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Salt affected soils of Upper Krishna Command, Karnataka. I. Physical and chemical characteristics

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Abstract

An investigation was carried out to characterize the salt affected Vertisols of Upper Krishna Command, Karnataka. Soils were neutral to strongly alkaline in reaction (pH - 7.5 to 9.1). Calcium and magnesium are the major contributing exchangeable cations followed by sodium. CEC was found to be higher (32.2 to 59.2 cmol (p+) kg^{-1} . Electrical conductivity decreased down the profile depth and, in the soil water extract, sodium dominated the cationic composition followed closely by the combined concentration of Ca and Mg. Salinity was of chloride- sulphate type. Seven Vertisol profiles investigated were sodic. The analytical results point towards the possibility of further sodification in these soils.

Additional key words : command area, salt affected soils, sodicity, physical and chemical properties, sodification.

Introduction

Salt affected soils, which constitute one of the main degradation concerns of tropical countries, occupy a relatively smaller area of 0.40 million hectares in Karnataka. However, decline in soil productivity due to salinity continues to be the striking concern of the farming community of northern Karnataka, where an estimated 2.2 lakh ha area is affected by various degrees of soil salinity (Anonymous 1993).

In Upper Krishna Project (U.K.P.) command, dominated by black soils (77 per cent), an area of 27 thousand ha is salt affected, thus seriously hampering the crop production on these otherwise potentially productive soils. The present investigation, therefore, was intended to furnish comprehensive information on physical and chemical properties of some representative salt affected soils of the above-said region, as an effort to provide a database for adoption of a proper reclamation technology.

Materials and methods

The U.K.P. command in Gulbarga district of Karnataka, selected as the study area, lies between $16^0 10'$ and $16^0 35'$ N latitude and $76^0 15'$ and $76^0 55'$ E longitude, at an elevation of 400 to 580 m above msl. Within this region, seven representative Vertisol profiles (site characters in Table 1) were exposed and samples were collected from six depths of each. The soil samples were analysed for maximum water holding capacity (MWHC) and volume expansion by Keen Raczkowski brass cup method (Sankaram, 1966), while other physical and chemical properties were determined following the standard procedures (Black 1965)

Results and discussion

The data relating to soil physical and exchange properties are presented in table 2, and in table 3 are the results of analysis of soil water extract.

The soils showed a progressive increase in clay content up to fourth or fifth depth, probably on account of illuviation (Krishnamoorthy and Govindarajan 1977) and sodicity

Table 1. Classification and geographical setting of the soil profiles

	Classification			Geographical setting			
Profile	Parent material	Sub-group (Family)	Series	Topography	Drainage	Land use	Distribution
P1, P2, P3 P4 and P5	Granite-gneiss	Typic Chromusterts (Isohyper thermic)	Tumkur	Nearly level to very gently sloping (1-3% slope)	Moderately well drained	Cotton, rabi sorghum	Shorapur taluk of Gulbarga dist.
P6 and P7	Limestone	Typic Pellusterts (Hyper thermic)	Kagalgomb	Nearly level to very gently sloping (1-3% slope)	Moderately well to imperfectly drained	Cotton, Kharif sorghum	Shahapur, Shorapur & Jewargi taluks of Gulbarga dist.

*Both the soil series are competing and give rise to similar soils

related dispersion in surface layers and migration of clay particles (Dubey *et al.* 1984). Organic carbon, which decreased with the depth, was always less than one per cent due to its decomposition in arid climate.

Soil particle density varied from 2.54 to 2.78 Mg m^{-3} and, it did not exhibit greater variations within or among the profiles. On the other hand, bulk density values, which showed negative correlation with organic carbon ($r = -0.59^{**}$), tended to increase with the depth, and relatively higher values in comparison with those recorded by Doddamani *et al.* (1994) in the normal soils of same region. This could be attributed to clogging of pores by dispersed clays in subsoil layers (Mathan and Mahendran 1994) and reduction of organic carbon with depth.

Owing to similar causes, per cent porosity (38.6 to 47.8) reduced down the layers, while MWHC and volume expansion, varying from 40.1 to 73.2 and 34.7 to 47.1 per cent, respectively showed trends almost similar to that of clay. Both exhibited strong, positive associations with clay ($r = 0.83^{**}$, 0.80^{**}) and ESP (0.67^{**}, 0.44^{**}), indicating their direct relation with soil texture (Ghildyal and Satyanarayana 1965) and sodicity (Pandey and Pathak 1975),

The soils were neutral to strongly alkaline in reaction and pH values (7.5 to 9.1) showed an invariable increase with the profile depth, possibly owing to decrease in EC and rise of ESP with depth. Comparatively higher pH values (9.0) in P2, P4 and P7 could be due to higher exchangeable and water soluble Na^+ in those profiles.

Cation exchange capacity (CEC) of the soils was in the range of 32.2 to 59.2 cmol (p^+)/ kg and these high values are due to dominance of smectite clay mineral. A larger contribution to the CEC of inorganic fraction (clay) was brought out by a highly positive association ($r = 0.71^{**}$) between the two, while organic carbon had no influence on it.

Together, Ca^{2+} and Mg^{2+} accounted for greater portion of soil CEC and ranging between 24.0 and 46.8 cmol(p+)/kg, their variation within a profile remained generally within 10 units. Similar observations were made by Doddamani *et al.* (1994). Exchangeable Na^+ was the next in order of dominance. Among the profiles investigated, P1 and

Table 2. Physical properties and exchange characteristics of soils of Upper krishna Command, Karnataka

Profile	location	Depth (cm)	Clay (%)	O.C. (%)	B.D. (Mgm^{-3})	P.D. (Mgm^{-3})	Porosity (%)	MWHC (%)	V.E. (%)	Exch. Cations Ca^{2+}+ Mg^{2+} (cmol(p$^+$)/kg^{-1})	K^+ (cmol(p$^+$)/kg^{-1})	Na^+ (cmol(p$^+$)/kg^{-1})	CEC (cmol(p$^+$)/kg^{-1})	ESP
P1	Hebbal (B)	0-15	55.2	0.63	1.38	2.58	46.5	40.1	38.7	31.4	0.53	3.0	34.8	8.7
		15-30	59.5	0.42	1.43	2.63	45.6	41.3	40.0	35.0	0.42	3.7	39.2	9.4
		30-60	61.8	0.40	1.44	2.62	45.0	44.9	41.8	37.2	0.37	4.1	41.8	9.9
		60-90	64.3	0.33	ND	2.61	ND	46.8	43.4	40.4	0.34	4.6	45.2	10.1
		90-120	62.3	0.30	1.50	2.64	43.3	45.9	43.7	39.4	0.27	3.9	43.5	9.0
		120-150	57.3	0.20	1.54	2.64	41.7	43.2	42.0	39.2	0.25	3.7	42.2	8.7
P2	Hebbal (K)	0-15	42.4	0.54	1.42	2.68	47.0	46.8	38.2	30.6	0.52	6.5	39.2	16.6
		15-30	47.2	0.45	1.43	2.68	46.6	50.8	41.6	41.0	0.31	8.9	52.2	17.1
		30-60	49.1	0.33	1.47	2.71	45.8	53.9	42.1	42.2	0.21	8.5	53.1	15.9
		60-90	49.9	0.21	1.47	2.73	45.6	5.90	44.1	46.8	0.42	10.0	59.2	10.9
		90-120	45.1	0.18	1.52	2.75	45.0	54.2	44.1	42.4	0.34	8.3	53.1	15.6
		120-150	38.3	0.12	1.53	2.78	44.7	50.8	38.1	31.8	0.37	7.6	41.8	18.2
P3	Havinal	0-15	44.8	0.36	1.42	2.67	46.8	58.8	39.7	29.4	0.48	3.3	34.8	9.4
		15-30	47.1	0.21	1.42	2.65	46.4	61.0	42.9	31.0	0.24	5.7	38.2	15.1
		30-60	51.2	0.16	ND	2.62	ND	62.2	44.9	41.8	0.25	7.6	50.5	15.1
		60-90	55.9	0.15	ND	2.68	ND	62.2	46.6	36.4	0.32	6.7	44.2	15.1
		90-120	53.1	0.10	1.46	2.70	43.9	58.4	45.0	32.2	0.43	5.0	38.3	13.0
		120-150	48.9	0.09	1.52	2.71	43.7	57.9	42.1	28.2	0.36	3.3	33.1	9.9
P4	ARS, Kawadi-matti	0-15	51.9	0.33	1.51	2.70	44.1	71.5	39.8	36.8	0.15	8.0	45.2	17.8
		15-30	48.7	0.45	1.53	2.69	43.1	70.9	41.2	42.6	0.26	14.1	58.3	24.2
		30-60	53.7	0.36	ND	2.71	ND	70.8	43.9	37.6	0.28	9.3	48.7	19.2
		60-90	54.5	0.21	1.54	2.68	42.5	73.2	45.5	37.2	0.35	13.2	51.3	25.8
		90-120	50.5	0.15	1.55	2.60	40.4	71.1	43.4	38.8	0.29	8.0	48.7	16.5
		120-150	46.4	0.12	1.60	2.70	40.7	69.4	41.1	38.2	0.34	7.1	47.0	15.1

Table 2 continued

Profile location		Depth (cm)	Clay (%)	O.C. (%)	B.D. (Mgm^{-3})	P.D.	Porosity (%)	MWHC (%)	V.E. (%)	Exch. Cations Ca^{2+}+ Mg^{2+} (cmol(p$^+$) kg^{-1})	K^+	Na^+	CEC	ESP
P5	Farmer's field Kawadimatti	0-15	43.1	0.42	1.43	2.74	47.8	41.3	34.7	30.0	0.43	3.5	33.1	10.5
		15-30	47.7	0.24	1.47	2.71	45.8	42.1	35.5	32.6	0.39	4.6	37.4	12.2
		30-60	51.8	0.21	1.51	2.68	43.7	44.9	38.8	37.8	0.36	5.6	43.5	13.0
		60-90	55.9	0.21	1.53	2.71	43.5	45.9	40.3	39.6	0.31	6.3	46.1	13.6
		90-120	48.9	0.12	1.54	2.60	40.7	43.2	37.6	39.0	0.27	5.0	44.2	11.0
		120-150	44.8	0.12	1.56	2.54	38.6	42.7	36.0	37.0	0.21	3.7	40.9	9.0
P6	Islampur	0-15	44.1	0.60	1.45	2.70	46.3	50.8	40.9	35.4	0.53	4.1	41.8	9.9
		15-30	59.3	0.54	1.47	2.71	45.8	55.8	43.0	37.0	0.50	5.2	44.4	11.7
		30-60	48.8	0.42	1.49	2.74	45.6	59.0	46.3	42.0	0.41	5.6	49.6	11.4
		60-90	53.1	0.39	ND	2.74	ND	61.0	47.1	36.6	0.51	6.9	43.5	16.0
		90-120	50.6	0.23	1.52	2.76	44.9	59.2	45.1	35.6	0.21	7.6	42.2	16.8
		120-150	42.4	0.21	1.53	2.76	44.6	57.9	44.5	32.8	0.27	4.3	37.4	11.6
P7	Devapur (J)	0-15	40.3	0.62	1.40	2.59	46.0	53.9	37.9	24.0	0.62	6.1	32.2	18.9
		15-30	45.1	0.60	1.42	2.65	46.4	54.2	39.5	25.2	0.41	7.7	33.3	23.2
		30-60	49.0	0.51	1.42	2.60	45.4	58.4	41.1	28.4	0.39	9.3	40.0	23.3
		60-90	49.6	0.33	1.46	2.67	45.3	62.2	44.9	34.4	0.57	11.0	47.0	23.4
		90-120	51.3	0.25	1.50	2.70	44.4	61.2	42.7	33.0	0.27	7.2	42.6	16.8
		120-150	41.4	0.18	1.53	2.70	43.3	60.4	40.6	30.4	0.40	5.7	38.3	15.0

Table 3. Ionic composition of 1:5 soil water extracts in salt affected soils of Upper Krishna Command, Karnataka

Profile location		Depth (cm)	pH	EC (dS/m)	Water soluble cations			Water soluble anions				SAR
					$Ca^{2+}+Mg^{2+}$	Na^+	K^+	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	
					me L^{-1}			me L^{-1}				
P1	Hebbal (B)	0-15	7.9	5.4	26.4	26.9	0.02	28.5	24.6	2.0	tr	7.4
		15-30	7.8	5.3	25.8	27.3	0.02	29.0	20.2	4.8	tr	7.6
		30-60	7.7	5.2	24.2	28.2	0.01	29.5	21.0	2.0	tr	8.1
		60-90	7.8	5.1	22.6	27.8	0.01	26.0	20.4	4.6	tr	8.3
		90-120	8.1	5.0	24.4	24.7	0.01	27.0	19.2	2.8	tr	7.1
		120-150	8.3	4.9	24.6	24.7	0.01	28.5	18.5	2.6	tr	7.1
P2	Hebbal (K)	0-15	8.4	4.1	16.6	23.9	0.02	20.5	14.6	6.0	tr	8.3
		15-30	8.4	4.0	15.4	23.4	0.07	23.0	12.9	4.0	tr	8.4
		30-60	8.6	3.3	14.0	19.1	0.04	22.5	8.5	2.2	0.3	7.2
		60-90	8.7	2.1	7.0	15.2	0.01	14.0	7.2	2.0	0.7	8.1
		90-120	8.8	1.5	5.2	11.3	0.01	10.5	5.0	1.8	0.6	7.0
		120-150	8.9	1.1	2.0	9.1	0.01	10.0	3.0	1.4	0.4	9.1
P3	Havinal	0-15	7.9	6.1	30.0	30.4	0.05	28.0	30.9	2.4	tr	7.9
		15-30	8.0	5.0	22.4	26.5	0.03	31.0	16.3	4.0	tr	7.9
		30-60	8.1	4.8	22.6	26.9	0.03	32.0	12.0	4.2	tr	8.0
		60-90	8.1	4.7	22.2	24.3	0.02	32.5	11.8	2.0	tr	7.3
		90-120	8.4	4.5	22.4	23.0	0.01	31.5	10.2	4.0	tr	6.9
		120-150	8.4	4.1	20.2	21.7	0.01	27.0	9.8	4.2	tr	6.8
P4	ARS, Kawadi-matti	0-15	8.5	4.2	16.2	26.0	0.02	18.5	20.0	4.0	0.1	9.1
		15-30	8.6	2.2	4.2	17.8	0.02	12.5	10.8	2.0	0.5	12.3
		30-60	8.7	1.8	4.0	14.8	0.01	10.0	7.2	2.2	0.7	10.5
		60-90	8.8	1.6	2.8	15.6	0.02	9.5	7.8	1.6	0.2	13.2
		90-120	8.8	1.3	3.0	10.0	0.01	8.0	5.2	1.8	1.3	8.1
		120-150	8.9	1.0	3.0	9.6	0.02	7.0	4.5	1.6	0.9	7.8

Profile	location	Depth (cm)	pH	EC (dS/m)	Water soluble cations			Water soluble anions				SAR
					$Ca^{2+}+Mg^{2+}$	Na^+	K^+	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	
					me L^{-1}			me L^{-1}				
P5	Farmer's field Kawadimatti	0-15	7.5	5.4	32.0	32.2	0.04	34.5	24.8	6.2	tr	8.0
		15-30	7.8	6.2	30.0	32.6	0.04	32.0	26.4	2.0	tr	8.4
		30-60	8.0	6.0	26.6	33.4	0.01	30.5	27.2	2.0	tr	9.2
		60-90	8.4	5.9	25.6	33.0	0.01	27.0	28.0	2.0	tr	9.2
		90-120	8.4	5.4	26.0	27.3	0.01	26.0	24.2	2.2	tr	7.6
		120-150	8.5	4.0	19.2	20.4	0.01	22.0	16.5	4.0	tr	6.6
P6	Islapur	0-15	7.9	4.9	23.4	24.7	0.15	24.0	19.2	6.4	tr	7.2
		15-30	7.9	4.6	20.6	25.2	0.04	24.5	19.7	1.8	tr	7.8
		30-60	8.1	4.4	18.8	25.4	0.03	25.0	20.2	2.0	tr	8.3
		60-90	8.3	4.4	18.4	25.2	0.02	22.0	19.9	2.2	tr	8.3
		90-120	7.7	4.6	17.0	24.0	0.01	25.5	18.3	2.0	tr	8.2
		120-150	8.1	4.0	16.8	22.1	0.01	200	16.2	4.2	tr	7.6
P7	Devapur (J)	0-15	8.4	4.1	14.0	26.5	0.12	24.0	11.3	6.0	tr	9.9
		15-30	8.6	2.4	5.2	18.2	0.04	13.0	7.8	4.0	0.7	11.3
		30-60	8.8	2.2	4.8	17.8	0.03	12.5	7.4	2.2	0.4	11.5
		60-90	8.9	1.9	4.7	14.3	0.03	11.5	7.1	2.0	1.2	9.4
		90-120	8.9	1.2	3.0	10.4	0.01	8.0	4.2	1.8	0.7	8.5
		120-150	9.1	1.1	2.4	8.3	0.01	6.5	4.0	1.8	1.8	7.5

P5 were associated with an ESP of less than 10.0, whereas all or few subsurface depths were sodic in P3 and P6. However, values exceeding critical limit (15.0) were observed in P2, P4 and P7, the profiles which recorded higher pH. The tendency of ESP to increase with the depth in the latter profiles indicates the beginning of the sodifiation process in subsoils. These observations are in conformity with those observed in Vertisols of the Purna valley of Maharashtra by Balpande *et al.* (1996).

The data on composition of soil water extract (Table 3) indicates that the soil EC values, ranging between 1.0 to 6.4 dS m^{-1}, were higher in surface layers indicating the salt accumulation facilitated by the arid conditions. Soil water cationic composition, as opposed to exchange surface, was dominated by Na^+ (8.3 to 33.4 me L^{-1}), which might be due to divalent cation preference of 2:1 clays. However, concentration of water soluble Ca^{2+} remained nearly close to that of Na^+, particularly in P1, P3, P5 and P6.

Among the anions, although chlorides were the dominant, sulphates were also present in almost similar quantities (3.0 to 30.9 me L^{-1}), indicating the chloride-sulphate type of soil salinity. In spite of highly calcareous nature of soils studied (Anonymous 1981), bicarbonates were found in small amounts, while concentration of carbonates was negligible.

Vertisols under study have ESP > 5 and high content of clay and CEC. In general, these soils have inherently low hydraulic conductivity due to the dispersion of clay particles caused by high exchangeable magnesium and also to a slight increase in ESP (Balpande *et al.* 1996). Therefore, it is advocated that lower limit of ESP for sodic soils should be placed at ESP 5 rather than ESP 15 as suggested by United States Salinity Laboratory (1954). This is because there are severe limitations to the use of such soils owing to the adverse physical conditions even at such a low ESP (Balpande, *et al.* 1996). This, coupled with lower level of organic carbon, points towards the possiblity of further sodification of these soils. Hence to prevent further degradation the need for taking up appropriate reclamation measures assumes greater significance.

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