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Characterization and classification of coastal saline soils of Paradip, Orissa

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Coastal saline soils cover 3.1 million hectare land in the country. Of which 0.40 million hectare (Rakshit 1981) belongs to a narrow strip (445 km long and 2 to 15 km wide) along the sea-coast (Bandyopadhyay *et al.* 1984) in Balasore, Cuttak, Puri, Ganjam and Jagatsinghpur districts of Orissa. The climate of the coastal area is sub-humid (mean annual rainfall 1480 mm) with maximum and minimum temperatures of 41.4° C and 8.9° C, respectively. The coastal saline soils have high concentration of salts that increases the osmotic potential of soil solution, accentuates water deficiency and nutrient immobility. Ground water at shallower depth (75 to 125 cm) made the situation further worse for developing agro-management strategies. Therefore, these soils call for immediate attention. The characterization and classification are the first step for successful management and present investigation aims to do so.

Two representative pedons (P1: near to the Satra creek, Paradip; N 20°15.845′; E 86°35.305′, 1.2′ MSL, P2: two km south-west of Satra creek, Paradip; N 20°15.364′; E 86°35.002′, 4.5′ MSL) occurring on nearly level plains (1 to 3 % slope) were studied (Soil Survey Staff 1995) and classified (Soil Survey Staff 2003) Horizon-wise samples were collected and passed through 2 mm sieve for various chemical and physical properties using standard methods (Richards 1954; Black 1965). For the estimation of available nitrogen (alkaline-$KMnO_4$), phosphorus (Bray P_1, NH_4F+HCl) and potassium (NH_4OAc), the methods outlined by Subbaiah and Asija (1956), Bray and Kurtz (1945) and Black (1965) were adopted, respectively. The concentration of micronutrients were extracted using DTPA-$CaCl_2$-TEA soluation (Lindsay and Norvell 1978) and determined by ICP-OES.

The soils are deep to very deep, clay loam to clay in texture, moderately well to poorly drained and exhibit yellower hue (10 YR), grayer value (5 to 6) and darker chroma (2 to 3). The sub-surface soils showed low chroma, mottles and massive/platy soil structure. The dry, moist and wet consistencies were very hard, very firm and very sticky and plastic, respectively (Table 1). The clay content in the soils ranged from 32 to 40% and silt

Table 1. Morphological characteristics of the pedons

Depth (cm)	Colour (Dry)	Colour (moist)
Pedon 1		
0-20	10YR5/2	10YR5/2
20-35	10YR6/3	10YR5/2
35-50	10YR6/2	10YR5/2
50-80	10YR5/3	10YR4/3
80+	water	
Pedon 2		
0-20	10YR6/3	10YR5/3
20-35	10YR6/2	10YR5/2
35-45	10YR6/2	10YR5/2
45-85	10YR6/3	10YR5/2
85+	water	

Soil texture is clay loam, structure massive, platy and consistence very hard, very firm and very sticky and very firm for all the layers.

Table 2. Physical and chemical characteristics of soils

Depth (cm)	Sand	Silt	Clay	pHs	ECe	O.C.	CEC	Exchangeable cations				Base Saturation	ESP
	(%)				(dS m^{-1})	(%)		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}		
								(cmol (p^{+}) kg^{-1})				%	
Pedon 1 (Haplosalids)													
0-20	42	26	32	7.1	23.7	0.84	20.82	4.2	5.7	5.14	0.15	73.4	24.69
20-35	41	26	33	6.9	42.1	0.72	19.08	6.1	3.9	5.72	0.16	83.2	29.98
35-50	40	27	33	6.9	32.5	0.74	17.35	4.7	5.5	5.49	0.18	91 5	31.64
50-80	41	21	38	7.1	38.2	0.89	19.66	2 1	9.8	5.95	0.19	92.3	30.26
Pedon 2 (Fluvents)													
0-20	40	22	38	5.5	18.8	1 39	17.35	6.2	4.1	2.66	0.24	76.1	15.33
20-35	40	20	40	6.3	9.3	0.91	17.93	5 7	6.8	3.06	0.25	88.2	17.07
35-45	37	27	36	6 9	7.4	0.70	16.19	5.5	6.7	2.54	0.27	92.7	15.69
45-85	41	26	33	7.3	3 7	0.82	17.93	6.3	8.6	1.90	0.24	90.0	10.60

Table 3. Ionic composition of saturation extract of soils

Depth (cm)	Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^{2}	HCO_3^-	Cl^-	SO_4^{2-}	$CO_3^{2-}+HCO_3/Cl^-+SO_4^{2-}$	$Na^+/Cl^-+SO_4^{2-}$
	me L^{-1}									
Pedon 1 (Haplosalids)										
0-20	186.9	1.5	14.4	45.7	-	4.3	234.2	10.5	0.02	0.76
20-35	338.7	2.8	18.3	86.4	-	5.3	434.2	6.7	0.01	0.77
35-50	256.1	2.1	16.3	68.6	-	2.9	335.6	4.3	0.01	0.75
50-80	297.1	2.1	19.3	84.1	-	5.7	390.4	6.9	0.01	0.75
Pedon 2 (Fluvents)										
0-20	117.8	1.9	17.7	59.0	-	6.9	165.7	19.3	0.04	0.64
20-35	73.3	1.4	14.7	7.3	-	4.9	83.6	5.3	0.06	0.82
35-45	48.3	1.1	9.7	16.2	-	2.0	70.5	3.0	0.03	0.66
45-85	20.4	0.7	6.5	9.7	-	0.8	35.7	1.1	0.02	0.55

from 10 to 27%. The organic carbon decreased with depth. The soil pH of soil was moderately acidic to slightly alkaline (5.5 to 7.3) and electrical conductivity (ECe) ranged from 3.7 to 23.7 dSm^{-1} on the surface and 18.8 to 42.1 dSm^{-1} in the sub-surface soils. The CEC of the soils ranged from 16 to 22 cmol (p^+) kg^{-1}. The exchange complex was dominated by Ca^{+2} followed by Mg^{+2} and Na^+. Exchangeable sodium percentage was higher in pedon P1 (24 to 32 %) than P2 (10 to 17 %).

The ionic composition of saturation extract indicated that salts were chloride, sulphate and bicarbonates of sodium, magnesium, calcium and potassium in the decreasing order of preponderance (Table 3). Ionic ratios of $[(CO_3^{2-}+HCO_3^-)/ (Cl^-+SO_4^{2-})]$ and $[Na^+/ (Cl^-+SO_4^{2-})]$ were below one. The soils were related as low in available N, medium to high in available P and high in available K (Table 4). The DTPA-extractable micronutrient cations were above the critical limit.

Classification

Based on the presence of salic horizon, water within 100 cm of the soil profile and absence of sulfidic material, soils of pedon P1 were classified in Aridisol soil order, while soils of pedon P2 were classified as Inceptisols owing to aquic condition within 100 cm of the mineral soil surface and decrease in exchangeable sodium percentage with depth. The salic horizon has precedence over other characteristic for classifying Aridisols into Salids at the sub order level, while aquic moisture regime was the main criteria at suborder level (Aquepts) for classifying the soils of pedon P2. Aquic moisture regime was considered at the great group level for classifying Salids into Aquisalids, while exchangeable sodium percentage and its distribution with depth was considered for classifying Aquepts into Halaquepts. Based on the central concept of great group, Pedon P1 and P2 were classified as Typic Aquisalids and Typic Halaquepts, respectively at the subgroup level. Particle-size class, mineralogy and soil temperature regime were considered as the criteria for classifying the soils of pedons P1 and P2 as a member of fine-loamy, mixed, hyperthermic family of Typic Aquisalids and Typic Halaquepts subgroup, respectively.

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Table 4. Available macro and micronutrient status of soils

Depth (cm)	Available macronutrients (kg ha^{-1})			Available micronutrients (mg kg^{-1})			
	N	P	K	Cu	Fe	Mn	Zn
Pedon 1 (Haplosalids)							
0-20	122.30	17.37	790.72	4.18	43.92	24.15	2.32
20-35	116.03	22.35	869.79	3.36	30.46	7.45	1.15
35-50	112.89	23.99	869.79	3.36	31.04	18.53	1.14
50-80	119.16	29.18	1186.08	4.60	21.88	9.92	0.95
Pedon 2 (Fluvents)							
0-20	163.07	15.46	1107.01	6.49	165.38	85.69	2.21
20-35	122.30	11.20	1146.54	5.36	51.60	54.79	1.04
35-45	122.35	15.98	1107.01	5.57	27.68	28.05	0.66
45-85	106.62	9.86	1027.94	5.36	26.26	24.41	0.44

References

Bandyopadhyay, A. K., Bhargava, G. P. and Bandyopadhyay, B. K. (1984). Coastal Saline Soils of Orissa. CSSRI, RRS, Canning Town, West Bengal, p. 56.

Black, C. A. (1965). 'Methods of Soil Analysis. Part 2, Chemical and Microbiological properties'. Agron. Mono. No. 9. (American Society of Agronomy, Madison, WI, USA).

Bray, R. H. and Kurtz, L. T. (1945). Determination of total, organic and available forms of phosphorus in soils. *Soil Science* **59**, 39-45.

Lindsay, W. L. and Norvell, W. A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper *Proceedings of Soil Science Society of America* **42**, 421 – 428.

Rakshit, S. C. (1981). Management of coastal saline soils of Orissa. Proceeding of second conference on problem and management of coastal saline soils. Bombay and Panvel, Sep. 21-22. p. 67-80.

Richards, L. A. (1954). 'Diagnosis and Improvement of Saline Alkali Soils' (USDA Hand book No. 60. Washington, DC, USA).

Soil Survey Staff (1995). Soil Survey Laboratory Information Manual. Soil Survey Investigations Rep. 45. Version 1.0. (U.S. Gov. Print. Office, Washington, DC).

Soil Survey Staff. (2000). Soil rating for plant growth, a system for arraying soils according to their inherent productivity and suitability for crops. (Eds. S. Holzhey and H.R. Sinclair, Jr. United States Department of Agriculture, NRCS, National Soil Survey Center: Lincoln, NE).

Soil Survey Staff (2003). 'Key to Soil Taxonomy', 9th edition. (United States Department of Agriculture, Natural Resource Conservation Services, Lincoln, NE).

Subbaiah, B. V. and Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soil *Current Science* **25**, 258 – 260.