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Distribution and classification of some soils of Singarayakonda Mandal in Prakasam District of Andhra Pradesh

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Abstract

Seven representative pedons of Singarayakonda Mandal of prakasam district namely Singarayakonda, Pakala, Pataihgaripalem, Kalikivaya, Binginepalle, Old Singarayakonda and Modaguntapadu of Singarayakonda Mandal in Prakasam district of Andhra Pradesh were selected and studied. Based on the morphology and laboratory data, the soils were classified as per USDA Soil Taxonomy. Based on morphology, physical, physico-chemical and climatological data of the study area, pedon 1 and 6 were classified under Alfisols, pedon 2 and 4 under Vertisols, pedon 3 and 7 under Inceptisols and pedon 5 under Entisols.

Keywords: Pedons, Soil Taxonomy, Alfisols, Vertisols, Inceptisols and Entisols

Introduction

The systematic study of soil characteristics is the pre-requisite for complete exploitation of soil types by appropriate management practices. The clay mineralogical data is necessary for predicting physico-chemical behaviour of soils and for the management of sustainable agriculture. Soil health is also very much dependent on the nature and quality of minerals present in clay fractions. According to Buol *et al.* (1998) ^[1] understanding of soil genesis and classification is a pre-requisite for sound land use planning and land management. Systematic study of soils is important for better scientific utilization for agricultural production.

The present study is on the soils of Singarayakonda Mandal in Prakasam district of Andhra Pradesh which has both red and black soils. Singarayakonda Mandal of Prakasam district in Andhra Pradesh lies in between 16° 2' 30" to 17° 13' N latitude and 80° 51' 45" to 80° 10' E longitude with an altitude of 60 meters above mean sea level. It has a geographical area of 37, 510 acres. The soils of the mandal has got agricultural importance as these soils are under food, vegetable and commercial crops cultivation. Keeping in mind the agricultural potential of the soils of Singarayakonda and the lack of systematic studies of these soils the present investigation has been taken to classify these soils in a scientific manner with the specific objective.

Materials and Methods**A. Processing Soil Samples**

Soil samples were air-dried under shade and pounded with wooden hammer. They were passed through 2 mm sieve.

B. Physical Properties**1. Particle size analysis**

The particle size analysis was carried out by Bouyoucos Hydrometer method.

2. Soil density

Particle density was determined by specific gravity bottle method. Bulk density was determined by Clod method. For determining the density of sandy soils, Core sampler method was used (Jackson, 1973) ^[2].

3. Colour

Munsell's colour notation of hue, value and chroma were evaluated both for air dried and moist samples as per standard procedure.

4. Water holding capacity, pore space and volume expansion

These parameters were determined by following Keen Raczkwsk's method as described by standard procedure. Sticky point was determined by the method of Sowers as described by standard procedures.

5. Co-efficient of linear extensibility (COLE)

COLE is the ratio of the difference between the moist length and dry length of a clod to its dry length. It is $(L_m - L_d)/L_d$ where L_m is the length of moist clod and L_d is the length when dry (Keys to Soil Taxonomy, 1998) [12].

C. Chemical Properties

1. Soil reaction (pH)

pH of the soil samples was determined in 1:2 soil water suspension and 1:2 IN KC1 by using pH meter (Jackson, 1973) [2].

2. Electrical conductivity (EC)

The electrical conductivity was determined in 1:2 soil water suspension by using conductivity bridge (Jackson, 1973) [2].

3. Organic carbon

Organic carbon content of the soil samples was estimated by wet digestion method of Walkley and Black is rapid titration method as described by Jackson, 1973 [2].

4. Free calcium carbonate

The free calcium carbonate content was determined by rapid titration method as described by Piper (1966) [9].

5. Cation exchange capacity

Cation exchange capacity of the soils was estimated by saturating a known weight of the soil with IN sodium acetate solution (pH: 8.2). Excess sodium acetate was leached out by washing it with 95 per cent ethanol. The adsorbed sodium was displaced with IN neutral ammonium acetate (pH: 7.0) solution. The concentration of the sodium in the leachate was estimated by aspirating directly into the flame photometer the CEC was expressed as C mol (p+) kg^{-1} (Jackson, 1973) [2].

6. Exchangeable cations

The exchangeable cations Ca^{+2} , Mg^{+2} , Na , K^{+} were determined by extracting the soil with IN neutral ammonium acetate. Potassium and sodium were determined by aspirating the leachate directly into the flame photometer. The exchangeable calcium and magnesium were determined by Versenate method.

7. Available macro nutrients

A. Nitrogen was estimated by the alkaline permanganate method as described by Subbaiah and Asija (1956) [14]. Available phosphorus content in the soils was extracted by adding Olsen's reagent as described by Olsen *et al* (1954) [8]. The phosphorus in the extract was determined by Murphy and Diley method (using ascorbic acid as reducing agent) as described by Watanabe and Olsen (1965) [8] using spectrophotometer with red filter at 660 nm wavelength. Potassium in the soils was extracted by using neutral normal

ammonium acetate and estimated by aspirating the extract into the flame photometer (Jackson, 1973) [2]. Available sulphur in the soil sample was extracted with 0.15 per cent Calcium chloride solution as described by standard procedure. It was estimated by turbidimetric method.

8. Available micro nutrients

Twenty grams of soil was shaken with 40 ml of Diethylene triamine penta acidic acid (DTPA) extractant of pH 7.3 for 2 hours. The contents were filtered. In the available filtrate, zinc, copper, iron and manganese were determined in the titrate by using atomic absorption spectrophotometer. The results were expressed as parts per million (Lindsay and Norvell, 1978) [5].

Seven pedons were classified up to family level according to Keys to Soil Taxonomy (Soil Survey Staff, 1998) [12]. Clay fraction from soil samples of second horizon of each pedon was separated by following the procedure outlined by Jackson (1976) [3]. The X-ray diffraction analysis was carried out on Philips X-ray diffractometer PW 1140. Seven pedons were classified up to family level according to Keys to Soil Taxonomy (Soil Survey Staff, 1998) [12].

Results and Discussion

The climate of the study area was semi-arid monsoonic type with mean annual rainfall of 916.23 mm distinct summer, rainy and winter seasons (Figure 1). The details of the various pedons with different horizons are enlisted in table. 1. Black soils were formed on (pedons 2, 3 and 4) plain lands with granite-gneiss parent materials. Red soils (pedons 1, 6 and 7) were derived from gently sloping terrain on gneiss with ferruginous concretions as parent materials. Pedon 5 (sandy soil) was derived from low lying and marine deposits parent material. The soils were occurring in low lying, gently sloping and plain topography. The details of vegetation is presented in table 3. All the black soils were slightly alkaline to moderately alkaline and red soils acidic to moderately acidic in soil reaction. Sandy soils were almost neutral in reaction. All these soils were non-saline. All the black soils (pedons 2, 3 and 4) had shown low CaCO_3 content.

The cation exchange capacity was low in red soils, very low in sandy soil (pedon 5) and medium to high in black soils with higher per cent of base saturation. The exchangeable cations on the exchange complex were in the order of $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^+ > \text{K}^+$.

Chemical composition of the soils revealed that sandy soil were more siliceous. In case of black and red soils (pedons 1, 2, 3, 4, 6 and 7) a decreasing trend of silica was observed with depth in all the black and red soil pedons. Sandy soils had high amount of silica content than other soils.

The nutrient status of the soils showed low to medium nitrogen and phosphorus, deficient to sufficient in available sulphur and were well supplied with potassium. Regarding micro nutrients in black soils, zinc and iron were deficient in range, whereas copper and manganese were in sufficient range. In red soils, iron was sufficient and zinc was deficient and copper and manganese were sufficient. In sandy soil, deficiency in zinc and iron was observed while copper and manganese were sufficient in range. The results are depicted in table 4.

The results of the X-ray diffraction analysis of the clay fraction revealed that smectite was the dominant clay mineral in pedons 2, 3 and 4 (black soils). In pedons, 1, 6 and 7 (red soils), kaolinite was dominant. In case of sandy soils,

kaolinite was the dominant mineral followed by quartz and illite. The details of d spacing are presented in the table 2.

All the pedons were deep to very deep. ABC profile development was observed in black soil pedons of 2, 3 and 4 AC horizons were identified in black soil pedons (2 and 4) and sandy soil (pedon 5). Diagnostic (Bt) argillic horizon was identified in pedons 1, 6 and 7 and Bw horizon in pedons 3

and 7. Transitional horizon 'AB' was also identified in pedon 5.

Based on morphological features, physical properties and chemical properties, the soils of Singarayakonda Mandal of Prakasam district had been classified up to family level according to USDA Soil Taxonomy (Soil Survey Staff, 1998) [12].

Table 1: Details of the pedons of soil profiles of Singarayakonda mandal

Pedon No	Location	Horizon	Horizon thickness
1	Singarayakonda	Ap	0.00 - 0.09
		Ap2	0.09 - 0.25
		Bt ₁	0.25 - 0.42
		Bt ₂	0.42 - 0.69
		C	0.69-1.18
2	Pakala	Ap	0.00 - 0.06
		B	0.06 - 0.39
		Bssi	0.39 - 0.65
		Bss ₂	0.65 - 0.92
		Bss ₃	0.92-1.24
3	Potaiahgaripalem	AC	Below 1.24
		Ap	0.00 - 0.08
		B ₁	0.08 - 0.32
		B ₂	0.32 - 0.64
		Bwi	0.64 - 0.77
4	Kalikivayi	Bw ₂	0.77 -1.08
		C	Below 1.08
		Ap	0.00 - 0.11
		Bwi	0.11 - 0.24
		Bw ₂	0.24 - 0.52
5	Binganipalli	Bss ₁	0.52 - 0.87
		BSS ₂	0.87-1.32
		AC	Below 1.32
		Ap	0.00 - 0.09
		AB	0.09 - 0.34
6	Old Singarayakonda	c	0.34 - 0.69
		c ₂	0.69 - 0.94
		c ₃	0.94-1.36
		Ca	Below 1.36
		Ap	0.00 - 0.16
7	Mulaguntapadu	B	0.16 - 0.54
		Bt ₁	0.54 - 0.78
		Bt ₂	0.78 -1.02
		Bt ₃	1.02-1.27
		C	Below 1.27
		AP	0.00 - 0.11
		Bwi	0.11 - 0.35
		BW ₂	0.35 - 0.72
		Bt ₁	0.72-1.12
		C	Below 1.12

Table 2: d Spacing (Å) of X-RAY Diffractograms in clay fraction (< 2 micron fractions)

Pedon	Calcium saturated		Potassium saturated				Clay mineral
	Glycerol Solvated	Room temperature	Room temperature	110°C	300°C	550°C	
Pedon 1	10.04	10.04	9.61	9.61	10.04	10.04	Illite
	-	-	-	-	4.92	-	
	3.32	3.32	-	-	3.32	-	Kaolinite
	7.13	7.13	7.13	-	7.13	-	
	3.59	3.59	-	-	3.59	-	
Pedon 2	18.41	14.9	13.81	13.81	13.81	10.04	Smectite
	10.04	10.04	10.04	10.04	10.04	10.04	Illite
	4.92	4.92	4.92	-	4.92	-	
	3.32	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	3.53	3.53	-	-	3.53	-	
Pedon 3	18.41	15.78	13.81	13.81	13.81	10.04	Smectite
	10.04	10.04	10.04	10.04	10.04	10.04	Illite

	4.92	4.92	4.92	-	4.92	-	Kaolinite
	3.32	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	
	-	3.53	-	-	3.53	-	
Pedon 4	18.41	15.78	13.81	13.81	13.81	10.04	Smectite
	-	10.04	-	10.04	10.04	10.04	Illite
	-	4.92	-	-	4.92	-	
	3.37	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	-	-	-	-	3.56	-	Feldspars, Plagioclase, Feldspar
	3.14	3.14	-	-	-	-	
	3.05	-	-	-	-	-	
	6.91	-	-	-	-	-	
Pedon 5	10.04	10.04	10.04	10.04	10.04	10.04	Illite
	4.92	4.92	-	-	4.92	-	
	3.37	3.37	-	-	3.37	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	3.59	3.59	-	-	-	-	Quartz
	4.27	4.23	-	-	4.27	-	
Pedon 6	15.23	15.23	-	-	15.23	10.04	Smectite
	10.04	10.04	10.04	10.04	10.04	-	Illite
	4.92	4.92	-	-	4.92	-	
	3.32	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	3.59	3.59	-	-	3.59	-	
Pedon 7	10.04	10.04	10.04	10.04	10.04	10.04	Illite
	-	4.92	-	-	4.92	-	
	3.32	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	3.59	3.59	-	-	3.59	-	
	3.05	3.05	-	-	3.14	-	Feldspars

Table 3: Vegetation of the studied area:

Pedon	Location	Natural Vegetation	Land Use
1	Singarayakonda	Mango, Eucalyptus, etc.	Citrus, blackgram
2	Pakala	Acacia, Borassus spp.	Sorghum, cotton
3	Pataiahgaripalem	Acacia, Polmyrah spp.	Cotton
4	Kalikavayi	Gingelly, Subabul	Tobacco
5	Binganipalli	Acacia, Borassus spp.	Groundnut
6	Old Singarayakonda	Polmyrah, Subabul	Groundnut, mango
7	Mulaguntapadu	Neem, Mango	Groundnut

Table 4: Various physical and chemical properties of the studied area

Horizon	Depth (m)	N(mg kg ⁻¹)	P(mg kg ⁻¹)	K(mg kg ⁻¹)	S(mg kg ⁻¹)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Bulk density Mg m ⁻³	Particle density Mg m ⁻³	WHC %
Ap	0.00 - 0.09	129	14.2	225	17.6	0.52	1.86	21.00	27.60	1.41	2.43	31.35
Ap ₂	0.09 - 0.25	110	12.4	210	15.0	0.48	1.84	19.00	27.60	1.43	2.45	32.40
B _t	0.25 - 0.42	89	11.0	175	12.8	0.32	1.82	18.50	26.00	1.46	2.46	33.80
B _{t2}	0.42 - 0.69	81	8.9	160	11.4	0.56	1.71	15.60	24.50	1.48	2.48	34.02
C	0.69-1.18	67	6.0	150	10.6	0.51	1.62	14.00	20.00	1.50	2.45	33.25
2. Ap	0.00 - 0.06	145	20.5	291	24.5	0.92	3.94	9.50	20.60	1.29	2.55	46.00
B	0.06 - 0.39	131	20.0	287	20.0	0.98	2.20	8.00	20.20	1.35	2.51	49.50
B _{ss1}	0.39 - 0.65	110	14.4	285	17.5	1.60	3.92	7.50	21.60	1.36	2.56	52.60
B _{ss2}	0.65 - 0.92	96	10.6	223	12.6	1.66	2.16	6.70	20.00	1.41	2.60	56.40
B _{ss3}	0.92-1.24	79	8.3	201	15.6	0.94	2.40	6.60	20.00	1.48	2.52	57.65
AC	>1.24	70	5.9	196	11.9	0.91	2.06	5.90	20.80	1.54	2.58	60.75
3. Ap	0.00 - 0.08	151	22.0	301	23.5	0.88	2.32	18.00	23.20	1.32	2.60	50.00
B ₁	0.08 - 0.32	136	12.5	284	19.4	0.80	2.31	16.60	25.20	1.34	2.54	49.55
B ₂	0.32 - 0.64	112	15.6	240	16.8	0.74	2.38	16.50	21.20	1.41	2.60	52.66
B _{w1}	0.64 - 0.77	86	12.1	192	11.9	0.61	2.36	14.00	19.10	1.46	2.52	56.00
BW ₂	0.77-1.08	64	7.9	186	10.8	0.62	2.38	14.80	20.80	1.52	2.58	58.00
4. Ap	0.00-0.11	156	19.5	289	20.5	0.96	2.00	11.50	23.60	1.31	2.58	47.50
B _{w1}	0.11-0.24	139	17.1	251	21.0	1.08	2.38	10.10	21.00	1.36	2.54	51.00
B _{w2}	0.24 - 0.52	120	16.0	232	16.5	0.94	2.38	9.75	23.00	1.40	2.41	52.50
B _{ss1}	0.52 - 0.87	76	15.4	186	12.1	0.91	2.26	8.50	18.80	1.47	2.60	56.00
B _{ss2}	0.87-1.32	70	11.0	171	10.2	0.87	2.12	8.00	21.20	1.48	2.52	58.90
AC	1.32 +	64	6.5	140	9.6	0.88	2.17	7.60	21.00	1.50	2.57	59.75
5. Ap	0.00 - 0.09	101	5.7	171	6.4	0.54	1.41	2.76	17.40	1.49	2.56	18.75

AB	0.09 - 0.34	92	5.1	132	5.1	0.56	1.28	2.34	17.60	1.52	2.49	18.15
C ₁	0.34 - 0.69	67	4.2	119	4.2	0.36	1.70	2.30	15.60	1.54	2.62	17.25
C ₂	0.69 - 0.94	51	4.6	112	3.1	0.34	1.62	2.15	16.25	1.63	2.60	16.45
C ₃	0.94-1.36	40	3.1	99	2.8	0.29	1.31	2.00	15.80	1.60	2.59	15.25
C ₄	1.36 +	36	2.9	89	2.1	0.38	1.04	2.00	14.00	1.61	2.57	14.75
6. Ap	0.00 - 0.16	121	15.0	240	18.0	0.56	2.68	21.00	22.60	1.42	2.44	30.13
B	0.16 - 0.54	103	13.4	225	14.0	0.58	2.06	20.00	22.20	1.44	2.49	31.05
B _{t1}	0.54 - 0.78	72	12.0	182	15.0	0.56	1.74	19.50	21.80	1.47	2.50	32.90
B _{t2}	0.78 - 1.02	65	10.6	171	11.6	0.49	1.62	17.50	22.40	1.51	2.53	33.70
B _{t3}	1.02-1.27	60	8.2	162	8.9	0.41	1.74	13.00	20.20	1.49	2.50	33.95
c ₁	1.27 +	56	7.1	149	7.2	0.38	1.61	11.50	20.00	1.47	2.48	32.70
7. Ap	0.00 - 0.11	130	14.7	247	17.9	0.47	1.10	19.00	20.20	1.37	2.52	30.75
Bw₁	0.11 - 0.35	119	13.0	210	15.2	0.44	1.28	16.50	17.20	1.43	2.50	31.62
Bw₂	0.35 - 0.72	102	12.6	192	13.1	0.42	1.54	14.00	16.40	1.46	2.53	27.05
B _{t1}	0.72-1.12	86	10.5	171	10.5	0.41	1.80	13.00	19.80	1.50	2.54	30.04
C	> 1.12	61	8.6	154	8.2	0.39	1.71	11.00	17.20	1.51	2.51	32.51

Fig 1: Ombrothermic diagram of studied area (Singarayakonda)

A. Pedon 1 and 6

Pedon 1 and 6 showed the sub-surface argillic horizons. The argillic horizon was identified by the presence of following features:

1. Order level

Sandy clay loam to sandy clay texture. The clay content was greater than 1.2 times in the finer earth fraction than in the surface horizon. Thickness of the horizon was more than 7.5 cm. Argillans (clay cutans) were also present formed due to the illuviation of the clay from the surface horizon.

The base saturation was more than 35 per cent throughout the thickness.

Based on the presence of argillic horizon in sub-surface, pedons 1 and 6 were qualified under Alfisols.

2. Sub-order level

The pedoclimate was Ustic moisture regime. Mean annual air temperature was more than 22 °C and soil was dry for more than 90 cumulative days. Hence classified as "Ustalfs".

Madhusudhana Rao (1993)^[6], Manjulatha (1999)^[7] classified the red soils of Prakasam district of Andhra Pradesh, Chebrolu Mandal in Guntur district of Andhra Pradesh as Ustalfs respectively.

3. Great group level:

Pedon 1 exhibited a hue of 2.5 YR, dry value no more than 2 unit higher than the moist. Hence it was grouped under "Haplustalfs".

Pedon 6 exhibited a hue of 2.5 YR, dry value no more than 1 unit higher than the moist, a colour value moist 3 in argillic horizon. Hence it was grouped under Rhodustalfs.

4. Sub-group level

The following observations were made at the sub-group level:

1. There was no lithic contact.
2. Udic moisture conditions were also not noticed.
3. Hence grouped under "Typic Haplustalfs", "Typic Rhodustalfs" respectively.

5. Family level

1. More than 30 per cent clay content on weighted average in fine earth fraction, hence placed under "loamy" particle size class.
2. Dominant in kaolinite clay mineral and qualified for "kaolinitic" clay mineralogy class at family level.

B. Classification of Pedons 2 and 4

1. Order level

Pedons exhibited the following features:

1. Depth of the pedons extended to more than 1 m.
2. Cracks that are opened and closed periodically.
3. Slickensides are present in deeper layers.
4. More than 30 per cent clay in fine earth fraction of all the horizons.

Based on the above features, these pedons were classified under order "Vertisols".

2. Sub order level

1. These soils exhibited cracks of 5 mm or more wide extending up to 40 cm or more within 50 cm of the mineral soil surface for 90 or more cumulative days per year.
2. The mean annual soil temperature (MAST) of the study area was greater than 22 °C Based on these features, they were classified under "Usterts".

3. Great group level

1. The EC was less than 4 dSm⁻¹ in all horizons.
2. Absence of salic, gypsic, calcic horizons.

Hence classified as Haplusterts at great group level.

Based on the similar features, Walia and Rao (1997)^[17] and Singh *et al.* (1998)^[11] classified the black soils of trans Yamuna plain and alluvial soils of Bihar as Haplusterts respectively.

4. Sub-group level

Pedon 2 showed the following features.

1. Chroma of 3 or 4 in all the horizons and less than 15 ESP.
2. 1 - 2 cm cracks in normal years up to 50 cm depth for less than 150 cumulative days per year. Hence qualified for "Chromic Udic Haplusterts". Based on the similar features, Thakur *et al.* (1998)^[15] classified the Vertisols of central India.

The pedon 4 fulfilled all the conditions mentioned above except in colour value. Therefore it was placed under "Udic Haplusterts" at sub-group level.

5. Order level

The B horizon of this pedon was recognised as cambic horizon and had shown the following features.

1. Texture was finer than very fine sand or loamy very fine sand.
2. No rock structure.
3. No argillic, kandic, oxic and spodic horizons.
4. Absence of cementation.
5. Regular decrease in the amount of organic carbon with depth.
6. Higher clay content than the overlying horizons.

The presence of cambic horizon in these two pedons was recognised by the above features. Hence these two pedons were keyed out as "Inceptisols" at order level. Walia and Rao (1996)^[16] also observed similar type of features in black soils of Arunachal hills and keyed out as Inceptisols at order level.

6. Sub-order level

These soils had Ustic soil moisture regime, hence qualified as "Ustept" at this category.

7. Great group level

As these pedons were not having the features of either duripan or calcic horizon and base saturation was more than 60 per cent in all the horizons. These characters indicated that the pedons represented central concept of Ustepts. So they were grouped as "Haplustepts" at great group level.

8. Sub-group level

Pedon 3 had vertic features like COLE cracks 2-4 mm wide to 35 cm deep and indistinct slickensides in lower horizons. Because of the presence of these vertic characters this pedon was classified as "Vertic Haplustept".

Pedon 7 was further classified as "Typic Haplustept" at sub-group level, because of ISO-hyperthermic soil temperature regime and of a moisture control section which was dry for more than 120 cumulative days per year. Similar type of results observed in Jagannadham *et al.* (1994)^[4].

C. Classification of Pedon 5

1. Order level

1. Soils are of recent origin.
2. Weakly developed profiles.
3. Based on the above features, the pedon 5 was classified as "Entisol" at order level.

2. Sub-order level

1. They had sandy texture in all horizons.
2. They did not have any diagnostic horizons.
3. They were not permanently saturated with water.

Hence the pedon was keyed out as "Psamments" at sub-order level. Ramalakshmi (1999)^[10] classified the sandy soils of Guntur district of Andhra Pradesh in the same manner.

3. Great group level

This pedon had no aridic, xeric and udic moisture regimes, but had ustic moisture regime. Hence, were placed under "Ustipsamments" at great group level. Sidhu *et al.* (1998)^[13] classified the sandy soils of Punjab, West Bengal and Aravali hills as Ustipsamments.

4. Sub-group level

Pedon 5 was saturated with water for short period within 100 cm of the mineral soil surface in normal year. So these are classified under "Oxyaquic" subgroup of "Ustipsamments".

D. Classification of Pedons at Family Level

These black soil pedons had clay textural class with more than 35 per cent and less than 50 per cent clay content in the control section, hence the particle size class was fine. Red soils (pedons 1, 6 and 7) had sandy clay textural class with more than 30 per cent and 40 per cent clay content in the control section, hence the particle size class was loamy. Sandy soil (pedon 5) had high sand content. So the particle size class was sandy. Smectite was the dominant clay mineral in the clay fraction of black soils. So, the clay mineralogical class at family level was "smectitic". In red soils kaolinite was the dominant clay mineral in the clay fraction. So the clay mineralogical class at family was "kaolinitic". The mineralogical class of sandy soil was "Siliceous" because of more content of sand fraction and siliceous nature of the soil. (15.02%). The detailed classification of pedons are mentioned in table.5.

Soil Survey Staff (1998)^[12] recognized June, July and August as summer months and December, January and February as winter months for the places in northern hemisphere. As per these criteria the difference between mean summer and winter temperatures was less than 6°C and mean annual temperature was more than 22°C. Therefore, the study area was classified as Iso-hyperthermic soil temperature regime.

Classification of pedons up to family level.

1. Pedon 1: Loamy, kaolinitic, iso-hyperthermic, Typic Haplustalf.
2. Pedon 2: Fine, smectitic, iso-hyperthermic, Chromic Udic Haplustert.
3. Pedon 3: Fine, smectitic, iso-hyperthermic, Vertic Haplustept.
4. Pedon 4: Fine, smectitic, iso-hyperthermic, Udic Haplustert.
5. Pedon 5: Sandy, siliceous, iso-hyperthermic, Oxyaquic Ustipsamment.
6. Pedon 6: Loamy, kaolinitic, iso-hyperthermic, Typic Rhodustalf.
7. Pedon 7: Loamy, kaolinitic, iso-hyperthermic, Typic Haplustalf.

Table 5: Soil Classification of studied area

Pedon No.	Order	Sub-order	Great group	Sub-group	Family
1	Alfisol	Ustalf	Haplustalf	Typic Haplustalf	Loamy, kaolinitic, iso-hyperthermic, Typic Haplustalf
2	Vertisol	Ustert	Haplustert	Chromic Haplustert	Fine, smectitic, iso-hyperthermic, Chromic Haplustert
3	Inceptisol	Ustept	Haplustept	Vertic Haplustept	Fine, smectitic, iso-hyperthermic, Vertic Haplustept
4	Vertisol	Ustert	Haplustert	Udic Haplustert	Fine, smectitic, iso-hyperthermic, Udic Haplustert
5	Entisol	Psamment	Ustic Psamment	Acquic Ustic Psamment	Sandy, siliceous, iso-hyperthermic, Acquic Ustic Psamment
6	Alfisol	Ustalf	Rhodustalf	Typic Rhodustalf	Loamy, kaolinitic, iso-hyperthermic, Typic Rhodustalf
7	Inceptisol	Ustept	Haplustept	Typic Haplustept	Loamy, kaolinitic, iso-hyperthermic, Typic Haplustept

Conclusion

Based on morphology, physical, physico-chemical and climatological data of the study area, pedon 1 and 6 were classified under Alfisols, pedon 2 and 4 under Vertisols, pedon 3 and 7 under Inceptisols and pedon 5 under Entisols.

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