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Characterization and classification of the soils of Central Research Station, Bhubaneswar

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Abstract

Five pedons, three on upper ridge (P_1 to P_3) and two on low lying waterlogged area (P_4 & P_5) of Central Research Station (OUAT), Bhubaneswar were characterised and classified. The pedons on upper ridge have soil colour variation from light yellowish brown on the surface to red in the subsurface horizons. The soil structure changes from weak, medium subangular blocky on the surface to moderate, coarse sub-angular/angular blocky in the sub-surface horizons. Crotovinas, mottles, concretions of Fe and Mn, and thin patchy clay cutans were observed. Pedons situated on lower elevation have soil colour variation from pinkish gray of surface to light brownish gray in subsurface layers whereas structure varies from subangular blocky to granular. The soil reaction is acidic, organic carbon content is low and decreases with depth. Free Fe_2O_3 increased and free Al_2O_3 decreased with depth. The value of CEC varies from 4.8 to 28.0 cmol (p+) kg^{-1} and increased with depth and have positive correlation with clay (r=0.96). Ca^{2+} ions dominate the exchange complex followed by Mg^{2+}, K^+ and Na^+ ions. Exchange acidity contributed by H^+ is more than Al^{3+} ions. Vertical distribution of available nutrients indicated the value of N, P_2O_5 and K_2O gradually decreased with depth. Soils, P_1 and P_3 are classified as Ultic Haplustalfs, P_2 as Ultic Paleustalfs, P_4 as Typic Haplustepts and P_5 as Typic Fluvaquents.

Additional key words : Morphology, physical and chemical characteristics.

Introduction

East and south eastern coastal plain zone of Orissa occupies an area of 7.9 lakh ha. Alfisols and Entisols are the major soil orders in this zone. Crop production in these soils are not satisfactory because of some soil related constraints. Systematic soil characterization and classification have not yet been made for their low productivity. Central Research Station represents the soils of this zone. An attempt has been made in the present investigation to characterize and classify the soils occurring in this zone.

Materials and methods

Three pedons (P_1, P_2 and P_3) occurring on upper ridge and two pedons (P_4 and P_5) lying in low lands in the Central Research Station of Orissa University of Agriculture and Technology, Bhubaneswar were selected for the study. Pedon P4 occupies relatively higher element of topography than P_5. The research station is situated at 81° 52'E longitude and 20° 15'N latitude at an elevation of 25 to 53 m. above msl. The climate is hot and sub-humid with an average annual rainfall of 1467 mm mostly distributed during June to September. The mean maximum and minimum annual temperatures are 31.5°C and

Table 1. Morphological characteristics of soils

Horizon	Depth (cm)	Colour Matrix	Colour Mottles	Texture	Structure	Consistence	Special features
Pedon - 1 Ultic Haplustalfs							
Ap	0 - 14	10 YR 6/4	-	ls	f 1 sbk	dl mfr wso wpo	-
Bt1	14 - 58	7.5 YR5/6		l	m 2 sbk	ds mfr wss wps	Thin, patchy, clay cutans
Bt2	58 - 72	7.5 YR7/4	-	l	m 2 abk	dsh, mfr, wss, wps	Thin, patchy, clay cutans
C	72+ Unconsolidated laterite mass						
Pedon - 2 Ultic Paleustalfs							
A	0 - 15	5YR 6/4	-	l	f 2 sbk	ds mfr wso wpo	-
Bt1	15-33	7.5YR 6/4	5 YR 3/2	cl	m 2 sbk	dh mfr wss wpo	Mottles. clay, cutans
Bt2	33- 93	7.5 YR 5/6	5YR 3/2	c	m 2 abk	dh mfr wss wp	Crotovinas, mottles, cutans, conir
Bt3	93-157	7.5 YR 6/6	5 YR 3/2	c	c 2 abk	dvh mfi ws wsp	Crotovinas, mottles, cutans, conir
Bt4	157-210	5 YR 5/6	2.5 YR 4/6	c	c 3 abk	deh mvfi ws, wp	Mottles, cutans, conir
C	210 -225	10R 5/8	-	c	vc 3 m	deh mvfi ws wp	Unconsolidated laterite murrum
R	225 + hard consolidated latertie mass.						
Pedon - 3 Ultic Haplustalfs							
AP	0-15	5 YR 5/8	-	ls	m 2 sbk	dh mfr wso wpo	-
B1	15 - 28	5 YR 5/8	2.5 YR 5/8	sil	m 2 sbk	dh mft wss wpo	Mottles
Bt1	28-49	5YR 5/6	2.5 YR 5/8	l	m 2 abk	dsh mfr wss wpo	Crotovinas, cutans, conir, mottles
Bt2	49-80	2.5 YR 5/8	2.5 YR 5/6	l	m 2 abk	dh mfi ws wsp	Crotovinas, cutans, conir, mottles
Bt3	80-91	2.5 YR 5/8	-	sil	c 3 m	dh mfi wso wpo	Crotovinas, cutans, conir
C	91 + Unconsolidated laterite mass						
Pedon - 4 Typic Haplustepts							
A1	0-15	7.5 YR 6/2	5YR 5/6	sic	m 1 sbk	dh mfi ws wp	Mottles, Conca, Conir, conma
Bw1	15 - 35	7.5 YR 7/2	5 YR 6/6	sic	m 2 abk	dvh mfi wvs wp	Mottles, Conca, Conir, conma
Bw2	35 - 85	10 YR 6/1	7.5 YR 6/4	c	c 2 abk	dvh mfi wvs wp	Mottles, Conca, Conir, conma
Pedon - 5 Typic Fluvaquents							
A1	0 - 14	5Y 6/1	5 YR 6/8	l	m 1 gr	dsh mfr wso wpo	-
A2	14-35	2.5 Y 7/1	2.5 YR 4/6	l	m 2 sbk	dsh mfi wss wps	Red mottles along root channels
A3	35 - 70	2.5 Y 6/2	2.5 YR 4/6	l	m 2 sbk	dsh mfi wss wps	Red mottles along root channels
A4	70-120	10 YR 6/2	10 YR 5/3	sl	f 1 sbk	dl mfr wso wpo	Brown mottles along root channels

Table 2. Physical and chemical properties of soils

Depth (cm)	Particle size distribution (%) Sand (2000-50μ)	Silt (20-2μ)	Clay (<2 μ)	B.D. Mg m^{-3}	P.D. Mg m^{-3}	WHC (%)	pH (1:2)	EC (1:2) dSm^{-1}	OC gkg^{-1}	Free Fe_2O_3(%)	Free Al_2O_3 (%)	Free $CaCO_3$ (g kg^{-1})
Pedon - 1 UlticHaplustalfs												
0 - 14	80.2	11.0	8.8	1.35	2.58	40.1	5.2	0.06	4.7	10.4	2.4	-
14- 58	65.2	16.0	18.8	1.40	2.64	42.2	5.3	0.03	3.7	11.7	3.4	-
58- 72	67.2	13.0	19.8	1.45	2.65	42.1	5.4	0.03	3.3	12.2	4.3	-
Pedon - 2 UlticPaleustalfs												
0 - 15	56.2	23.0	20.8	1.30	2.55	41.0	5.4	0.10	5.8	11.7	2.8	-
15- 33	41.2	21.0	37.8	1.31	2.55	43.5	5.5	0.08	4.7	11.9	2.9	-
33- 98	23.2	19.0	57.8	1.35	2.56	50.9	5.8	0.03	3.9	12.7	3.8	-
93-157	22.2	17.0	60.8	1.35	2.58	51.3	6.0	0.02	2.7	12.8	3.9	-
157-210	30.2	13.0	56.8	1.31	2.60	50.3	6.1	0.03	1.1	12.8	4.2	-
210 -225	33.2	16.0	50.8	1.32	2.60	43.2	6.1	0.04	1.0	13.12	4.2	-
Pedon - 3 Ultic Haplustalfs												
0-15	77.2	14.0	8.8	1.40	2.50	45.0	5.2	0.20	6.0	10.9	2.4	-
15-28	58.2	27.0	14.8	1.45	2.55	43.6	5.4	0.31	5.2	11.0	2.4	-
28-49	61.2	20.0	18.8	1.46	2.55	42.0	5.6	0.20	4.1	11.5	3.3	-
49-80	57.2	22.0	20.8	1.48	2.52	40.0	5.6	0.20	3.4	11.9	3.9	-
80-91	49.2	38.0	12.8	1.50	2.56	38.1	5.4	0.25	3.3	12.1	3.5	-
Pedon - 4 Typic Haplustepts												
0-15	31.2	26.0	42.8	1.26	2.47	47.0	5.6	0.90	10.2	12.4	1.7	-
15 - 35	34.2	25.0	40.8	1.31	2.50	45.0	6.7	0.30	7.2	8.4	2.4	1.5
35 - 85	32.2	18.0	49.8	1.39	2.56	46.0	7.9	0.20	1.7	8.3	4.0	9.6
Pedon - 5 Typic Fluvaquents												
0 - 14	70.2	12.0	17.8	1.37	2.60	40.0	4.7	0.06	5.4	3.8	1.8	-
14 - 35	60.2	17.0	22.8	1.35	2.58	42.0	4.7	0.03	2.5	3.8	1.7	-
35- 70	70.2	12.0	17.8	1.40	2.65	40.0	4.5	0.04	2.9	3.8	1.7	-
70- 120	81.2	7.0	11.8	1.42	2.65	38.0	5.2	0.05	1.3	3.8	1.9	-

22.3°C, respectively. Morphological characteristics were studied in the field as per Soil Survey Division Staff (1995). Soil samples collected horizonwise were air-dried and passed through 2 mm seive. Physical and chemical properties were determined following standard methods (Black 1965) and classified (Soil Survey Staff 1998).

Results and discussion

Morphological characteristics : Among the three pedons studied on the upper ridges, P_1 and P_3 have unconsolidated laterite murrum within 1 m depth but P_2 is comparatively deep (Table 1). The colour of P_1, P_2 and P_3 ranged from light yellowish brown to yellowish red on the surface to red in the subsurface horizon. Soil structure varies from subangular blocky on the surface to angular blocky in the subsurface horizon. Thin patchy clay cutans are observed in the subsurface layers of these pedons. Crotovinas and fine distinct dark brown to red mottles are observed in P_2 and P_3. Soil colour of P_4 varies from pinkish gray to gray and that of P_5 from light gray to light brownish gray from surface to subsurface horizon. The structure of P_4 is subangular to angular blocky and that of P_5 is granular. Fine distinct reddish yellow to red mottles along the root channels are common in both the pedons.

Physical characteristics : Data on mechanical composition (Table 2) indicated that in P_1, P_2 and P_3, the content of sand ranged from 22.2 to 80.2 per cent in different horizons and decreased downwards with a concurrent increase in clay which ranged from 8.8 to 60.8 per cent. Soil texture varied from loamy sand on surface to clay in subsurface horizons. In P_4 and P_5, sand fraction ranged from 31.2 to 81.2 per cent and that of clay from 11.8 to 49.8 per cent and no regular trend could be observed. The value of bulk density varied from 1.26 to 1.50 Mg m^{-3} which increased with depth. This might be due to heavy soil texture, decrease in organic matter content and increase in soil compaction (Govind Rajan and Datta Biswas 1968). The value of particle density ranges from 2.47 to 2.65 Mg m^{-3} and water holding capacity from 38.0 to 51.3 per cent.

Chemical characteristics : In general, the value of pH increased down the depth (Table 2). Soil reaction is acidic in all the pedons except P_4 in which a higher pH (7.9) is observed in the last layer. This might be due to the presence of free $CaCO_3$ in this layer. Electrical conductivity ranged from 0.02 to 0.90 dSm^{-1}. Organic carbon content in different layers varies from 1.0 to 10.2 g kg^{-1} and the value decreased from surface downwards. The free Fe_2O_3 content varied from 10.36 to 13.18 per cent in P_1, P_2 and P_3 and the value increased from the surface downwards which is in conformity with the work of Sahu *et al.* (1983) in some laterite soils of Orissa. Consequently the value of free Al_2O_3 increased with the depth. But in P_4 the free Fe_2O_3 content decreased with depth and almost similar value was obtained in P_5 which might be due to fresh deposits of these oxides on the surface layer.

Table 3. Exchange characteristics of soils

Depth (cm)	CEC	Exchangeable cations					Exchange acidity	Exchangeable		Base Saturation (%)	CEC/ clay (%)
		Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Total		Al^{3+}	H^{+}		
		cmol (p+) kg^{-1}									
Pedon - 1 Ultic Haplustalfs											
0-14	4.8	1.4	0.7	0.3	0.2	2.5	2.1	0.9	1.0	53	54
14-58	8.7	2.8	1.2	0.5	0.1	4.7	3.8	0.2	3.5	54	46
58-72	9.7	3.0	1.3	0.7	0.2	5.2	3.8	0.1	3.8	56	47
Pedon - 2 Ultic Paleustalfs											
0 - 15	10.2	3.5	1.6	0.8	0.3	6.2	3.7	0.1	3.4	60	49
15-33	16.7	6.2	2.8	1.2	0.4	10.6	5.3	-	4.8	63	44
33-93	26.8	10.6	4.5	2.6	0.7	18.4	7.8	-	7.3	70	46
93-157	28.0	11.3	5.6	3.0	0.7	20.7	7.2	-	6.6	74	46
157-210	25.6	10.9	4.9	2.9	0.7	19.4	5.8	-	5.7	76	45
210-225	23.1	10.1	4.3	2.3	0.6	17.6	4.9	-	4.1	76	45
Pedon - 3 Ultic Haplustalfs											
0-15	4.8	1.5	0.8	0.2	0.1	2.6	1.8	0.2	1.5	54	54
15 - 28	7.2	2.4	1.0	0.5	0.2	4.1	2.7	0.0	1.8	56	48
28-49	8.6	3.3	1.4	0.9	0.3	5.9	2.6	-	2.3	69	45
49-80	9.2	3.6	1.6	0.9	0.3	6.4	2.1	-	2.0	69	44
80-91	6.1	2.0	1.1	0.4	0.1	3.5	2.1	0.1	1.6	57	47
Pedon - 4 Typic Haplustepts											
0-15	20.4	8.7	3.4	1.6	0.5	14.2	4.8	-	4.4	70	48
15-35	19.2	9.8	4.2	1.7	0.5	16.3	0.8	-	0.7	85	47
35 - 85	23.8	12.5	6.3	2.8	1.0	22.6	-	-	-	95	47
Pedon - 5 Typic Fluvaquents											
0-14	8.68	2.7	1.0	0.5	0.1	4.3	3.1	2.0	1.0	50	48
14-35	10.7	2.9	1.3	0.5	0.2	4.9	4.9	2.6	2.2	42	46
35-70	8.3	2.1	1.0	0.4	0.1	3.7	4.3	2.4	0.9	45	46
70-120	5.2	1.5	0.8	0.4	0.1	2.7	2.1	0.9	1.0	53	44

Table 4. Available nutrients (kg/ha) of soils.

Depth (cm)	N	Status	P_2O_5 (Bray's–1)	Status	K_2O (NH_4OAc)	Status
Pedon - 1 Ultic Haplustalfs						
0-14	376.3	m	27.14	m	100	l
14-58	226.3	l	21.43	m	70	l
58-72	188.5	l	13.14	l	70	l
	(263.7)*		(20.57)*		(80.0)*	
Pedon - 2 Ultic Paleustalfs						
0 - 15	400.5	m	22.85	m	240	m
15-33	379.6	m	15.35	m	220	m
33-98	250.1	m	10.00	l	190	m
93-157	175.3	l	10.35	l	180	m
157-210	112.8	l	9.07	l	160	m
210-215	91.9	l	8.78	l	140	m
	(235.0)*		(12.73)*		(188.34)*	
Pedon - 3 Ultic Haplustalfs						
0-15	349.5	m	18.40	m	105	l
15 - 28	302.6	m	15.30	m	80	l
28-49	232.5	l	14.20	m	60	l
49-80	160.0	l	10.10	l	60	l
80-91	120.3	l	8.00	l	50	l
	(232.9)*		(13.20)*		(71)*	
Pedon - 4 Typic Haplustepts						
0-15	868.3	h	22.14	m	290	m
15-35	625.6	h	19.28	m	150	m
38 - 85	354.5	m	17.86	m	190	m
	(616.1)*		(19.76)*		(210)*	
Pedon - 5 Typic Fluvaquents						
0-14	383.9	m	9.29	l	70	l
14-35	217.0	l	7.87	l	60	l
35-70	175.3	l	10.71	l	60	l
70-120	150.2	l	13.57	l	50	l
	(231.6)*		(10.36)*		(60)*	

* Figures in bracket are average values of the nutrients
l = low, m = medium, h = high.

The value of CEC (Table 3) ranged from 4.8 to 28.0 c mol (p^+)kg^{-1} and is positively correlated with clay (r = 0.96) and organic carbon. The base saturation ranged from 44.9 to 95.0 per cent and well correlated with pH (r = 0.91). The CEC/clay per cent varied from 44 to 54 indicating mixed mineralogy class of soils. The value of exchange acidity varied from 0.85 to 7.79 c mol (p^+) kg^{-1} and mostly contributed by H^+ and Al^{3+} which is in conformity with the works of Das *et al.* (1992). Among different cations Ca^{2+} dominates the exchange complex followed by Mg^{2+}, K^+ and Na^+.

Available nutrient status : Vertical distribution of available nutrients of the pedons presented in table 4 indicated that N, P_2O_5 and K_2O content ranges from 91.9 to 868.3, 7.87 to 22.14 and 50.0 to 290.0 kg ha^{-1}, respectively and the values decrease with depth. Considering 250-500, 14 - 40 and 118-280 kg ha^{-1} available N, P_2O_5 and K_2O, respectively as medium value for the status of available nutrients (Mitra *et al.* 1985).

Classification : Based on the morphological, physical and chemical properties of the soils, P_1, P_2 and P_3 are grouped under Alfisols order because of presence of argillic horizon and percentage base saturation of more than 35 per cent. Pedons P_1 and P_3 are classified as Ultic Haplustalfs because of presence of ustic soil moisture regime and have base saturation (by sum of cations) of less than 75 per cent in the argillic horizon. Pedon P2 is classified as Ultic Paleustalfs as there is no densic, lithic or paralithic contact within 150 cm of mineral soil surface. Pedon P_4 is grouped under Typic Haplustepts as it has an ochric epipedon, a cambic horizon and a ustic moisture regime. Pedon P_5 is grouped under Typic Fluvaquents as it has no evidence of pedogenic horizons, but has an aquic moisture regime and organic carbon content that decreases irregularly with depth and remain above 0.2 per cent to a depth of 1.25 m. At the family level P_1 and P_3 are placed under fine loamy, mixed hyperthermic, P_2 and P_4 under fine, mixed, hyperthermic and P_5 under coarse loamy, mixed, hyperthermic.

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