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Characterization and taxonomic classification of salt-affected soils of Bhind district of Madhya Pradesh

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Soil is one of the most important fundamental components of the terrestrial ecosystem. It is recognized as one of the most valuable, life supporting natural resources on whose proper use depends the supply of food, fibre, fuel, *etc.* Salt-affected soils present diverse problems and differ largely from normal soils in respect of morphological features, physical and chemical characteristics. They show wide variations from place to place and have been distinguished into several categories, the important ones being the saline and the sodic soils. Systematic studies on the characterization and classification of salt-affected soils are of prime importance before undertaking any reclamation measures. Soil salinization/ alkalization is one of the most serious forms of land degradation affecting approximately 10% of the total land surface of the globe (CSSRI Report 1996). An area of more than 2.5 lakh ha of salt-affected soils is estimated to exist in the Chambal Command Area of Madhya Pradesh covering 23 districts and spread over two physiographic regions *i.e.* black soil region and the Indo-Gangtic Plains. High water table in irrigation commands like Chambal, Tawa and Barna is a common phenomenon which may have been responsible for wide spread secondary salinization in the region. For understanding the intensity and areal coverage of the problem, the present study was taken up to characterize and classify the soils of Bhind district of Chambal region.

The study area lies between 25°50' and 26°50' N latitude and 78°10' and 79°08' E longitude and comprises typical wastelands of Bhind district of Madhya Pradesh. The area falls under the Agro-ecological Region 4 characterized by hot semi-arid climate with alluvium-derived soils (N8D2). The area experiences annual precipitation of about 690 to 850 mm, 80% of which is received during the months of June to August. The minimum and maximum air temperatures are 8°C and 48°C respectively, and the mean annual temperature is about 32°C. The annual potential evapotranspiration is 1400 to 1900 mm and the soil moisture regime is *ustic* and temperature regime is *hyperthermic*. The soils have been developed from the alluvium of the river Chambal and its tributaries *viz*. *Kali Sind, Kuwari, Pahuj, etc*. Detailed soil survey was conducted in the area as per procedure outlined in the soil survey manual. Thirteen typical soil sites, in Gohad (7), Mehgaon (5) and Lahar (1) tehsils of Bhind district of Madhya Pradesh were studied for morphological features following standard methods. For the sake of brevity, only five soil profiles (Gohad - P2, Loharpura - P4, Chitora - P8, Tukeda - P10 and Parechha - P13) were taken for this work. Soil samples (<2 mm) were analyzed for mechanical composition, pHs, ECe, CEC and exchangeable cations adopting standard procedures (Richards, 1954). The soils were classified according to Keys to Soil Taxonomy (Soil Survey Staff 1998).

The physical and chemical characteristics of the different pedons are presented in table 1. Soil colour varies from light gray (10YR 7/1) to dark grayish brown (10 YR 3/2) in moist condition. Usually few, fine, faint yellowish brown (10YR 5/8) and few, fine, distinct strong brown (7.5 YR 5/6) mottles were observed in the lower horizons of P2. The soil texture in the area varies from sandy loam to clay. The structure ranges from fine to moderate medium sub angular to angular blocky (Subbaiah and Manickan 1992; Singh 1999). The pH ranged between 7.5 and 8.8 in all pedons (Table 2). P10

had the highest ECe (5.0 to 31.0 dSm^{-1}) followed by P13 (ECe, 3.6 to 9.2 dSm^{-1}), P2 (ECe, 0.9 to 6.2 dSm^{-1}), P4 (ECe, 1.9 to 6.1 dSm^{-1}) and P8 (ECe, 1.2 to 3.4 dSm^{-1}). The difference of sand/ silt ratio was always less than 0.2 between the two adjacent horizons confirming homogeneity of parent materials except in P2 where lithological discontinuity occurred at the depth of 75-122 cm. The variation in clay / silt ratio was not much pronounced in P4 and P13, while it was slightly higher in B horizon of P10 as compared with overlying and underlying horizons. The higher clay/ silt ratio indicated slightly higher rate of weathering due to presence of soil water for fairly long time as compared to the surface horizons. The Ca^{++}, Mg^{++} ions were the two dominant cations on the exchange complex for all the soils except in the pedons P2 and P13 where Na^{+} was dominant over others (Table 2). Comparatively narrower Ca^{++}/ Mg^{++} ratio was registered in P2 and P8. The cation exchange capacity of the soils and clays (Table 2) suggested mixed mineralogical composition of these soils.

Table 1. Physical and chemical properties of the typical pedons selected from different locations of Bhind district of M.P.

Depth (m)	pH	ECe (dSm^{-1})	$CaCO_3$ (%)	Particle size distribution (%)			Sand/ silt ratio	Clay/ silt ratio	(Sand + Silt)/ Clay
				Sand	Silt	Clay			
Pedon-2 : Gohad (Fine-loamy, mixed hyperthermic family of *Typic Natrustalfs*)									
0.00-0.15	8.2	6.2	04.9	61.7	25.3	13.0	2.44	0.51	6.69
0.15-0.30	8.4	3.9	04.9	47.7	33.3	19.0	1.43	0.57	4.26
0.30-0.75	8.0	3.3	05.9	37.7	33.3	29.0	1.13	0.87	2.45
0.75-1.22	8.0	2.3	05.9	41.7	25.3	33.0	1.64	1.30	2.03
1.22-1.65	8.4	0.9	18.7	39.7	33.3	27.0	1.19	0.81	2.70
Pedon-4: Luharpura (Fine, smectitic hyperthermic family of *Vertic Natrustalfs*)									
0.00-0.15	8.1	6.1	05.9	29.5	38.0	32.5	0.78	0.85	2.08
0.15-0.38	8.0	6.1	02.9	21.5	36.0	42.5	0.60	1.18	1.35
0.38-0.80	8.1	4.3	02.9	21.5	34.0	44.5	0.63	1.31	1.25
0.80-1.25	8.2	1.9	02.9	13.5	40.0	48.5	0.34	1.21	1.10
1.25-1.70+	8.2	1.9	02.9	19.5	32.0	48.5	0.61	1.51	1.06
Pedon -8: Chitora (Fine-loamy, mixed hyperthermic family of *Sodic Haplustalfs*)									
0.00-0.15	7.7	3.4	03.9	35.0	46.5	18.5	0.75	0.40	4.41
0.15-0.35	7.7	2.9	03.9	39.0	44.5	16.5	0.88	0.37	5.06
0.35-0.52	7.5	2.2	05.8	31.0	40.5	28.5	0.77	0.70	2.51
0.52-0.80	7.5	2.2	16.6	25.0	40.5	34.5	0.62	0.85	1.90
0.80-1.25	7.6	1.6	16.6	17.0	42.5	40.5	0.40	0.95	1.47
1.25-1.55	7.8	1.4	07.8	25.0	38.5	36.5	0.65	0.94	1.74
1.55+	7.7	1.2	07.8	29.0	38.5	32.5	0.75	0.84	2.08
Pedon-10: Tukeda (Fine, smectitic hyperthermic family of *Typic Natrustalfs*)									
0.00-0.10	8.0	31.0	02.0	43.5	32.6	33.9	1.34	1.04	2.24
0.10-0.23	8.3	18.0	05.9	33.5	36.6	29.9	0.92	0.82	2.34
0.23-0.46	8.0	18.0	03.9	33.5	24.6	41.9	1.36	1.70	1.39
0.46-0.65	8.0	15.0	11.8	33.5	26.6	39.9	1.26	1.50	1.51
0.65-0.99	8.3	12.0	11.8	31.5	28.6	39.9	1.10	1.40	1.51
0.99-1.42	8.2	09.0	15.7	19.5	34.6	45.9	0.56	1.33	1.18
1.42+	8.2	05.0	15.7	28.2	29.9	41.9	0.95	1.40	1.39
Pedon-13: Parechha (Fine-loamy, mixed hyperthermic family of *Sodic Haplustalfs*)									
0.00-0.06	8.8	9.2	11.0	26.2	56.6	17.2	0.46	0.30	4.81
0.06-0.17	8.7	8.4	11.0	34.2	46.6	19.2	0.74	0.41	4.21
0.17-0.37	8.5	7.2	07.4	38.2	44.6	17.2	0.86	0.39	4.81
0.37-0.57	8.2	6.4	07.4	40.2	40.6	19.2	0.99	0.47	4.21
0.57-1.16	8.0	3.6	09.2	34.2	44.6	21.2	0.77	0.48	3.72

Table 2. Exchangeable cations, CEC, Clay, ESP and Saturation % of the typical pedons selected from different locations of Bhind district of M.P.

Depth (m)	Exchangeable cations [cmol (p^+) kg^{-1}]			Ca^{2+}/ Mg^{2+} ratio	CEC [cmol (p^+) kg^{-1}]	Clay	ESP
	Ca^{2+}	Mg^{2+}	Na^+				
Pedon-2 : Gohad (Fine-loamy, mixed hyperthermic family of *Typic Natrustalfs*)							
0.00-0.15	2.4	1.6	3.9	1.50	8.0	13.0	49.2
0.15-0.30	3.8	1.8	8.2	2.11	14.0	19.0	58.3
0.30-0.75	6.3	3.2	10.3	1.96	20.5	29.0	50.2
0.75-1.22	7.8	4.1	11.3	1.90	23.5	33.0	48.0
1.22-1.65	4.6	2.8	7.1	1.64	14.8	27.0	48.0
Pedon-4: Luharpura (Fine, smectitic hyperthermic family of *Vertic Natrustalfs*)							
0.00-0.15	10.5	5.0	8.7	2.10	24.5	32.5	35.5
0.15-0.38	13.6	6.3	11.8	2.15	32.0	42.5	37.0
0.38-0.80	15.9	8.4	9.8	1.89	34.5	44.5	28.5
0.80-1.25	17.5	9.4	9.3	1.86	36.5	48.5	25.5
1.25-1.70+	18.3	9.6	83.1	1.90	36.3	48.5	22.2
Pedon -8: Chitora (Fine-loamy, mixed hyperthermic family of *Sodic Haplustalfs*)							
0.00-0.15	5.0	3.8	3.1	1.31	12.0	18.5	25.8
0.15-0.35	5.4	3.2	2.8	1.68	11.5	16.5	24.3
0.35-0.52	12.1	4.1	4.3	2.95	20.5	28.5	20.9
0.52-0.80	11.9	6.5	5.4	1.83	23.0	34.5	23.4
0.80-1.25	15.8	8.5	6.2	1.85	32.0	40.5	19.3
1.25-1.55	15.2	8.9	6.3	1.70	32.0	36.5	19.6
1.55+	16.2	9.2	5.8	1.76	32.0	32.5	18.1
Pedon -10: Tukeda (Fine, smectitic hyperthermic family of *Typic Natrustalfs*)							
0.00-0.10	8.0	3.8	03.1	2.10	15.4	33.92	20.1
0.10-0.23	8.5	5.4	03.8	1.57	21.3	29.92	17.8
0.23-0.46	14.5	7.4	10.5	1.95	32.5	41.92	32.3
0.46-0.65	14.3	7.3	10.7	1.95	32.5	39.92	32.9
0.65-0.99	14.1	7.7	09.3	1.83	31.7	39.92	29.3
0.99-1.42	15.0	8.1	11.8	1.85	35.3	45.92	33.4
1.42+	15.9	9.2	09.8	1.72	35.3	41.92	27.7
Pedon -13: Parechha (Fine-loamy, mixed hyperthermic family of *Sodic Haplustalfs*)							
0.00-0.06	3.3	1.5	8.8	2.20	14.3	17.20	61.5
0.06-0.17	4.7	2.8	7.1	1.67	15.2	19.20	46.7
0.17-0.37	3.8	2.2	7.2	1.72	13.2	17.20	54.5
0.37-0.57	3.7	2.5	7.4	1.48	13.7	19.20	54.0
0.57-1.16	5.3	2.8	5.8	1.89	14.3	21.20	40.0

Besides presence of *argillic* horizon in P2, P4 and P10 also contained exchangeable sodium percentage more than 15, coupled with columnar structure along with fine to moderate medium to coarse sub angular and angular blocky structure, thus qualifying for *natric* horizon. The soils of pedon P2 and P13 relatively lower in topographic position associated with high ground water contributing to its salinization than pedons P4, P8 and P10 had better developed *natric* horizon because of accumulation of Na.

The characteristics; morphology of the pedon 4 showed presence of 1 cm wide vertical cracks with shiny pressure faces on ped surface. These features lead to the classification of this pedon into fine, smectitic, hyperthermic family of *Vertic Natrustalfs*. P2 and P10 were classified to *Typic Natrustalfs* owing to the presence of columnar structure and very high ESP (>15). The other two pedons (P8 and P13) though had very high ESP, but did not have columnar structure. The results show that soils derived from the clay-rich alluvium were responsible for the formation of *Natrustalfs*, whereas lighter alluvium were responsible for the formation of *Sodic Haplustalfs*. These soils need immediate attention for amelioration with gypsum to attain higher productivity.

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