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Characterization and classification of red soils from Hasegaonwadi of Latur district

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Abstract
The investigation entitled "Characterization and classification of red soils for land use planning from Hasegaonwadi of Latur district" was conducted during the year 2018-2019. The study area is located in Hasegaonwadi village in Ausa tahsil of Latur district situated at 18^0 16' 51" N latitude and 76^0 37' 31" E longitudes. The study area was surveyed and four soil profiles and forty surface soil samples (0-30cm) were collected for laboratory analysis. The soils of Hasegaonwadi were shallow to moderately deep (53 to 85 cm), dark reddish brown (5 YR 3/4) to reddish brown (5YR 4/4) in colour, granular to sub-angular blocky in structure, sandy clay in texture. The saturated hydraulic conductivity of these soils varied from 17.23 to 49.16 cm hr^{-1}. These soils were neutral to moderately alkaline in reaction (6.76 to 8.17). The electrical conductivity of these soils was < 1.0 dSm^{-1}. The organic carbon content was low to moderate and varied from 0.22 to 0.94 per cent. The calcium carbonate content varied from 6.8 to 13.8 per cent indicated that these soils were calcareous in nature. The CEC varied from 13.10 to 40.36 cmol(p^+)kg^{-1}. Calcium was the dominated cation followed by magnesium, sodium and potassium in all profiles. The base saturation per cent varied from 81.68 to 96.42 per cent. These soils belongs to two soil orders viz. Entisols and Inceptisols and at subgroup level classified as Typic Ustorthents and Typic Haplustepts, respectively.

Keywords: Characterization, classification, soil profile, soil order, soil colour, texture

Introduction
Red soil develops in a warm, temperate, moist climate under deciduous or mixed forest, having thin organic and organic-mineral layers overlying a yellowish-brown leached layer resting on an illuvium red layer. Red soils are generally derived from crystalline rock. They are usually poor growing soils, low in nutrients and humus and difficult to cultivate because of its low water holding capacity. Their colour is mainly due to ferric oxides occurring as thin coatings on the soil particles while the iron oxide occurs as haematite or as hydrous ferric oxide, the color is red and when it occurs in the hydrate form as limonite the soil gets a yellow colour. The texture of red soil varies from, sand to clay, the majority being loam. Their other characteristics include porous and friable structure, absence of lime, kankar and free carbonates, and small quantity of soluble salts.

Material and methods
Study Area
The study area of Hasegaonwadi is situated at 18^0 16' 51" N latitude and 76^0 37' 31" E longitudes. It is 25 km away from the Latur city and 18 km away from Ausa which is tahsil of Hasegaonwadi. Total Geographical area of Hasegaonwadi is 1016 ha. The area include red soil hill and its adjoining area having also red colour soils.

Soil Characteristics
The area is covered by the basaltic lava-flows. Same layer of the lava-flow are hard and compact while other are soft. These basalt flows are the result of intense volcanic activity during Cretaceous Eocene period (almost seventy million year ago). When the lava flows were ejected through long narrow fissures on the earth surface. This area has shallow cover of gravelly sediments over a hard basaltic contact within 50 cm of the surface.

Climate

The study area is characterized by hot, dry and arid climate. It has uneven distribution of rains during the monsoon season. The annual rainfall of 794 mm at which nearly 85 per cent is received during June to September. The mean maximum and minimum temperature are 32.12 ^{0}C and 19.69 ^{0}C respectively. April and May have high temperature (37.80 ^{0}C and 39.82 ^{0}C mean temperature), December and January coolest month (12.06 ^{0}C and 13.54 ^{0}C mean temperature). The length of growing period 149 days and humid period were 104 days. The soils has Ustic moisture regime and Hyperthermic temperature regime.

Land use and natural vegetation

The study area is under natural tress viz. Babul, Pimpal and Fruit tress viz. Tamarind (*Tamarindus indica*), Ber (*Zizyphus jujube*), Mango (*Mangifera indica*), Custard apple (*Annona reticulate*). Field bunds and banks of nalas are covered under dry deciduous plant species and grasses. Other commonly occurring crops are Pigeon pea (*Cajanus cajan*), Gram (*Cicer ariantinum*), Sorghum (*Sorghum bicolar*), Soybean (*Glycine max),* Congress Grass (*Parthenium hysterophorus*), Kans (*Succharum spontaneum*).

Analysis of samples

The soil samples were collected during summer, air dried in laboratory at room temperature, grinded using wooden mortar and pestle and sieved through 2 mm sieve, properly labeled and stored in polythene bags for the determination of soil reaction, organic matter, macronutrients and micronutrients content by adopting standard laboratory methods.

Morphological properties of soils were studied in the field and profile description was done as per the procedure suggested by USDA and Soil Survey Staff (1975). The analysis of particle size distribution was carried out as per the International pipette method (Jackson, 1979). Hydraulic conductivity is estimated by disturbed soil samples were fully saturated and then leached with deionized water and hydraulic conductivity of soil was determined by constant head method as described by Richard (1954) [8]. pH of 1:2.5 Soil: water suspension was determined electrometrically using pH meter as per method described by Jackson (1979). Electrical conductivity is determined by 1:2.5 soil: water suspension as per the method described by Jackson (1979). The calcium carbonate was estimated by rapid titration method as described by Piper (1950) [7]. Modified Walkley and Black's method was followed for estimation of organic carbon content in soil. (Jackson, 1979). The exchangeable cations and cation exchange capacity of soils were determined using methods outlined by Richards (1954) [8]. The Soils were classified according to U.S. comprehensive system of soil classification (Soil Survey Staff 2006) [11].

Results and discussion

Soil site characteristics

Soil site characteristics such as location, landform, slope and erosion were also studied and recorded (Table 1).

Table 1: Soils sites characteristics of Hasegaonwadi of Latur district

Location	Land form	Parent Material	Slope (%)	Runoff	Drainage	Erosion
Pedon 1 Hasegaonwadi	Moderately sloping	Weathered basalt	3-5	Medium	Well drained	Moderate
Pedon 2 Hasegaonwadi	Moderately sloping	Weathered basalt	3-5	Medium	Well drained	Moderate
Pedon 3 Hasegaonwadi	Moderately sloping	Weathered basalt	3-5	Medium	Well drained	Moderate
Pedon 4 Hasegaonwadi	Nearly level plain	Weathered basalt	1-3	Medium	Well drained	Moderate

Morphological properties

The morphological characteristics of different pedons studied during present investigation and presented in table 2. Soil morphology is the study of soil and their characteristics under field condition. Soils are studied only in the field and can be best evaluated in situ examination of soil profile. However, in laboratory soil samples were analyzed for further interpretation. Soil description is based on classifying soil in defined categories in the profile. Various soil horizons were studied. Each horizon was observed and describe in respect of various characteristics such as depth, color, texture, consistency etc.

The morphological characteristics of red soils of Hasegaonwadi of Latur district showed that soil depth in Typic Ustorthents (P1, P2, and P4) was shallow to moderately deep (53-70 cm) and moderately deep (85 cm) in Typic Haplustepts. This variation in soil depth might be due to the land form setting (Vadivelu, 1983) [14]. The soils of the study area had colours in the hue ranging from 5 YR, values ranging from 3 to 5 and chroma of 2 to 4. The low chroma indicates poor drainage of the soils and the dark colour of the soils may be due to high dark coloured ferromagnesian minerals, most surface soils of the study area were dark reddish brown (5YR 3/4) to reddish brown (5YR 4/4) in colour. The pedon P1, P2 and P4 (Typic Ustorthents) soils colour varied from dark reddish brown (5 YR 3/4) to reddish brown (5YR 4/4). The pedon P3 (Typic Haplustepts) soils colour varied from dark reddish brown (5 YR 3/4) to very dark grayish brown (10YR 3/2) in colour. Soil structure in Typic Ustorthents (P1, P2 and P4) was medium weak granular structure and in Typic Haplustepts (P3) soils structure varied from medium weak granular to fine weak sub-angular blocky soils structure. Soil consistency from table 2 shows that in pedon P1, P2 and P4 (Typic Ustorthents) the soil consistency was non-sticky and non-plastic in wet condition. The pedon P3 (Typic Haplustepts) soil consistency was varied from loose in dry condition, friable in moist condition, non-sticky, non-plastic in wet condition to hard in dry condition, friable in moist condition, very-sticky, very-plastic in wet condition. The soil consistency closely associated with proportion of sand, silt and clay in soil.

Table 2: Morphological properties of Hasegaonwadi of Latur district.

Horizon	Depth (cm)	Boundary	Matrix Colour	Texture	Structure	Consistency	Pores	Roots	Effervescence
Pedon 1: Hasegaonwadi of Latur district. (Typic Ustorthents)									
Ap	0-11	cs	5YR 3/4	s	m 1 gr	1,fr,nsnp	fm,cm	vfm,fm	e
Ac	11-22	cs	5YR 3/4	s	m 1 gr	1,fr,nsnp	fm,cm	vfm,fm	e
Cr	22-65	-	5YR 3/4	s	m 1 gr	1,fr,nsnp	fm,cm	fm,cf	e
Pedon 2: Hasegaonwadi of Latur district. (Typic Ustorthents)									
Ap	0-10	cs	5YR 3/4	s	m 1 gr	1,fr,nsnp	fm,cm	vfm,fm	e
Ac	10-16	cs	5YR 3/4	s	m 1 gr	1,fr,nsnp	fm,cm	vfm,fm	e
Cr	16-53	-	5YR 3/4	s	m 1 gr	1,fr,nsnp	fm,cm	fm,cf	e
Pedon 3: Hasegaonwadi of Latur district. (Typic Haplustepts)									
Ap	0-18	cs	5YR 4/4	s	m 1 gr	1,fr,nsnp	fm,cm	vfm,fm	e
Ac	18-40	cs	5YR 3/4	s	m 1 gr	1,fr,nsnp	fm,cm	vfm,fm	e
Bw1	40-70	cs	10YR 3/2	cl	f 1 sbk	h,fr,vsvp	vfm,fm	vfm,fm	es
Cr	70-85	-	5YR 4/4	s	m 1 gr	1,fr,nsnp	fm,cm	fm,cm	e
Pedon 4: Hasegaonwadi of Latur district. (Typic Ustorthents)									
Ap	0-18	cs	5YR 4/4	s	m 1 gr	1,fr,nsnp	fm,cm	vfm,fm	e
Ac	18-40	cs	5YR 4/4	s	m 1 gr	1,fr,nsnp	fm,cm	vfm,fm	e
Cr	40-70	-	5YR 5/3	s	m 1 gr	1,fr,nsnp	-	-	e

Physical properties

The coarse fragments of the soils in Typic Ustorthents (P1, P2 and P4) ranged from 9.91 to 42.23 per cent, followed by Typic Haplustepts (P3) was 14.63 to 22.55 per cent. Therefore, it was obvious that the presence of coarse fragments were related with topographic situation. The maximum coarse fragments were noticed in C horizon. The variation in soil separates may be due to soil development on different physiographic units and its parent material (Murthy *et al.* 1994) [4]. The saturated hydraulic conductivity of soils of the study area varied from 17.23 to 49.16 cm hr^{-1}. This variation attributed to textural difference. The saturated hydraulic conductivity of Typic Ustorthents (P1, P2 and P4) was ranged from 29.56 to 49.16 cm hr^{-1}, and in Typic Haplustepts (P3) varied from 17.23 to 41.76 cm hr^{-1}. The hydraulic conductivity of surface horizon (Ap) was less as compared to sub surfaces. This variation may be attributed to high amount of clay content in surface soil as compared to murrum layer in subsurface soil, similar observations were also reported by Vaidya *et al.* (2013) [15] and Pawar *et al.* (2015) [6]. The particle size distribution analysis indicates the general picture of physical nature of soil. The particle size distribution analysis indicates the general picture of physical nature of soil. The particle size distribution related directly or indirectly to plant growth and provides understanding in respect of soil water retention, nutrient retention and their availability, workability, drainage condition and crop suitability. From the data on particle size distribution (Table 3) it was observed that the texture surface soil samples in the study area were sandy in nature. The highest sand content was found in the pedon 1 (48.48 per cent). The sand particles of Typic Ustorthents (P1, P2 and P4) varied from 35.43 to 48.48 per cent and in Typic Haplustepts varied from 17.88 to 39.71 percent. The highest clay content was recorded in the pedon 3 (32.69 per cent), this may be attributed due to land scape. In soils of Typic Ustortents (P1, P2 and P4) clay content ranged between 23.29 to 29.91 per cent and in Typic Haplustepts (P3) it was ranged between 18.29 to 32.69 per cent. The data showed that soil developed on lower topographic position showed higher clay content as compared to soil developed on higher topographic position. Satyavathi and Reddy (2003) [9] recorded similar results and reported that the topography and slope of the land affect the particle size distribution of soil.

Table 3: Physical properties of Hasegaonwadi of Latur district.

Horizons	Depth (cm)	Coarse Fragment (%)	HC (cm hr^{-1})	Particle size analysis (%)		
				Sand	Silt	Clay
Pedon 1: Hasegaonwadi of Latur district. (Typic Ustorthents)						
Ap	0-11	24.84	31.04	40.87	31.05	27.18
Ac	11-22	41.19	41.76	42.47	30.91	25.62
Cr	22-65	42.23	46.04	48.48	27.23	23.29
Pedon 2: Hasegaonwadi of Latur district. (Typic Ustorthents)						
Ap	0-10	12.63	35.42	38.94	31.38	29.03
Ac	10-16	14.93	44.82	42.14	29.19	27.82
Cr	16-53	34.66	49.16	44.01	27.75	27.29
Pedon 3: Hasegaonwadi of Latur district. (Typic Haplustepts)						
Ap	0-18	18.65	17.23	17.88	48.53	32.69
Ac	18-40	21.87	25.49	26.14	46.15	26.71
Bw1	40-70	14.63	27.42	33.70	43.22	22.43
Cr	70-85	22.55	41.76	39.71	41.20	18.29
Pedon 4: Hasegaonwadi of Latur district. (Typic Ustorthents)						
Ap	0-18	15.33	29.56	35.43	33.56	29.91
Ac	18-40	15.51	37.12	39.99	30.83	28.43
Cr	40-70	9.91	44.82	42.24	28.87	27.89

Chemical properties

The pH data presented in the table 4 indicated that the soils of Hasegaonwadi were neutral to moderately alkaline in reaction (6.76 to 8.17). In Typic Ustorthents (P1, P2 and P4) values varied from 6.83 to 8.17 and in Typic Haplustepts (P3) it was varied from 6.76 to 7.56. The data shows that pH of these soils decreased with increasing depth of soils. The pH of soil was decreased with increasing altitude. (Pachpor *et al.* (2012) [5] and Gautam *et al.* (2018) [2]. The data regarding electrical conductivity of soils from Hasegaonwadi was represented in table 4 and indicated that the Electrical conductivity of the studied soil varied from 0.13 to 0.28 dSm^{-1}, which was well within safe limit of electrical conductivity range, designated for normal soil (Richards, 1954) [8] and all soils comes under non-saline class. The organic carbon content of Typic Ustorthents (P1, P2 and P4) varied from 0.22 to 0.79 per cent and in Typic Haplustepts (P3) varied from 0.37 to 0.94 per cent. Soils were low to moderate in organic carbon content. The organic carbon content was low in murrum layer as compared to the overlying horizons. The low organic matter content in lower layers of soil was attributed due to the prevalence of tropical condition, where the degradation of organic matter occurs at faster rate coupled with low vegetation cover, thereby leaving less organic carbon in soil (Sireesha and Naidu, (2013) [10]. The data on calcium carbonate content in soils of Hasegaonwadi are represented in table 4 and indicated that the calcium carbonate content in soils of Typic Ustorthents (P1, P2 and P4) were varied from 6.8 to 13.8 percent and in Typic Haplustepts (P3) it varied from 7.2 to 10.8 percent. The high calcium carbonate in soil affects the available water capacity of soil which has a great influence on crop production under rainfed conditions. High calcium carbonate affects the physical and chemical properties of soil and may prevent the root penetration (Sys, 1985). Cation exchange capacity of soil indicated that the cation exchange capacity of Typic Ustorthents (P1, P2 and P4) ranged from 13.10 to 34.91 $cmol(P^+)\ kg^{-1}$, and in Typic Haplustepts (P3) ranged from 22.51 to 40.36 $cmol(p^+)\ kg^{-1}$. The CEC values indicated that the black soils were less weathered than the red soils. Higher CEC values indicates the less weathered nature of the soils with weatherable primary minerals (Buol *et al.* (1998) [1] and Satyavathi and Reddy (2003) [9]. The data on exchangeable bases (Table 4) indicated that the exchangeable sites had dominance of calcium followed by magnesium, sodium and potassium in all profiles. In Typic Ustorthents (P1, P2 and P4) Ca++ ranged from 9.2 to 29.2 $cmol(p^+)\ kg^{-1}$, Mg++ ranged from 1.2 to 3.7 $cmol(p^+)\ kg^{-1}$, Na+ ranged from 0.17 to 0.60 $cmol(p^+)\ kg^{-1}$ while K+ ranged from 0.13 to 0.27 $cmol(p^+)\ kg^{-1}$. In Typic Haplustepts (P3) the exchangeable Ca++ ranged from 15.6 to 33.6 $cmol(p^+)\ kg^{-1}$ while Mg++ ranged from 2.7 to 3.6 $cmol(p^+)\ kg^{-1}$, Na+ ranged from 0.43 to 0.63 $cmol(p^+)\ kg^{-1}$, and K+ ranged from 0.15 to 0.24 $cmol(p^+)\ kg^{-1}$. In general these soils were saturated with bases especially calcium and magnesium. The data represented in table 4.4 indicated that the soil exhibit narrow variation in percent base saturation among themselves. Base saturation in Typic Ustorthents (P1, P2 and P4) varied from 81.68 to 96.42 percent, and in Typic Haplustepts it varied from 85.20 to 95.54 per cent. The high base saturation of both soil and murrum was attributed to basaltic parent material, which is basic in nature and presence of free lime.

Table 4: Chemical properties of Hasegaonwadi of Latur district.

Horizons	Depth (cm)	pH	EC(dSm^{-1})	O.C (%)	$CaCO_3$ (%)	CEC (Cmol kg^{-1})	Cations ($cmol(P^+)kg^{-1}$)					Base Saturation (%)
							Ca++	Mg++	Na^+	K+	Sum of Cations	
Pedon 1: Hasegaonwadi of Latur District. (Typic Ustorthents)												
Ap	0-11	6.98	0.20	0.58	13.8	19.59	12.4	3.2	0.22	0.23	16.05	81.92
Ac	11-22	6.89	0.26	0.27	11.2	17.18	11.2	3.6	0.24	0.15	15.19	88.41
Cr	22-65	6.83	0.13	0.22	11.8	17.02	11.6	2.8	0.31	0.14	14.85	87.25
Pedon 2: Hasegaonwadi of Latur District. (Typic Ustorthents)												
Ap	0-10	7.21	0.23	0.79	10.8	18.32	12	2.8	0.22	0.27	15.29	83.46
Ac	10-16	7.05	0.20	0.64	12.4	16.25	12	1.6	0.25	0.18	14.03	86.34
Cr	16-53	6.89	0.17	0.58	8.0	13.10	9.2	1.2	0.17	0.13	10.70	81.68
Pedon 3: Hasegaonwadi of Latur District. (Typic Haplustepts)												
Ap	0-18	7.56	0.24	0.94	7.2	40.36	33.6	3.6	0.43	0.24	37.87	93.83
Ac	18-40	7.11	0.26	0.67	7.8	29.14	23.6	3.6	0.44	0.20	27.84	95.54
Bw1	40-70	6.90	0.19	0.57	8.8	24.43	17.6	2.8	0.55	0.18	21.13	86.49
Cr	70-85	6.76	0.27	0.37	10.8	22.51	15.7	2.7	0.63	0.15	19.18	85.20
Pedon 4: Hasegaonwadi of Latur District. (Typic Ustorthents)												
Ap	0-18	8.17	0.28	0.49	7.8	34.91	29.2	3.7	0.44	0.18	33.52	96.01
Ac	18-40	7.92	0.25	0.42	6.8	26.43	21.2	3.2	0.48	0.15	25.03	94.70
Cr	40-70	7.83	0.21	0.31	7.2	26.89	21.6	3.6	0.60	0.13	25.93	96.42

Soil classification

Based on field morphology and laboratory characterization the soils on various landforms have been classified according to U.S. comprehensive system of soil classification (Soil Survey Staff 2006 and 2014) [11]. The dominant soils of the study area belonging to two order *viz.* Entisols and Inceptisols (Table 5).

Table 5: Classification of soils from Hasegaonwadi of Latur district

Sr. No.	Order	Sub- order	Great group	Subgroup	Family
1.	Entisols	Orthents	Ustorthents	Typic Ustorthents	Montmorilonitic, hyperthermic
2.	Entisols	Orthents	Ustorthents	Typic Ustorthents	Montmorilonitic, hyperthermic
3.	Inceptisols	Ustepts	Haplustepts	Typic Haplustepts	Clay, Montmorilonitic, hyperthermic
4.	Entisols	Orthents	Ustorthents	Typic Ustorthents	Montmorilonitic, hyperthermic

Conclusions

The study of characterization and classification of red soils from Hasegoanwadi of Latur district reveled that these soils were shallow to moderately deep (53-85 cm), sandy clay in texture and granular to sub angular blocky in structure. The course fragment of the soil varied from 9.91 to 42.23 per cent. The saturated hydraulic conductivity of the study area varied from 17.23 to 49.16 cm hr^{-1}. These soils were neutral to moderately alkaline in nature (pH 6.76 to 8.17), electrical conductivity of these soils was < 1.0 dsm^{-1}. The organic carbon content of studied soil was low to moderate (0.22 to 0.94 per cent). The calcium carbonate content was varied from 6.8 to 13.8 per cent. The cation exchange capacity was ranged from 13.10 to 40.36 cmol(P^{+}) kg-1 and the base saturation per cent varied from 81.68 to 96.42 per cent. Taxonomically these soils were classified into Entisols and Inceptisols and at subgroup level they were classified as Typic Ustorthents and Typic Haplustepts, respectively.

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