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Characterization and Classification of different Soil Type of Gariyaband District of Chhattisgarh

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ABSTRACT

A study was carried out during 2014-15 on soil characterization and classification of Gariyaband district of Chhattisgarh. The objectives of the study were to characterize the major soil types of the district. Three soil profiles were identified, excavated, described and sampled for morphological, physical and chemical properties and were classified in to three different soil- groups. Pedon-1 indicated the presence of cambic B horizons and placed in *Inceptisols*, pedon-2 showed argillic horizons keyed out in *Alfisols* and pedon-3 was classed in *Vertisols* soil order due to the presence of wide cracks, slicken sides and high clay content. All the pedons belonged to *Ustepts* suborder since they had *Ustic* soil moisture regime. The horizons were simple and no calcic orgypsic or duripan were observed, they were placed in *Haplustepts* Great Group. All the pedons represented the central concepts of great group and hence classified as Typic *Haplustepts* at subgroup level. Based on the different properties the soils were classified as for pedon -1 as Fine sand clay loamy, kaolinitic hyperthermic, *Typic Haplustepts*, pedon-2 as Fine clay loamy, kaolinitic mixed hyperthermic, *Typic Haplustalfs* and pedon-3 as Fine clay, Montmorillonitic mixed hyperthermic, *Typic Haplusterts*.

Keywords

Characterization, Classification, Soil Profile study, Soil type

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Introduction

Soil is the uppermost layer of variable depth of the earth consisting of loose material, which is the main support for natural vegetation and other life forms of our planet. Soil is an independent dynamic body of nature that acquires properties in accordance with the forces which act upon it. The important soil forming factors such as parent material,

climate, relief, organism and time have direct impact on soil properties. The soil forming processes as oxidation, reduction, eluviations and illuviation are related to soil solution and further on stages of soil development (Tamgadge *et al.*, 2002). Soil profile characteristics as conditioned by different processes and factors of soil formation have great influence on fertility of soil and productivity of land. Therefore an

understanding of morphology and physico-chemical characteristics in relation to added fertilizer is necessary to suggest appropriate fertilizer schedule for different crops in order to obtain optimum yield (Mishra, 2005). Knowledge of vertical distribution of plant nutrients in soil is useful as roots of most of the crop plants go beyond the surface layer and draw part of their nutrient requirements from the sub-surface layer (Brar and Sekhon, 1987; Pal and Muckhopadhyay, 1992; Sangwan and Singh, 1993; Kumar *et al.*, 1996). Soil characterization and classification provides an accurate and scientific inventory of different soils, their kind and nature, and extent of distribution so that one can make prediction about their characters and potentialities. It also provides adequate information in terms of land form, slope, profile characteristics of soils (*viz.*, depth, color, texture, structure etc.) which can be utilized for the planning and development.

Materials and Methods

Chhattisgarh state has been divided into three agro-climatic zones *viz.* Chhattisgarh plains, Bastar Plateau, and Northern hills zone covering 51, 28 and 21 % of the geographical area, respectively. The location of the state is such that it is close to the Bay of Bengal, which is instrumental in bringing monsoon in the Northern part of the country. The state lies at 17°46' N to 24°5'N latitude and 80°15' E to 84°20' E longitude.

Gariyaband district is situated in the fertile plains of Chhattisgarh Region. This district is situated between 20° 57' N and 81° 53' E and at an altitude of 292 meters MSL. The Gariyaband district is surrounded by district Raipur, Mahasamund, Dhamtari and Orissa State in the East. The present investigation were carried in 91 villages out of 710 villages of five blocks (*viz.*, Fingeshwar, Chhura, Gariyaband, Mainpur and Devbhog) in

Gariyaband district of Chhattisgarh. Geographical and other information related to district given in Table 1. The region comes under hot, sub humid climate, having average rainfall of 1157.1 mm. The maximum temperature during the summer may exceed up to 46⁰C and the minimum temperature often falls below 9.0⁰C during winter season. The hottest and coolest months are May and December, respectively.

Geological and morphological parameters were used to facilitate the selection. Three soil profiles were identified, excavated, described and sampled following standard procedures (FAO, 1977; Munsell Color Company, 1954; Soil Survey Staff, 1999). The colour of the soil horizons were determined by matching the colour with Munshell Soil Color Chart. Exact locations of the sites in terms of international coordinates were determined using Global Positioning System (GPS) Receiver.

Results and Discussion

Morphological Characteristics of Soils

Three representative pedons were examined for morphological properties and results are presented in Table 2.

Depth of soil

The results presented in Table 2 revealed that the depth of different pedons varied from 70 cm to 156 cm. The lowest depth of 70 cm was observed in pedon-1 and depth of pedon- 2 and pedon-3 were recorded 155 and 156 cm, respectively. The soils on more slopping positions are generally shallow and have weekly-developed profile in pedon-1 due to accelerated erosion that removes surface materials before it has time to develop. Percolation of water through the soil gets reduced because of runoff. Moreover, availability of water to plants is reduced which

are responsible for checking of erosion and soil formation. On nearly leveled topographic positions, almost the entire water received as rainfall percolate through the soil. Therefore, deep profiles were observed in pedon-2 and pedon-3. Similar result was also observed by Parmasivan and Jawahar (2014) and they reported that the maximum depth of the soils *Vertisols* ranged from 115 to 150 cm in southern region of Tamil Nadu state of India.

Soil Color

The data in Table 2 presents morphological characteristics of three representative pedons of the Gariyaband district. It is evident from the results that yellowish brown (10YR5/4) to very dark gray (10Y3/1) in color. The yellowish brown (10YR 5/4 to 10YR 5/6) color in case of pedon-1, dark grayish brown (2.5Y3/2) to grayish brown (2.5Y5/2) color for pedon-2 and gray (10YR5/1) to very dark gray (10YR3/1) for pedon-3 were observed. Meena *et al.*, (2014) and Bhaskar and Sarkar (2013) observed the similar characteristics for Inceptisols of Hubali district at Karnataka. In case of pedon-3, lower chromas exhibited darker color in surface horizon due to presence of higher organic matter contents. However, at lower depth higher chromas with decreasing level of organic matter were also recorded. Such reports were also presented by Parmasivan and Jawahar (2014) who had noticed hue 10 YR with value varied from 3-4 and chroma 1-2 due to the occurrence of free cations in *Vertisols* of southern region at Tamil Nadu.

Soil Texture

The data presented in the Table 2 indicate that textural classes of soil of different pedons varied from sandy clay loam to clay soil. Sandy clay loam texture was observed in surface and subsurface horizons of pedon-1. Likewise, Meena *et al.*, (2014) reported that

the sandy loam to sandy clay loam texture were observed in surface and subsurface soils (*Inceptisols*) of Hobli district of Karnataka. Pedon-2 displayed clay loam texture in surface and subsurface horizons up to depth 77 cm and sandy clay texture were found in other lower horizons of pedon-2. Clayey texture was found in entire horizons of pedon-3 and clay content progressively increased in lower horizons. These results are in accordance with the earlier findings of Srinivasa Rao *et al.*, (2008) in Black soils where clay content increased with increase in depth. The mean values of sand percent were 58.17, 39.18 and 28.3 in pedon-1, pedon-2 and pedon-3 respectively. Sand fraction decreased with increasing soil depth in pedon-1 however, pedon-2 and pedon-3 showed an increasing trends. The average percent of silt fraction in three pedons (pedon-1, pedon-2 and pedon-3) were in the order of 11.93, 23.20 and 17.88, respectively. In general, these fractions was found higher in surface horizons and lower percent were found in sub surface horizons of pedons-2 and pedon-3, while such variation was not observed in pedon-1 although it decreased in lower horizon. The average values of percent clay contents were 29.90, 37.62 and 53.82 in pedon-1, pedon-2 and pedon-3, respectively. The percent clay content was lower in upper horizons and increased with increasing depth. The enrichment of clay content in lower horizon may be due to illuviation or vertical migration of clay. Similar results were also opined by Sarkar *et al.*, (2002).

Soil Structure

The data pertaining to soil structure in three pedons are presented in Table 2. Results revealed that subangular blocky (sbk) type of structure was identified in all pedons except in pedon-2 wherein angular blocky type structure was observed in subsurface horizon (B_{t4}). Weak grade (1) in surface horizon of the

pedon-1 and pedon-3 and moderate grade (2) was found in pedon-2. Subsurface horizon (2,m,sbk) were noticed to be common in pedon-1 and pedon- 2.

Subsurface horizon (3,m,sbk) were found in pedon-2, Almost all the horizons of the profiles strong, medium, and sub angular blocky (2,m,sbk) and angular blocky (3,m,abk) type of structure observed in subsurface horizon which may be attributed to higher clay content and low organic matter content (Singh and Agrawal, 2005).

The surface horizon of pedon-1 had very hard (dry) and friable (moist) consistency. Whereas, Pedon-3 showed characteristics of *Vertisols* such as slickensides, pressure faces and cracks. These soils had well developed slickenside in B_{ss3}.

Intersecting slickensides forming structural aggregates that break mostly to strong coarse, angular blocky peds. Few, very fine to fine roots 2 to 11 cm wide with continuous vertical cracks and diffused wavy boundaries between horizons has been observed. Similar characteristics of *Vertisols* group was also described by Ram *et al.* (2010).

Bulk Density

Bulk density of different horizons Table 2 ranged from 1.36-1.47, 1.32-1.49 and 1.24 - 1.37 Mg m⁻³ with mean value of 1.43, 1.41, and 1.31 Mg m⁻³ in pedon -1, pedon -2 and pedon -3, respectively. In general, bulk density increased with depth. Lower bulk density of surface soils could be attributed to higher organic matter content (Rao *et al.*, 2008), whereas higher bulk density in sub-surface horizons might be due to greater compaction in soils (Jewitt *et al.*, 1979; Ahuja *et al.*, 1988).

Soil reaction (pH) and electrical conductivity

The data in Table 3 showed the pH values of different pedons. The pH value ranged from 5.7 to 6.1, 6.1 to 7.3 and 7.0 to 7.9 with an average value of 5.3, 6.6 and 7.4 of pedon-1, pedon-2 and pedon-3, respectively. The pH value was lower in surface soil and increased in sub surface horizons of all pedons.

The variations in pH with varying soil depth may be ascribed due to intensive weathering and subsequent leaching of bases in sloping landforms as reported by (Patagundi *et al.*, 1996; Nayak *et al.*, 2002). Baruah *et al.*, (2014) also reported similar results in *Alfisols* in Gerua farm of Assam state.

These soils are slightly acidic to mildly alkaline (pH of 6.1 to 7.6). In *Vertisols*, the soil reaction ranged from moderately alkaline (pH 7.9 to 8.6) in surface and sub surface horizons. These results are in line with the findings of Parmasivan and Jawahar (2014).

Electrical conductivity in three pedons recorded in the range of 0.02 to 0.03, 0.02 to 0.29 and 0.54 to 0.99 dS m⁻¹ with mean value of 0.03, 0.09 and 0.07 for pedon -1, pedon -2 and pedon -3, respectively. Our results corroborated the reports of Raam *et al.*, (2014). The concentrations of soluble salts varied in different pedons however, values fall under the normal range (Table 3). Almost similar salt concentration was found in surface and sub surface horizons of all pedons except B_{ss3} horizon (depth 110-156 cm) of pedon-3.

Salts in different horizons increased with depth in all the horizons which might be due to translocation of salts from upper layers and their accumulation in lower horizon (Graget *et al.*, 2000).

Table.1 Salient features of profile under investigation

	Pedon-1	Pedon-2	Pedon-3
Location	Village –Mohanda Tehsil- Mohanda Distt- Gariyaband	KVK farm – Gariyaband Tehsil- Gariyaband Distt- Gariyaband	Village – Kokdi Tehsil- Gariyabandh Distt- Gariyabandh
Physiographic position	20 ⁰ 22' N latitude 83 ⁰ 13' E longitude	20 ⁰ 38' N latitude 82 ⁰ 04' E longitude	20 ⁰ 38' N latitude 82 ⁰ 57' E longitude
Annual av. rainfall (mm)	1200 -1400 mm	1200 -1400 mm	1200 -1400 mm
Land slope	3-6 % Gently slopping	1-4 % Very gently slopping	1-3 % Very gently slopping
Drainage and permeability	Well drain and slow permeability	Moderately drain and slow permeability	Poorly drain
Land use and vegetation	Urd, Tamarin d, Babul, Plum	Chickpea Paddy, Wheat, , Tamarind, Guava , Plum	Paddy, palaas and Babul,
Geology and parent material	Quartzide, sandstone	Alluvium	Alluvium

Plate.1 Soil belonging to *Inceptisols*



Plate.2 Soils belonging to *Alfisols*



Plate.3 Soil belonging to *Vertisols*



Table.2 Morphological and physical properties of the Pedons

	Sl. No.	Depth (cm)	Horizon	Color	Sand (%)	Silt (%)	Clay (%)	Structure	Texture	Bulk Density (g/cc)
Pedon-1	1	0 – 20	Ap	10YR5/4	61.1	12.8	26.1	1,m,sbk	Scl	1.36
	2	20 – 45	BW ₁	10YR5/6	57.6	13.2	29.2	2,m,sbk	Scl	1.40
	3	45 – 70	BW ₂	10YR5/6	55.8	9.8	34.4	2,m,sbk	Scl	1.47
	4	70 – 100	C _r	Weathering Parent Material						
	Mean		-	-	58.17	11.93	29.90	-	-	1.43
Pedon-2	1	0 – 17	Ap	2.5YR5/2	35.5	31.4	33.1	2,m,sbk	Cl	1.32
	2	17 – 47	Bt ₁	2.5YR4/2	37.3	26.6	36.1	3,m,sbk	Cl	1.34
	3	47 – 77	Bt ₂	2.5YR4/2	39.7	21.7	38.6	3,m,sbk	Cl	1.44
	4	77 – 130	Bt ₃	2.5YR3/2	41.6	19.2	39.2	3,m,sbk	SC	1.49
	5	130 – 155	Bt ₄	2.5YR3/2	41.8	17.1	41.1	3,c,abk	SC	1.46
	Mean		-	-	39.18	23.20	37.62	-	-	1.41
Pedon 3	1	0 – 18	Ap	10YR5/1	20.5	29.1	50.4	1,m,sbk	C	1.24
	2	18 – 42	BW;	10YR4/2	33.7	12.8	53.5	2,m,sbk	C	1.29
	3	42 – 68	B _{SS1}	10YR4/2	25.6	18.9	55.5	2,m,sbk	C	1.30
	4	68 – 110	B _{SS2}	10YR3/1	27.8	13.9	58.3	2,m,sbk	C	1.34
	5	110 – 156	B _{SS3}	10YR3/1	33.9	14.7	51.4	2,m,sbk	C	1.37
	Mean		-	-	28.3	17.88	53.82	-	-	1.31

Table.3 Chemical properties of the Pedons

Pedons	Depth (cm)	Horizon	pH	Ec (dS m ⁻¹)	OC (%)	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)	S (kg ha ⁻¹)	B (mg kg ⁻¹)	CEC (meq+/100 g)
Pedon-1	0 – 20	Ap	5.7	0.03	0.56	213	14.5	163	39.3	0.69	13.71
	20 – 45	BW ₁	6.0	0.02	0.36	137	13.0	161	21.2	0.44	15.05
	45 – 70	BW ₂	6.1	0.03	0.33	125	7.9	136	13.9	0.25	17.83
70 – 100			C_r		Weathering Parent Material						
	Mean		5.9	0.03	0.42	158	11.80	153.3	24.8	0.46	15.53
Pedon-2	0 – 17	Ap	6.1	0.78	0.73	296	22.43	490	46.5	0.72	20.60
	17 – 47	Bt ₁	6.6	0.75	0.67	238	15.36	316	37.9	0.63	27.70
	47 – 77	Bt ₂	6.8	0.54	0.43	125	13.73	200	25.3	0.60	30.40
	77 – 130	Bt ₃	7.3	0.99	0.47	122	14.96	194	18.1	0.39	32.80
	130–155	Bt ₄	6.3	0.83	0.27	112	10.08	166	12.5	0.24	37.60
	Mean		6.6	0.77	0.51	178	15.31	273	28.0	0.52	29.82
Pedon-3	0 – 18	Ap	7.0	0.02	0.70	301	38.1	511	66.9	0.78	33.70
	18 – 42	B _w	7.2	0.06	0.61	239	21.6	469	52.9	0.69	41.20
	42 – 68	B _{ss1}	7.7	0.07	0.57	201	12.2	428	44.5	0.57	43.50
	68 – 110	B _{ss2}	7.9	0.05	0.38	120	12.3	434	42.5	0.51	47.40
	110–156	B _{ss3}	7.2	0.29	0.31	88	10.6	416	38.9	0.48	49.10
	Mean		7.4	0.09	0.51	189	18.9	451	49.1	0.60	42.98

Table.4 Classification of the different soils identified in Gariyaband district

Pedons	Classification	Soil order
Pedon 1	Fine sand clay loamy, kaolinitichyperthermic, <i>Typic Haplustepts</i>	<i>Inceptisols</i>
Pedon 2	Fine clay loamy, kaolinitic mixed hyperthermic, <i>Typic Haplustalfs</i>	<i>Alfisols</i>
Pedon 3	Fine clay , Montmorillonitic mixed hyperthermic, <i>Typic Haplusterts</i>	<i>Vertisols</i>

Cation exchange capacity

Cation Exchange Capacity (CEC) of the soil from three pedons under study as shown in Table 3 revealed that CEC of the surface soils varied from 13.71 to 17.83, 20.60 to 37.60 and 33.70 to 49.10 meq+/100g with mean value of 15.53, 29.82 and 42.98 meq+/100g for pedon -1, pedon -2 and pedon -3, respectively. The CEC of pedons were related to the content of cations on exchange complex. Since the soils with high pH value contain more exchangeable bases, they have high CEC. High CEC with increase in depth in different horizons may be attributed to the higher clay content in the lower layers. Similar results were also reported by Chaudhary *et al.*, (2006), Baruah *et al.*, (2014) and Parmasivan and Jawahar (2014).

Organic Carbon

The organic carbon content is an indicator of available nitrogen status of soils. Organic carbon content in soils of three pedons (pedon-1, pedon-2 and pedon-3) ranged from 0.33 to 0.56, 0.27 to 0.73 and 0.31 to 0.70 per cent with their mean value of 0.42, 0.51, and 0.51 per cent, respectively (Table 3). Organic C contents were found higher in surface soil than those of lower horizons. Decreasing trends in organic carbon content with lower soil depth/horizons in all three pedons might be due to the fact that less crop residues than surface layer. Similar results were also reported by Raam *et al.*, (2014) in *Inceptisols*, Baruah *et al.*, (2014) in *Alfisols* and Parmasivan and Jawahar (2014) in *Vertisols*.

Available N, P and K

The available N, P, and K contents in three representative pedons are given in Table 3. It is obvious from the data that available nitrogen contents ranged from 213 to 125 with their mean value of 158 kg ha⁻¹ in pedon-1, 112 to 376 with mean value of 194 kg ha⁻¹ in pedon- 2 and 88 to 401 kg ha⁻¹ with mean value of 249 kg ha⁻¹ in pedon-3.

The available phosphorus contents ranged from 7.90 to 14.50 with mean of 11.80 kg ha⁻¹, 10.08 to 22.43 with mean of 15.31 and 10.6 to 38.10 with mean of 18.90 kg ha⁻¹, for pedon-1, pedon-2 and pedon-3, respectively.

The available potassium ranged from 136 to 163 with mean of 153 kg ha⁻¹, 166 to 490 with mean of 273 kg ha⁻¹ and 416 to 511 with mean value of 451 kg ha⁻¹ for pedon-1, pedon-2 and pedon-3, respectively.

The low nitrogen, phosphorus and potassium content in *Inceptisols* could be attributed due to their low organic carbon contents (Prasuna Rani *et al.*, 1992), fixation of released phosphorus by clay minerals and oxides of Fe and Al (Vijay Kumar *et al.*, 1994).

In *Alfisols* and *Vertisols*, medium to high content of potassium may be due to weathering of K bearing minerals and release of K from organic residues (Sharma and Anil Kumar 2003 and Rao *et al.*, 2008). Similar results were also reported by Raam *et al.*, (2014) and Parmasivan and Jawahar (2014).

Available S

Available sulphur contents shown in Table 3 varied from 13.90-39.33, 12.52-46.50 and 38.90-66.90 kg ha⁻¹ in the surface and sub surface soils with an average value of 24.81, 28.06 and 49.14 kg ha⁻¹ in pedon-1, pedon-2 and pedon-3, respectively.

The available sulphur showed decreasing trend with depth in all three pedons. The range and trend of available sulphur was matched with results found in *Inceptisols* and *Vertisols* of Prakasam district of Andhra Pradesh as reported by Raam *et al.*, (2010).

Available B

Available B contents (Table 3) in three pedons varied from 0.25 to 0.69, 0.24 to 0.72 and 0.48 to 0.78 mg kg⁻¹ in the surface and subsurface depth with an average value of 0.46, 0.51 and 0.60 mg kg⁻¹ in pedon -1, pedon-2 and pedon-3, respectively. Available B statuses were higher in top soils and decreased with lower depth in all pedons. Raam *et al.*, (2010) observed the available B content in the range of 0.12 to 0.72 mg kg⁻¹ with an average value of 0.42 mg kg⁻¹. The concentrations of hot water soluble B ranged from 0.38 to 0.84 ppm in salt affected soils of Punjab (Sharma and Bajwa 1989), whereas in alluvium derived soils from Ferozepur and Faridkot districts of Punjab, it ranged from 0.20 to 3.85 mg kg⁻¹ soil (Singh and Nayyar 1999).

Available micronutrients

Available Cu content DTPA-extractable (Table 3) in three pedons varied from 0.30 to 1.10, 0.20 to 0.80 and 0.40 to 1.20 mg kg⁻¹ in the surface and subsurface depth with an average value of 0.29, 1.08 and 0.98 mg kg⁻¹ in pedon -1, pedon-2 and pedon-3, respectively.

Available Fe varied from 20.6 to 44.2, 8.6 to 34.3 and 10.1 to 26.6 with mean 29.63, 23.80

and 19.78, available Mn content varied from 16.80 to 26, 24 to 45 and 18.6 to 31.8 with average 21.13, 33.98 and 24.40. Available Zn ranges from 0.4- 1.1, 0.6-1.1 and 0.6 –0.8 with average 0.77, 0.72 and 0.68. These results are supported by Katyal and Rattan (2003) and Parmasivan and Jawahar (2014) in southern Tamil Nadu.

Soil classification

Based on morphological and physico-chemical characteristics, soils were classified into different soil-groups adopting the standard procedure (Soil Survey Staff, 1999).

The classification took in to account of presence and absence of diagnostic surface and subsurface horizons, temperature and moisture regimes and other specific characters (Table 4).

The Pedon 1 in the present study was grouped in *Inceptisols* soil order due to change in color and some accumulation of clay in sub-surface horizon indicating the presence of cambic B horizons. All the pedons belonged to *Ustips* suborder since they had *Ustic* soil moisture regime. The horizons were simple and no calcic or gypsic or duripan were observed, thus they fell in *Haplustepts* Great Group. All the pedons represented the central concepts of great group and hence classified as Typic *Haplustepts* at subgroup level. These results are in conformity with those of Patil and Prasad (2004).

The Pedon 2 were set out in *Alfisols* due the presence of argillic horizons (Bt i.e. accumulation of clays) with *ustic* soil moisture regime and thus belonged to *Ustalfs* suborder, since the horizons sampled had no calcic or gypsic or duripan observed and placed in *Haplustalfs* Great Group. Finally this pedon has been classified at subgroup level as Typic *Haplustalfs* being representing the central concept of Great Group. Gupta *et al.*, (1999)

and Pradeep and Verma (2005) have also reported the similar results with *Haplusters*.

The Pedon 3 was classed in *Vertisols* soil order because of the presence of wide cracks, slicken sides and high clay content. Due to the presence of ustic soil moisture regime, it was placed in *usterts* suborder. No salic or gypsic or calcic or duripan were observed in subsurface horizons, hence, it belonged to *Haplusters* Great Group. Further it was classified as *typic* at subgroup level since it represented the central concept of Great Group. The results corroborate the findings of Gupta *et al.*, (1999) and Singh *et al.*, (2000).

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