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CHARACTERIZATION AND CLASSIFICATION OF SHALLOW, MEDIUM DEEP AND DEEP RED AND BLACK SOILS OF NORTHERN TELANGANA ZONE IN ANDHRA PRADESH

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Abstract: Six pedons representing shallow, medium deep and deep red and black soils of Northern Telangana region under hot, moist, semiarid eco-subregion in Andhra Pradesh were studied morphologically and soil samples were analyzed for physical and chemical properties using standard methods. There is wide variation in colour, structure, texture, reaction and in other physical and chemical properties of the soils between these two broad groups of soils. All red soil pedons were noncalcareous, whereas black soils were calcareous. Cracks and slickensides were the characteristic features of black soils whereas significant increase in clay content in deeper horizons and occurrence of clay films were the characteristic features in red soils.

Red soils were classified as Typic Ustipsamments and Typic Haplustalfs. The black soils were classified as Vertic Calciustepts, Vertic Haplustepts and Typic Haplusterts at subgroup level. At the family level, the soils were qualified from sandy to clayey particle size classes, mixed and smectitic mineralogy class and isohyperthermic soil temperature class.

Key words: Alfisols, Andhra Pradesh, Entisols, Inceptisols, Soil Taxonomy, Vertisols

INTRODUCTION

Andhra Pradesh is the fifth largest state in India, accounting for 8.4 per cent of the country's geographical area. Based on the total quantity and distribution of rainfall, irrigation, soil types and cropping patterns, Andhra Pradesh is broadly divided into seven agro-climatic zones and the study area Northern Telangana zone (NTZ) is one of them (Northern Telangana Zone Status Report, 1989). NTZ spreads over 63,350 km^2 accounting for 22.9 per cent of the geographical area in the state. The zone consists of Adilabad, Karimnagar, Nizamabad, Medak (except southern borders), Warangal (except western portion), northeastern tip of Nalgonda and most of Khammam districts. The present study was undertaken to characterize the morphological, physical and chemical properties of dominant soil groups occurring in this area and to classify them.

MATERIALS AND METHODS

Soil samples were collected from representative soil groups of shallow, medium deep and deep red and black soils of Northern Telangana region of Andhra Pradesh. The study area has igneous (pink and gray granites), metamorphic (granite gneiss and hornblende schist) and sedimentary (sandstone) rocks. Annual rainfall is around 1000 mm, more than 90 per cent of which is received during June to November in a year. Climatically, this zone falls under semi-arid (moist) tropics.

Soil profiles were described in the field (soil survey staff, 1951) and horizon-wise samples were collected for laboratory analysis. The soil samples (<2mm) were analyzed for physical and chemical properties following standard procedures (Piper, 1942; Jackson, 1979). Soils were classified according to *Soil Taxonomy* (Soil Survey Staff, 1999).

RESULTS AND DISCUSSION

Morphological properties

The study area has shallow (<50 cm), moderately deep (50-100 cm) and deep (>100 cm) (Sehgal *et al.*, 1987) red and black soils (Table 1). The red soils had colours in the hue of 7.5YR to 2.5 YR. The colour grades to redder hues with depth. The values ranged between 3 to 6 and chromas between 3 to 8. Schwertmann and Taylor (1977) believed that 5YR colours might be due to the presence of both lepidocrocite and ferrihydrite. Childs and Wilson (1983) proved that haematite was associated with 2.5YR and 5YR colours while goethite with 7.5YR and 10YR colours. Free iron oxides played an important role in imparting red color to soil. The black soils had colours in the hue 10YR. The value ranged from 3 to 6 and chroma from 1 to 4. The presence of iron sulphide and manganese oxide in combination with the organic complex would induce dark colour in Vertisols (Murthy *et al*, 1982).

Table 1. Morphological properties of the soils

Pedon No.	Location	Horizon	Depth (cm)	Soil colour (moist)	Tex-ture	Structure	Consistence			Boundary DT
							Dry	Moist	Wet	
1	Karimnagar	Ap	0-8	7.5YR 5/6	gls	0 sg	1	1	so po	as
		Cr	8+	Weathered granite						
2	Malyal	Ap	0-6	5YR 4/6	ls	2 m sbk	s	fr	so po	as
		Bt1	6-30	2.5YR 4/6	scl	2 m sbk	sh	fi	ss ps	cs
		Bt2	30-60	2.5YR 4/6	scl	2 m sbk	h	fi	ss ps	cs
		Bt3	60-90	2.5YR 4/6	scl	2 m sbk	h	fi	ss ps	cs
		Cr	90+	Weathered granite						
3	Aswaraopet	Ap	0-21	7.5YR 3/4	ls	1 f gr	s	fr	so po	as
		Btl	21-50	2.5YR 4/6	sl	1 f sbk	s	v fr	so po	cw
		Bt2	50-79	2.5YR 4/6	l	1 fsbk	s	v fr	so po	gs
		Bt3	79-123	2.5YR 4/6	scl	2 m sbk	s	v fr	so po	gs
		Bt4	123-152	2.5YR 4/6	scl	2 m sbk	sh	v fr	so po	as
		Cr	152+	Weathered ferruginous sandstone						
4	Wyra	Ap	0-21	10YR 4/1	gc	2 msbk	h	fi	s p	cs
		Bw	21-34	10YR 4/2	gc	2 m sbk	vh	fi	s ps	cs
		Bck	34-64	10YR 4/2	gcl	2 msbk	vh	fi	s ps	as
		Crk	64+	Weathered hornblende schist with calcium carbonate accumulation						
5	Madhira	Ap	0-20	10YR 3/2	gc	2 m sbk	h	fi	ss ps	cs
		Bwl	20-64	10YR 3/2	gc	2 m sbk	h	fi	s p	cs
		Bw2	64-105	10YR 3/2	gc	2 msbk	h	fi	sp	cs
		Bck	105+	Weathered bedrock with calcium carbonate accumulation						
6	Adilabad	Ap	0-24	10YR 3/2	gc	2 m sbk	h	fi	ss ps	cs
		Bw	24-43	10YR 3/2	c	2 msbk	h	fi	ss ps	cs
		Bss1	43-79	10YR 3/2	gc	2 msbk	sh	fi	sp	cs
		Bss2	79-115	10YR 3/2	gc	2 m abk	sh	fi	sp	gs
		Bss3	115-152	10YR 5/4	gc	2 m abk	sh	fi	s p	cs
		Bss4	152-200	10YR 5/4	gsic	2 m abk	sh	fi"	sp	

Note: Abbreviations used are according to Soil Survey Staff (1951)

Texture: g = gravel; ls = loamy sand; sl = sandy loam; 1 = loam; si = silt; sil = silt loam; cl = clay loam; sicl = silty clay, loam; scl = sandy clay loam; sic = silty clay; c = clay; gc = gravelly clay; gls = gravelly loamy sand; gscl = gravelly sandy clay loam; gsl = gravelly sandy loam

Structure: a) Grade: 0 = structureless, 1 = weak, 2 = moderate, 3 = strong; b) Size : f = fine, m = medium, c = coarse, vc = very coarse; c) Type: abk = angular blocky, sbk = subangular blocky, gr = granular; sg = single grain

Consistence: Dry soil: 1 = loose, s = soft, sh = slightly hard, h = hard, vh = very hard, eh = extremely hard, Moist soil: 1 = loose, vfr = very friable, fr = friable, fi = firm, vfi = very firm, efi = extremely firm; Wet soil: so = non sticky, ss = slightly sticky, s = sticky, vs = very sticky, po = non plastic, ps = slightly plastic, p = plastic, vp = very plastic

Boundary: D = distinctness, a = abrupt, c = clear, g = gradual, d = diffuse, T = Topography, s = smooth, w = wavy, i = irregular, b = broken

The surface horizon of shallow red soil in Karimnagar had single grain structure, whereas others had weak to moderate, fine to medium and granular to sub-angular blocky structures with soft to slightly hard (dry) and loose to friable (moist) consistence. The bottom layers were grading from weak to moderate, fine to medium subangular blocky structure and soft to hard (dry) and friable to firm (moist) in consistence. Low clay content and type of clay mineral are responsible for the consistence in red soils. The surface horizons of black soils had moderate, medium subangular blocky structure and hard to very hard (dry) and friable to very firm (moist) consistence. The subsoil horizons had moderate to strong, medium to very coarse angular blocky structures and hard to extremely hard (dry) and firm to extremely firm (moist) consistence. These are the characteristic features of black soils with smectite as dominant mineral (Coulombe *et al.*, 1996). Similar findings regarding structure of red and black soils were made

Table 2. Physical properties of soils

Pedon No.	Location	Depth (cm)	Coarse fragments (>2 mm) % of soil	Size class and particle diameter (% of <2 mm)			Bulk density (clod method) Mg m^{-3}	Water retention		AWC (%)
				Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)		33 kPa (%)	1500 kPa (%)	
1	Karimnagar	0-8	15	85.9	5.4	8.7	1.57	5.4	2.5	2.9
		8+	Weathered granite							
2	Malyal	0-6	5	77.5	9.1	13.4	1.57	10.1	6.3	3.8
		6-30	5	65.1	9.5	25.4	1.55	23.0	18.1	4.9
		30-60	5	67.3	8.5	24.2	1.53	24.0	18.0	6.0
		60-90	10	55.8	8.8	35.4	1.56	28.0	18.3	9.7
		90+	Weathered granite							
3	Aswaraopet	0-21	2	76.6	13.9	9.5	1.52	8.0	4.9	3.1
		21-50	-	70.5	18.4	11.1	1.50	13.0	10.4	2.6
		50-79	1	48.1	28.2	23.7	1.56	16.2	12.9	3.3
		79-123	1	49.2	20.0	30.8	1.54	16.6	13.2	3.4
		123-152	5	53.2	18.5	28.3	1.59	14.1	11.4	2.7
		152+	Weathered ferruginous sandstone							
4	Wyra	0-21	20	37.9	19.9	42.2	1.70	32.5	21.1	11.4
		21-34	30	39.5	22.0	38.5	1.68	27.1	17.7	9.4
		34-64	40	42.4	24.1	33.5	1.64	24.3	15.0	9.3
		64+	Weathered hornblende schist with calcium carbonate accumulation							
5	Madhira	0-20	25	35.9	18.5	45.6	1.76	33.4	20.8	12.6
		20-64	20	31.3	20.1	48.6	1.73	33.2	23.0	10.2
		64-105	30	28.7	19.8	51.5	1.75	38.4	25.9	12.5
		105+	Weathered bedrock with calcium carbonate accumulation							
6	Adilabad	0-24	15	32.9	6.8	60.3	1.74	29.1	20.3	8.8
		24-43	10	27.8	15.2	57.0	1.72	30.1	21.3	8.8
		43-79	15	23.5	23.8	52.7	1.78	33.7	23.4	10.3
		79-115	20	20.4	28.0	51.6	1.80	38.3	25.3	13.0
		115-152	20	17.7	32.6	49.7	1.85	46.2	28.0	18.2
		152-200	25	15.3	40.0	44.7	1.85	47.7	28.9	18.8

by previous workers (Kaistha and Gupta, 1994; Nayak *et al.*, 1999; Rudramurthy and Dasog, 2001).

The black soil pedons were characterized by the presence of cracks varying in width from 1 to 12 cm, generally extending to depths more than 50 cm. The cracks remained open for periods varying from 90 to 150 cumulative days. The variation in the volume of cracks might be attributed to the variation in contents of cementing materials and exchangeable Na^+. If the cementing materials like iron and aluminium hydroxides were more, the extent of cracks will be less due to reduction in swelling property. If the soil is having more exchangeable Na, more will be the swelling and development of wider cracks (Nimkar *et al*, 1992).

In red soil pedons no calcium carbonate accumulation was found whereas all black soil pedons were calcareous. Secondary calcium carbonate was present as irregularly shaped kankars. Slickensides were found in deep black soil pedon of Adilabad starting at 50 cm depth.

Physical properties

The per cent coarse fragments increased with depth in all soils. The coarse fragments were mainly quartz gravel in red soils and lime concretions in black soils. Medium deep and

Table 3, Chemical properties of soils

Pedon No.	Location	Depth (cm)	pH (1:2.5 water)	EC (dS m^{-1})	$CaCO_3$ (%)	OC (%)
1	Karimnagar	0-8	6.1	0.16	-	0.37
		8+	Weathered granite			
2	Malyal	0-6	6.2	0.14	-	0.80
		6-30	5.9	0.15	-	0.72
		30-60	6.2	0.19	-	0.56
		60-90	6.3	0.16	-	0.56
		90+	Weathered granite			
3	Aswaraopet	0-21	5.2	0.09	-	1.38
		21-50	5.9	0.11	-	0.99
		50-79	4.7	0.12	-	0.82
		79-123	4.7	0.10	-	0.60
		123-152	4.9	0.11	-	0.53
		152+	Weathered ferruginous sandstone			
4	Wyra	0-21	7.6	0.47	12.3	0.88
		21-34	8.0	0.26	16.7	0.14
		34-64	8.1	0.25	24.3	0.06
		64+	Weathered hornblende schist with calcium carbonate accumulation			
5	Madhira	0-20	8.0	0.32	7.0	0.72
		20-64	8.0	0.30	8.4	0.41
		64-105	8.0	0.38	13.8	0.37
		105+	Weathered bedrock with calcium carbonate accumulation			
6	Adilabad	0-24	7.8	0.21	3.9	0.56
		24-43	8.0	0.24	4.5	0.53
		43-79	8.3	0.27	10.2	0.46
		79-115	8.6	0.38	9.7	0.37
		115-152	8.9	0.56	11.5	0.22
		152-200	9.2	0.46	11.5	0.17

deep red soils had insignificant amount of gravel (2-10%) in A and B horizons (Table 2).

The sand content of red soils varied between 48.1 to 85.9 per cent, the per cent sand decreeasing with depth. The sand content of black soils varied between 15.3 to 42.4 per cent. In shallow black soil the content of sand was observed to increase with the depth, whereas in medium deep and deep black soil pedons it decreased with depth.

The black soils showed higher content of silt compared to red soils. The silt content ranged from 5.4 to 28.2 per cent in red soils. In black soil pedons, the silt content ranged from 6.8 to 40 per cent. There is an increasing trend with depth in Adilabad pedon, while other pedons did not show any particular trend.

The clay content in black soil pedons was found high compared to red soils. In red soils its content ranged from 8.7 to 35.4 per cent. In black soil pedons, clay content varied from 33.5 to 60.3 per cent. In case of red soil pedons, the clay content increased with depth. This can be attributed to vertical migration of clay and translocation of clay from the surface to lower horizons (Torrent *et al.*, 1980; Klich *et al.*, 1990). The surface enrichment of sand fraction in red soils was also due to the removal of finer particles by clay eluviation and surface runoff.

The bulk density, moisture retention at 33 and 1500 kPa and available water capacity were more in black soils when compared with red soils, which may be due to high smectitic clay content, more CEC and more exchangeable Na^+ and Mg^+ (Hirekurubar *et al*, 1991).

Table 4. Ion exchange data of soils

Pedon No.	Location	Depth cm	Exchangeable bases*				CEC*	ESP %	CEC/ Clay	Ex. Ca/Mg	BS %
			Ca	Mg	Na	K					
1	Karimnagar	0-8	5.0	1.1	tr	0.1	6.9	tr	0.79	4.4	97
		8+	Weathered granite								
2	Malyal	0-6	4.5	1.9	tr	0.2	7.7	tr	0.57	2.4	86
		6-30	10.5	2.1	0.1	0.2	14.5	1	0.57	5.0	89
		30-60	10.6	4.6	0.4	0.2	16.2	2	0.67	2.3	97
		60-90	11.3	4.5	0.6	0.2	17.7	3	0.50	2.5	94
		90+	Weathered granite								
3	Aswaraopet	0-21	5.1	1.0	0.3	0.2	7.8	3	0.82	5.1	65
		21-50	4.2	1.5	tr	0.2	8.4	tr	0.76	2.8	70
		50-79	2.6	1.6	tr	0.1	10.3	tr	0.43	1.6	42
		79-123	3.0	1.5	0.1	0.2	11.1	1	0.36	2.0	43
		123-152	3.4	1.4	tr	0.1	7.7	tr	0.27	2.4	64
		152+	Weathered ferruginous sandstone								
4	Wyra	0-21	24.2	13.2	0.3	0.2	37.6	1	0.89	1.8	100
		21-34	24.8	10.2	0.9	0.2	36.0	2	0.93	2.4	100
		34-64	22.0	7.6	0.5	0.1	29.8	2	0.89	2.9	100
		64+	Weathered hornblende schist with calcium carbonate accumulation								
5	Madhira	0-20	40.8	4.5	0.5	0.3	45.1	1	0.99	9.1	100
		20-64	38.2	5.2	0.7	1.1	44.6	2	0.92	7.3	100
		64-105	44.0	7.2	0.8	0.2	51.3	2	1.00	6.1	100
		105+	Weathered bedrock with calcium carbonate accumulation								
6	Adilabad	0-24	32.4	9.2	tr	0.4	42.0	tr	0.70	3.5	100
		24-43	25.3	14.3	0.4	0.1	40.9	1	0.72	1.8	98
		43-79	22.3	17.0	1.4	0.2	40.6	3	0.77	1.3	100
		79-115	20.5	18.3	2.3	0.2	41.0	6	0.79	1.1	100
		115-152	16.0	19.1	5.4	0.2	40.4	13	0.81	0.8	100
		152-200	14.4	20.0	6.1	0.2	40.2	15	0.90	0.7	100

* cmol (p+) kg^{-1}; tr = trace

Chemical properties

There was a general trend of increasing pH with depth in all the pedons except for Aswaraopet pedon. The lower pH values in subsoil horizons of Aswaraopet red soil pedon indicate the high degree of development of the soil (Shrikant *et al.*, 1993). The electrical conductivity values ranged between 0.1 and 0.6 dS m^{-1} indicating that the soils are nonsaline. Organic carbon content was found to decrease with depth. Free calcium carbonate was absent in red soils. In black soils free $CaCO_3$ ranged from 4.5 to 24.3 and the content increased with depth. The cation exchange capacity (CEC) values varied from 6.9-to 14.5 cmol (p+) kg^{-1} soil in red soil pedons whereas CEC/clay ratio ranged from 0.27 to 0.82. The CEC values were ranged from 29.8 to 51.3 cmol (p+) kg^{-1} soil and CEC/clay ratios were found to vary from 0.70 to 1.00 in black soil pedons. The CEC values are indicating that the black soils are less weathered than the red soils. Higher CEC/clay values indicate the less weathered nature of the soils with weatherable primary minerals (Buol *et al.*, 1998).

Exchange complex was mostly saturated with Ca^{2+} followed by Mg^{2+}, Na^{+} and K^{+}. This order of abundance was in accordance with Jenny's (1941) view that the leaching caused preferential losses of Na^{+} and K^{+}. Higher values of ex.Ca/ex.Mg indicated the decrease in extractable magnesium content in soils. The ESP values for black soils were higher than red soils and there was an increasing trend with depth. Decrease in Ca/Mg ratio with depth in Adilabad

Table 5. Classification of the studied soils

Pedon no.	Location	Subgroup	Family
1	Karimnagar	Typic Ustipsamment	Mixed, isohyperthermic
2	Malyal	Typic Haplustalf	Fine-loamy, mixed, isohyperthermic
3	Aswaraopet	Typic Haplustalf	Fine-loamy, mixed, isohyperthermic
4	Wyra	Vertic Calciustept	Fine, smectitic, (calcareous), isohyperthermic
5	Madhira	Vertic Haplustept	Fine, smectitic, (calcareous), isohyperthermic
6	Adilabad	Typic Haplustert	Fine, smectitic, (calcareous), isohyperthermic

black soil pedon indicates that there is a tendency to develop sodicity in this soil. This is a general observation for the black and associated soils in the semi-arid regions of the peninsular India (Murthy *et al.*, 1982; Nimkar *et al.*, 1992).

The per cent base saturation was lowest in Aswaraopet red soil pedon ranging from 42 to 70 and it was nearer to 100 per cent in the remaining pedons (Table3).

Soil classification

The information generated in field and laboratory studies helped in grouping these soils at family level according to *Soil Taxonomy* (Soil Survey Staff, 1999).

Shallow red soil pedon of Karimnagar keyed out as Entisol order, Psamment at suborder because of less than 35 per cent rock fragments and a texture of loamy sand in the particle size control section; Ustipsamments at great group because they have an ustic moisture regime. At subgroup level, the soils had been keyed out as Typic Ustipsamments. At family level, the mineralogy class is mixed.

Medium deep red soil in Malyal and deep red soil in Aswaraopet have an argillic horizon and hence, they keyed out as Alfisols. They were keyed out as Ustalfs suborder because of ustic soil moisture regime and Haplustalfs great group. At subgroup level, these two soils had been keyed out as Typic Haplustalfs. At family level, the particle size class is fine loamy. Mineralogy class is mixed.

Shallow black soil in Wyra and medium deep black soil in Madhira keyed out as Inceptisols as per key to soil orders. Since they have ustic moisture regime, they keyed out as Ustepts. Wyra pedon keyed out as Calciustept as it has a calcic horizon with its upper boundary with in 100 cm of the mineral soil surface. Madhira pedon keyed out as Haplustepts great group. Both soils were qualified for "Vertic" subgroup.

Deep black soil in Adilabad keyed out as a Vertisol. It is an Ustert because this Vertisol, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more with in 50 cm of the mineral soil surface, for 90 or more cumulative days per year. It could meet the requirements of Haplusterts great group and Typic subgroup.

Families are differentiated with in a subgroup primarily on the basis of properties important to the growth of plants. Properties used to differentiate families are particle size, mineralogy, reaction, soil temperature and a few others. The particle size class of Wyra pedon is clayey-skeletal as it have 35 per cent or more (by volume) rock fragments and for the remaining two black soil pedons is fine because the weighted average of clay content is less than 60 per cent in the fine earth fraction. The mineralogy classes are based on the less than 0.002 mm fraction, which is smectitic for the black soils.

The soil temperature class is isohyperthermic for all the studied soils as they have a difference of less than 5°C between mean summer temperature and mean winter temperatures at a depth of 50 cm and a mean annual soil temperature of 22°C or higher.

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