soil is an important field property, changes in bulk density affect available water and air capacity and strongly influence permeability, drainage rate, traffic ability and penetration by plant roots (Archer and Smith, 1972). As bulk density relates to the combined volumes of the solids and pore space consequently any factor that influence soil pore space will effect bulk density. Increase in bulk density decreases pore space and plant growth is likely to be limited when air capacity is less than 10% (Baver and Farnswarth, 1940). Water contents increases and porosity decreases with increase in bulk density (Compaction). However, sever compaction (increase in bulk density beyond a certain level) results in decrease in moisture contents (Hill and Sumner, 1966). Plant growth is affected by bulk density,
Particle density and porosity as increase in bulk density or decrease in percent pore space will cause inadequate aeration and resistance to root penetration. The bulk density, particle density and porosity are affected by lay, silt, organic matter- and also by salts (Waller and Wallender, 1993). In Pakistan due to high evapotranspiration and low rainfall, there is a great problem of salinity/ Sodicity. So the aim of present study was to determine he effect of salts on bulk density, particle density and porosity of different textured soil series.

Materials and Methods

The project was conducted in the department of Soil Science, university of Agriculture Faisalabad during the year 1995-96. The undisturbed soil columns of the Rasulpur (Sandy Loam), Bhalwal (Silty clayloam) and Bhalike (Clay Loom) soil series were collected. These soil series are classified as Ustic Haplocampids, Ustic calciargids and Ustic haplocambids, respectively.

Development of Salinity/Sodicity: Brackish water having EC 0.64, 2,4,6 and 7.35dS m^{-1} and SAR 3.95,9.65, 18,26.35.and 32(mmol $L^{-1½}$) was applied to these undisturbed soil columns until steady states were achieved. At steady-states, samples were taken from the undisturbed soil columns. They were air dried, ground and passed through a 2 mm sieve. The EC and SAR levels achieved at steady-state are presented in Table 1. The ESP was calculated from SAR and TSS from EC levels achieved. ESP was calculated using the following formula derived by Franklin and Schmehl (1973) for soils of Punjab.

$$ESP = \frac{100(0.0063 + 0.0124\ SAR)}{1 + (0.0063 + 0.0124\ SAR)}$$

Particle-size analysis was carried out by the hydrometer method (Moodie *et al*., 1959). The pH of the saturated soil paste and the electrical conductivity of the soil paste extract were measured by the methods described by page *et al*. (1982). The $CaCO_3$ was determined by the procedure as described by Moodie *et al*. (1959).
Bulk density of the soil was determined by core method (Method 38, U.S. Salinity Laboratory Staff, 1954), Particle density was determined by pycnometer (Method 39, U.S. salinity laboratory staff, 1954). Porosity of soil was, determined by using the Millar *et al*.,1990) method.

Table 1: Observed SAR and EC of the soils at steady-states

Sandy loam		Silty clay loam		Clay loam	
SAR (mmol l^{-1})	EC (d sm^{-1})	SAR (mmol l^{-1})	EC (d Sm^{-1})	SAR ($mmol^{-1}$)	EC (d Sm^{-1})
1.71	1.57	2.28	3.66	2.57	1.67
5.59	1.16	8.37	2.68	9.26	1.23
9.02	1.40	8.52	1.27	13.97	2.81
9.33	1.24	16.52	3.60	14.77	3.31
9.76	1.04	19.79	3.42	17.60	2.39
10.25	1.07	27.61	2.28	19.82	3.83
14.09	2.26	27.65	4.21	33.87	4.33
17.39	1.77	57.55	9.87	34.66	4.41
28.44	2.99	62.44	8.30	34.86	3.73

Results and Discussion

The basic physical and chemical characteristics of the original soils are given in Table 2. the clay content of these soils ranges from 7.50 to 27.82 % and silt 21.50 to 50.00% reflecting a wide range of variations in their particle-size distribution. All the soils are calcareous with 3 to 7% $CaCO_3$. The bulk density, particle density and porosity of three soils under different salt levels are given in Tables 3,4, and 5. These tables show that bulk density increases with increase in salt levels in all the cases, whereas particle density and porosity decrease with increase in salt levels. The bulk density of soil is an important field property. Any factor that influences soil pore space will affect bulk density. Changes in bulk density affect available water and air capacity and strongly influence permeability, drainage rate, traffic ability and penetration by plant roots (Archer and smith, 1972).

Table 2: Physical and chemical properties of the original soils

Determinant	Rasulpur soils series	Bhalwal Soils series	Bhalike soils series
Sand (%)	71.00	19.50	33.49
Silt (%)	21.50	53.50	38.70
Clay	7.50	27.00	27.8
Textural class	Sandy loam	Silty clay	Clay loam
Bulk density (gcm^{-3})	1.59	1.53	1.57
Particle density	2.67	2.66	2.65
Saturation (%)	26.40	39.44	44.80
pH_s	7.65	7.70	7.65
Ec_s (dsm^{-1})	2.38	3.20	5.50
TSS ($mmol_c L^{-1}$)	27.00	35.00	61.00
SAR (Mmol l^{-1})	1.38	3.70	11.76
ESP (%)	2.28	4.98	13.20
$CACO_3$ (%)	3.42	6.49	6.84

Table 6 refers to the simple and multiple correlation coefficients between bulk density, TSS and ESP. In case of sandy loam soil bulk density is positively and highly significantly correlated with ESP (0.98**). The value of multiple correlation of TSS x ESP with bulk density is same as by ESP alone. Non significant correlation is found in case of TSS with bulk density (0.17). In case of silty clay loam soil the

Table 3: Bulk density, particle density and porosity of rasulpur soil series (sandy loam) under different salt levels

ESP(%)	TSSme L^{-1}	Bulk density ------g cm^{-3}-------	Particle density	Porosity (%)
2.16	16.00	1.63	2.67	39.00
7.04	11.80	1.65	2.65	37.97
10.56	14.50	1.68	2.64	36.36
10.87	13.00	1.69	2.63	35.74
11.29	10.50	1.70	2.62	25.11
11.77	10.80	1.71	2.61	34.48
15.33	24.00	1.72	2.60	33.84
18.16	19.00	1.74	2.59	32.83
26.41	33.00	1.78	2.59	29.37

Table 4: Bulk density, particle density and porosity of rasulpur soil series (sandy loam) under different salt levels

ESP (%)	TSS me L^{-1}	Bulk density ------g cm^{-3}-------	Particle density	Porosity(%)
2.96	39.00	1.57	2.66	40.98
9.92	29.00	1.60	2.62	38.93
10.07	18.00	1.61	2.61	38.31
17.43	38.00	1.65	2.60	36.54
17.66	37.00	1.66	2.59	35.91
25.84	35.00	1.69	2.58	34.50
25.88	46.00	1.71	2.58	34.11
41.84	120.00	1.77	2.53	30.04
43.84	99.00	1.78	2.52	29.36

Table 5: Bulk density, particle density and porosity of rasulpur soil series (sandy loam) under different salt levels

ESP(%)	TSS me L^{-1}	Bulk density ------g cm^{-3}-------	Particle density	Porosity(%)
2.76	11.50	1.64	2.68	38.00
10.80	12.50	1.67	2.67	36.00
15.22	31.00	1.70	2.65	33.33
15.92	37.00	1.71	2.65	3.00
18.34	25.00	1.72	2.63	35.00
20.13	43.00	1.75	2.62	35.50
29.88	50.00	1.79	2.59	38.60
30.36	50.00	1.80	2.57	31.60
30.49	41.00	1.81	2.57	29.96

Table 6: The simple and multiple correlation coefficients between bulk density and TSS and ESP

Soil type	Dependent variable	Independent variable				
Sandy loam	bulk density		TSS	r	=	-0.17
			ESP	r	=	-0.98**
		TSSx	ESP	R	=	-0.98**
Silt Caly loam	"		TSS	r	=	-0.84*
			ESP	r	=	-0.99**
		TSSX	ESP	R	=	-0.99**
Caly loam	"		TSS	r	=	-0.90**
			ESP	r	=	-0.99**
		TSSx	ESP	R	=	-0.99**

* Significant, **Highly significant

Table 7 : The simple and multiple correlation coefficients between particle density and TSS and ESP

Soil type	Dependent variable	Independent variable				
Sandy loam	bulk density		TSS	r	=	-0.15
			ESP	r	=	-0.90**
		TSSx	ESP	R	=	-0.98**
Silt Caly loam	"		TSS	r	=	-0.82*
			ESP	r	=	-0.95**
		TSSX	ESP	R	=	-0.95**
Caly loam	"		TSS	r	=	-0.86**
			ESP	r	=	-0.98**
		TSSx	ESP	R	=	-0.98**

* = Significant at p = o.05** = Highly significant at p = 0.01

bulk density is positively and highly significantly correlated with TSS (0.84**) and ESP (0.99**), However the value of correlation coefficient by the combined effect of TSS x ESP is same as by ESP. Almost similar trend is found in case of clay loam.

Table 7 shows the relationship between particle density and TSS and ESP. It is found that TSS has negative and non significant correlation with particle density (-0.15) in case of sandy loam soil. The values of negative but highly significant correlation coefficients of ESP and TSS x ESP with particle density are same (-0.98**). In case of silty clay loam soil the values of simple and multiple correlation coefficients of TSS and ESP with particle density are negative and highly significant. The value of correlation coefficient of TSS (-0.82**) is lower than ESP value (-0.95**). The value of correlation coefficient by the combined effect of TSS x ESP (-0.95**) is same as by ESP alone. Clay loam soil has almost similar trend as that of silty clay loam soil. Table 8 represents the simple and multiple correlation between porosity and TSS and ESP. In case of sandy loam soil TSS has negative and non significant correlation with porosity while the equal negative highly significant (-0.99**) simple and multiple correlation of ESP and TSS x ESP with porosity is found. In case of silty clay loam soil porosity has negative and highly significant correlation coefficient with TSS (-0.84**) which is lower than ESP value (-0.99**). The value of multiple correlation coefficient of TSS x ESP with porosity is equal to ESP value (-0.99**). For clay loam soil the porosity has negative non significant correlation (-0.47) with TSS. The value of negative highly significant correlation coefficients of ESP and TSS x ESP are equal, i.e., (-0.98**). From the above results it can be reasonably concluded that bulk density increase with increase in salinity and especially Sodicity, while particle density and porosity decrease. Increase in bulk density may be due to soil compaction with salinity and Sodicity. Soil compaction increases due to dispersive action of exchangeable sodium on soil colloids and altering the pore-size distribution (Levy and Torrento, 1995). High ESP reduces number of relatively large pores and increases number of relatively small sized pores and as a result total porosity decreases. This increase in bulk density due to high salinity and especially sodicity affect available water and porosity and thus it may strongly influence permeability, drainage rate and penetration by roots. Similar observations were reported by Hill and summer (1966), Abrol *et al.* (1978), Waller and Wallender (1993), Levy and Torrento (1995).

Table 8 : The simple and multiple correlation coefficients between particle density and TSS and ESP.

Soil type	Dependent variable	Independent variable				
Sandy loam	bulk density		TSS	r	=	-0.16
			ESP	r	=	-0.99**
		TSSx	ESP	R	=	-0.99**
Silt Caly loam	"		TSS	r	=	-0.84*
			ESP	r	=	-0.99**
		TSSx	ESP	R	=	-0.99**
Caly loam	"		TSS	r	=	-0.475
			ESP	r	=	-0.98**
		TSSx	ESP	R	=	-0.98**

* = Significant at p = .05** = Highly significant at p = 0.01

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