

Characterization and Classifications of Soils of Eastern Ghats Region of Karnataka

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Abstract: Characterization and classification of soil resources is essential scientifically plan agricultural land use agroforestry, agri-horticulture and silvipastoral farming systems. In the present study, an attempt was made to characterize and classify the soils occurring on different topography in three villages of Ramanagara district of Karnataka. Out of forty five pedons, nine representative pedons (covering all the soil types) very shallow to deep, dark reddish brown to yellowish red (red soils), to very dark brown to very dark greyish-brown (black soils) in colour. With sub-angular blocky in structure, These soils were sandy clay to clay in texture, strongly acidic to slightly alkaline (4.5-8.02) in reaction (non-saline soils) and had medium to high (0.5-1.33%) organic carbon content. Calcium and magnesium were the dominant exchangeable cations followed by sodium and potassium. Soils were grouped under Alfisols, Inceptisols and Entisols orders.

Keywords: Soil survey, soil characterization, soil classification, soil physical and chemical characteristics

Introduction

Soil is recognized as a base for every production system and knowledge of their properties, extent and spatial distribution is extremely important to maintain soil resources to sustain the ecosystem (Sarmah *et al.* 2019) and site-specific soil management practices.

The systematic study of morphology, physicchemical characteristics and taxonomy of soils provides information on the nature and type of soils, their constraints, potentials, capabilities and their suitability for various uses (Jagdish Prasad *et al.* 2009; Sashikala *et al.* 2019). The data generated through systematic soil resource inventory and characterization will help to formulate agro-interventions for management of these soils under existing delivery extension systems, agriculture schemes, and value chains, so that new technologies could be adopted for sustainable production.

Materials and Methods

Description of the study area

The study was carried out in Kanakapura Taluk (12° 26' 27" to 12° 23' 19" N; 77° 31' 36" to 77° 34' 53" E), Ramanagara district of Karnataka (Fig. 1) covering an area of 2123 ha at an altitude of 584 to 603 m above the mean sea level. The area a part of agro-ecological region 9 falls under the semi-arid tract of the state and receives an average annual rainfall of 790.6 mm. The temperature varies from 16 to 38°C. The average potential evapotranspiration (PET) is 1496.9 mm and varies from a low

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of 98.4 mm in December to 158 mm in the month of April. The length of the crop growing period (LGP) is 150 days. Red sandy soil covers (60%) of the district

(60%), while, red loamy soils cover the remaining part of the district percentage. In undulating land slopes, red sandy soil is mostly developed from granites and granitic-gneiss parent material.



Fig. 1. Location map of Ramanagara district

Soil sampling methodology

A detailed soil survey was carried out (using toposheets on 1:7920 scale) in three villages adopted under Farmers First programme in Ramanagara district, Karnataka. Out of forty five pedons nine typical pedons were selected based on landform and their soil morphological properties (Table 2). The horizon-wise soil samples were collected, processed and analyzed using standard analytical methods and soils were classified (Soil Survey Staff 2022).

Results and Discussion

Morphological characteristics

The thickness of the solum varied from 17 to 160 (very shallow to very deep). The pedons occurring

on the uplands (P1, P2, P3, P4, P5, P6, P7, P8) were shallow to deep in depth but low pedon (P9) area was very deep (Table 1). The upland pedons were well drained barring P8. The soil's hue ranged from 2.5YR to 10YR, with value 3 to 4 and chroma 2 to 6, respectively. The chemical, mineralogical, and textural constitution of soils, together with their topographic position and moisture regime, all appear to have a role in the variation in soil colour (Sireesha and Naidu 2013; Vasundhara et al. 2017). The red colour of the mottles in the lower layers may have resulted from alternate oxidation and reduction processes in the sub-surface soils (Jondhale and Jagdish Prasad 2006). The chroma 2 in the lower horizon of pedon-9 revealed gleying, which suggested the presence of water for a certain period (Bhattacharyya et al. 2009). The soils had textures of loamy sand to sandy clay. In surface and sub-surface horizons, the pedons exhibited weak to moderate, fine to medium, sub-angular

•	Depth	Matrix color	Structure	-	-	Consisten	cy		Root		Pores	-
Horizon	(cm)	(Moist)	Grade	Size	Type	D	Μ	W	ð	S	ð	S
Pedon 1 (VPI	J-T4/P1)-Typi	ic Usticpsaments			-						-	
Ap	0-8	7.5 YR 3/4	1	f	sbk	S	vfr	od os	f	vf	f	vf
A2	8-17	7.5 YR 3/4	1	m	sbk	S	vfr	so po	m	f	f	m
С	17-91	Weathered parent	material									
Pedon-2 (CG	D-BLP/R5)- T	Typic Haplusteps										
A	0-16	5 YR 3/4	2	m	sbk	sh	fr	du su	c	vf	с	f
Bt1	16-33	7.5 YR 3/4	1	ш	sbk		fr	du su	c	vf	c	f
Cr	33-79	Weathered parent	material	-	-		-			-	-	
Pedon-3 (BM	H-BLP/R7)-	Typic Rhodustalfs										
Ap	0-12	2.5 YR 3/4	2	m	sbk	sh	fr	du sui	c	vf	f	c
Bt1	12-31	2.5 YR 3/3	2	ш	sbk	1	fr	du su	f	vf	c	f
Bt2	31-46	2.5 YR 3/3	2	ш	sbk		fr	du sui	f	vf	c	f
Bt3	46-63	2.5 YR 3/4	2	m	sbk	,	fr	du sui	f	f	ш	f
cr	63-75	Weathered parent	material	-	-		-			-	-	
Pedon-4 (RM	D-U1/A)- Tyl	oic Rhodustalfs										
Ap	0-14	5 YR 3/4	1	m	sbk	1	vfr	ds ss	f	f	f	m
Bt1	14-37	2.5 YR 4/4	2	m	sbk	h	fr	du su	f	f	f	m
Bt2	37-96	2.5 YR 4/4	2	m	sbk	h	fr	dm sm	f	f	f	m
С	96-124	Weathered parent	material									
Pedon-5 (BL)	P-HSD-R1) -	Typic Rhodustalfs										
Ap	0-10	5 YR 3/3	1	f	sg	1	vfr	so po	c	vf	c	vf
Bt1	10-30	2.5 YR 3/4	2	ш	sbk		fr	du su	f	f	f	c
Bt2	30-51	2.5 YR 3/4	2	m	sbk		fr	du su	f	f	f	с
BC	51-77	5 YR 3/4	1	m	sbk		fr	ds ss	f	f	f	с
Cr	Weathered F	oarent material										
Pedon-6 (MB	D-BLP/R1)-	KanhaplicRhodust	alfs									
Ap	0-10	2.5 YR 3/3	2	m	sbk	sh	fr	du su	f	vf	с	f
Bt1	10-24	2.5 YR 3/3	2	m	sbk	-	fr	dm sm	f	vf	с	f
Bt2	24-50	2.5 YR 3/4	1	m	sbk		fr	ms mp	f	f	с	f
Bt3	50-76	2.5 YR 3/4	1	m	sbk	ı	fr	tus mp	f	f	c	f
BC	76-91	2.5 YR 3/4	1	m	sbk	ı	fr	tus mp	ı	ı	c	f
cr	91-91+	Weathered parent	material									
Pedon-7 (HR	G- SR /P2)- T	ypic Rhodustalfs										

Table 1. Soil morphological characteristics of representative pedons

f	f					f	f	f	f	f	c		vf	f	f				
m	m	1	I	I		c	c	c	c	c	f		f	c	С	I	I	I	ı
vf	vf	vf	vf	vf		vf	vf	vf	vf	f	1		m	ш	f	f	f	f	f
f	f	f	f	f		ш	ш	c	f	f	1		c	f	f	f	f	f	f
ds ss	ds ss	ds ss	ds ss	ds ss		ds ss	du sui	du sui	du sui	ds ss	so po		ds ss	du sui	dm sm				
vfr	fi	fi	vfi	vfi		fr	fr	fr	fr	fr	vfr		fr	fi	fi	fi	fr	fr	fr
1	1	Ч	vh	vh		sh	ı	ı	ı	-	1		h	ı	-	ı	ı	ı	ı
sbk	sbk	sbk	sbk	sbk		sbk	sbk	sbk	sbk	sbk	sbk		sbk						
m	m	m	ш	m		m	m	m	m	m	f		m	m	m	m	m	ш	m
2	2	3	3	3		1	2	2	2	1	1		1	2	2	2	2	2	2
7.5 YR 3/4	2.5 YR 3/4	2.5 YR 4/4	2.5 YR 3/6	5 YR 4/4	JlticHaplusteps	7.5 YR 3/3	7.5 YR 3/4	5 YR 3/3	5 YR 3/3	5 YR 3/4	5 YR 3/4	Typic Haplusteps	10 YR 3/2	10 YR 3/2	10 YR 3/2	10 YR 3/3	10 YR 3/3	10 YR 3/3	10 YR 3/2
0-18	18-41	41-68	68-88	88-110	- BLP /R8)- U	0-12	12-30	30-58	58-97	97-125	125-150	h- HSD/R7)- 7	0-15	15-35	35-75	75-106	106-128	128-150	150-160
Ap	Bt1	Bt2	Bt3	Bt4	Pedon-8 (HSL	Ap	Bt1	Bt2	Bt3	Bt4	Bw	Pedon-9 (CHC	Ap	Bw1	Bw2	Bw3	Bw4	Bw5	Bw6

Consistency: D – dry:l-loose, sh –slightly hard, h- hard, vh-very hard; M – moist:fi – firm, fr – friable, vfr -very friable; W – wet: ss – slightly sticky, sp -slightly plastic, ms - moderately sticky, mp -moderately plastic, so - non sticky, po -non plastic

Structure: Grade: 1- weak, 2 - moderate; Size: f-fine, m - medium: Type: sbk - sub angular blocky, sg-single grain

Root/ Pores: Q - quantity: f - few, c - common, m - many; S - size: vf - very fine, f-fine, c-coarse

blocky structures. Higher clay content and low organic carbon content may responsible for this kind of soil structure (Gurav et al. 2017). The soil's surface consistency ranged from loose to hard (dry), friable to very friable (wet), non-sticky, and non-plastic to moderately sticky but moderately plastic (wet). While, sub-surface had firm to extremely friable (moist), soft to very hard (dry), non-sticky, and non-plastic to moderately sticky and moderately plastic (wet) consistencies. The increase in stickiness and plasticity may be due to high clay content down the profile, in P2, P3, P4, P6 and P9 and vice-versa. Very fine to coarse, and few to many, roots/pores were found in both surface and sub-surface layers of the soil profiles in all the pedons. Pedons located in uplands had no diagnostic horizon (P1), argillic (Bt) horizon (P2 - P8), but P9 of lowland had cambic (Bw) horizon. These pedons were classified under Entisols, Alfisols, and Inceptisols orders.

Physical characteristics

The sand content of these pedons ranged from 45.2 to 83.3%, and it was uneven with depth in all the pedons. The silt content ranged from 8.54 to 22.7% and its distribution followed similar trends as sand distribution (Table 2). Clay content ranged from 6.4 to 43.6%. The higher concentration of clay in the lower horizon may be due to clay illuviation. In P1, P3, and P6, there was no wide textural class variation. This could be ascribed to increased compaction and decreased aggregation caused by decreased OC and clogging of pores by dispersed clay in sub-soil layers (Khan and Kamalakar 2012). The silt ratio varied from 2.19 to 9.76 in the pedons. The soil moisture content (SMC), which exhibits an erratic pattern with depth, ranged from 7.04 to 21.98% at 33kPa and 3.20 to 15.09% at1500 kPa. The heterogeneity of the parent material, variations in the clay and OC content could contribute to the difference in SMC. Nikam et al. (2006) reported that water retention at both the sections had positive correlation with clay content. The gradual increase in SMC with depth could be attributed to increased clay content and total pore space. Typically, coarse fragments ranged from 10 to

30%, but in some profiles, it was as high as 70% (P4, P6). All of the soil profiles had a sand.

Chemical characteristics

The pH of the soil ranged from 4.65 to 8.02 (slightly acidic to slightly alkaline). The leaching of bases is primarily responsible for lower pH in surface horizons. The EC of soils varied from 0.02 to 0.23 dS m⁻¹ (Table 3) indicating that the soils are non-saline. The OC content ranged from 0.24 to 2.14%, and categorized as low to the medium. The surface horizons had higher than the sub-surface horizons because of more biomass addition (Vasundhara *et al.* 2020). The exchangeable bases in the majority of the pedons were in the order of Ca⁺²> Mg⁺²> K⁺ > Na⁺ barring P2 and P8. The cation exchange capacity of the soils varied from 3.50 to 24.23 c mol (+) kg⁻¹ of soil through depth. The wide range of CEC is related to the amount and type of clay, and the of organic carbon content in these soils (Sekhar *et al.* 2017).

The CaCO₃ content of P7 and P9 ranged from 0.73 to 3.18 per cent and had an irregular distribution with depth, owing to different geological material and leaching of carbonates from the porous sandy layers (Singh and Agrawal 2005). The prevailing semi-arid environment leads to the depletion of Ca^{2+} ions in the soil solution in the form of calcretes and the concurrent increase in ESP with depth may be the cause of the high $CaCO_3$ in the soils (Balpande *et al.* 2007; Warhade *et al.* 2022). Except for P1 and P4, others pedons were highly base saturated, and base saturation in P2, P5, and P9 was found to increase with the depth indicated that the CEC: clay ratio of soils ranged from 0.12 to 0.96 which reflect the presence of kaolinte, mixed and semectitic mineralogy. The Ca: Mg ratio of soil profiles ranged from 1.11 to 4.63.

Soil classification

Based on the morphological, physical and chemical, properties of the the soils were classified up to sub group level (Soil Survey Staff 2022). Pedon represented VPD soil series had no diagnostic subsurface horizon and these soils were placed in Entisols

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Table 2.	

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		Particle	-size class	s (mm)								% Moi	sture	
Horizon	Depth (cm)	Sand (2.0- 0.05)	Silt (0.05- 0.002)	Clay (<0.002)	Very coarse (2.0- 1.0)	Coarse (1.0- 0.5)	Medium (0.5-0.25)	Fine (0.25- 0.1)	Very fine (0.1- 0.05)	Coarse fragments v/v (%)	Textural Class (USDA)	1/3 Bar	15 Bar	Sand/ Silt ratio
Pedon 1 (V	[PD-T4/P1]													
Ap	0-8	83.05*	10.57	6.38	22.60	19.27	11.91	16.35	12.92	15	ls	8.13	3.20	7.86
A2	8-17	81.18	10.63	8.19	17.40	16.17	11.80	21.16	14.65	15	ls	7.93	3.43	7.64
С	17-91	ı												
Pedon-2 (C	GD-BLP/R	5)												
A	0-16	49.58	14.64	35.79	10.55	8.76	8.86	11.81	9.60	20	sc	21.80	13.68	3.39
Bt1	16-33	63.63	14.07	22.30	7.65	6.08	20.96	15.93	13.00	15	scl	20.30	11.86	4.52
Cr	33-79	I												
Pedon-3 (B	MH-BLP/F	(7)												
Ap	0-12	62.50	12.17	25.33	14.34	13.52	11.17	14.65	8.81	15	scl	14.81	8.36	5.14
Bt1	12-31	56.71	10.61	32.67	14.26	13.95	8.99	3.31	16.22	15	scl	16.75	10.99	5.34
Bt2	31-46	62.14	13.61	24.25	14.51	12.04	11.21	16.77	7.61	25	scl	13.75	8.59	4.57
Bt3	46-63	47.56	19.66	32.77	8.29	11.92	8.08	10.88	8.39	30	scl	20.31	12.42	2.42
Cr	63-75	I												
Pedon-4 (R	(MD-U1/A)													
Ap	0-14	83.33	8.54	8.13	17.78	18.99	18.59	18.59	12.83	20	ls	7.04	3.76	9.76
Bt1	14-37	58.20	12.59	29.21	18.41	16.51	8.15	8.15	6.46	60	scl	16.36	11.76	4.62
Bt2	37-96	64.30	10.49	25.21	23.17	17.33	7.72	7.72	7.31	70	scl	15.84	9.85	6.13
С	96-124	I												
Pedon-5 (E	RP-HSD-R	1)												
Ap	0-10	74.72	12.39	12.90	19.67	12.23	10.60	19.57	12.64	15	sl	10.43	4.86	6.03
Bt1	10-30	60.89	12.22	26.89	17.85	16.37	8.18	9.99	8.50	15	scl	14.43	7.48	4.98
Bt2	30-51	63.34	13.10	23.56	18.17	11.55	14.29	9.77	9.56	10	scl	13.91	6.91	4.84
BC	51-77	65.19	14.13	20.69	16.83	14.92	10.05	12.59	10.79	20	scl	14.59	7.43	4.61
Cr	+27-77+	ı												
Pedon-6 (N	(IBD-BLP/)	R1)												
Ap	0-10	49.48	13.31	37.21	12.53	9.81	8.14	10.44	8.56	15	sc	18.87	11.95	3.72
Bt1	10-24	52.33	10.73	36.94	16.06	10.05	7.56	9.74	8.91	15	sc	17.94	12.02	4.88

4.11	3.74	4.76				3.82	3.82	3.82 4.74 4.33	3.82 4.74 4.33 4.88	3.82 3.82 4.74 4.33 4.88 5.07	3.82 3.82 4.74 4.33 4.33 5.07	3.82 3.82 4.74 4.33 4.33 5.07 3.78	3.82 3.82 4.74 4.33 4.33 5.07 5.07 2.98	3.82 3.82 3.82 4.74 4.33 4.33 5.07 5.07 3.78 3.78 3.78 3.78 3.78 3.94	3.82 3.82 4.74 4.33 4.33 5.07 5.07 5.07 5.07 3.78 2.98 3.94 4.96	3.82 3.82 3.82 4.74 4.33 4.33 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.08 3.78 3.94 9.58	3.82 3.82 4.74 4.33 4.33 5.07 5.07 5.07 5.07 3.78 3.78 3.78 3.78 9.58 9.58 6.26	3.82 3.82 3.82 4.74 4.33 4.33 5.07 5.07 3.78 3.78 3.78 3.78 3.78 3.78 9.58 9.58 9.58	3.82 3.82 3.82 4.74 4.33 5.07 5.08 5.50 5.50 5.50	3.82 3.82 3.82 4.74 4.33 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.08 3.78 3.78 3.78 3.94 4.96 9.58 9.58 6.26 2.19	3.82 3.82 3.82 3.82 4.74 4.33 5.07 5.07 5.07 5.07 5.07 5.08 3.78 3.78 3.78 3.78 3.94 4.96 9.58 9.58 5.06 2.19 3.08	3.82 3.82 3.82 4.74 4.74 5.07 5.07 5.07 5.07 5.07 5.08 3.78 3.78 2.98 9.58 3.08 2.19 2.19 2.88 2.88	3.82 3.82 3.82 3.82 4.74 4.33 5.07 5.08 5.08 5.09 5.09 5.09 5.09 5.09 5.09 5.09 5.08 5.07	3.82 3.82 3.82 3.82 4.74 4.33 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.07 5.08 5.08 2.84 2.84
	99 14.86	22 13.61				91 6.98	91 6.98 46 11.52	91 6.98 46 11.52 23 11.94	91 6.98 46 11.52 23 11.94 13 11.67	91 6.98 446 11.52 23 11.94 13 11.67 27 10.71	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 12 6.18	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 27 10.71 84 9.10	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 27 10.71 84 9.10 00 8.73	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 84 9.10 884 9.10 873 36 7.52	91 6.98 446 11.52 233 11.94 13 11.67 13 11.67 13 11.67 13 11.61 13 11.61 13 11.67 13 11.67 13 11.67 13 11.67 13 11.67 12 6.18 84 9.10 00 8.73 89 5.33	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 84 9.10 00 8.73 36 7.52 89 5.33 72 4.91	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 84 9.10 00 8.73 36 7.52 89 5.33 72 4.91	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 84 9.10 84 9.10 873 5.33 72 4.91 72 4.91 98 11.35	91 6.98 446 11.52 23 11.94 13 11.67 27 10.71 84 9.10 84 9.10 873 36 7.52 89 72 4.91 72 4.91 72 4.91 72 9.86 78 9.86	91 6.98 46 11.52 23 11.94 13 11.67 13 11.67 13 11.67 13 11.61 13 11.67 13 11.67 13 11.67 13 11.67 12 6.18 84 9.10 00 8.73 89 5.33 89 5.33 98 11.35 98 11.35 98 11.35 98 11.35 68 7.491	91 6.98 446 11.52 23 11.94 13 11.67 13 11.67 13 11.67 13 11.67 13 11.67 13 11.67 13 11.67 12 6.18 84 9.10 00 8.73 36 7.52 89 5.33 72 4.91 72 4.91 73 88 98 11.39 98 11.39 98 7.44 8.44 9.866	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 27 10.71 84 9.10 884 9.10 873 36 72 4.91 72 4.91 72 4.91 89 5.33 98 11.39 98 11.39 98 11.39 91 0.873 89 5.33 98 11.39 98 449 09 9.42	91 6.98 46 11.52 23 11.94 13 11.67 27 10.71 84 9.10 84 9.10 873 36 7.52 89 5.33 72 4.91 72 4.91 98 11.39 98 11.39 98 7.441 68 7.444 09 9.42 09 9.42 03 7.84
	20.9	20.23				14.9	14.9	14.9 17.4 20.2	14.9 17.4 20.2 18.1	14.9 17.4 20.2 18.1 18.1	14.9 17.4 20.2 18.1 18.2	14.9 17.4 18.1 18.1 18.2 18.2 13.1 1	14.9 17.4 18.1 18.1 18.2 18.2 13.1 17.8	14.9 17.4 17.4 18.1 18.1 18.2 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 117.8 16.0	14.9 17.4 17.4 18.1 18.1 18.1 18.1 18.1 18.1 18.1 17.8 17.8 17.3 17.3 17.3 17.3	14.9 17.4 17.4 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 13.1 13.1 13.1 17.8 17.8 17.8 17.3 10.8 10.8	14.9 17.44 17.44 18.1 18.1 18.1 18.1 18.1 18.1 17.8 17.8 17.8 17.8 17.8 10.8 10.8 10.7	14.9 17.4 17.4 18.1 18.1 18.1 18.1 17.8 17.8 17.8 17.8 17.8 17.8 17.8 17.8 10.8 10.8	14.9 17.4 17.4 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 17.8 17.8 17.8 17.3 17.3 17.3 17.3 10.7 10.7 21.9	14.9 17.4 17.4 18.1 18.1 18.2 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.2 19.7 17.8 17.8 17.8 17.3 17.3 17.3 17.3 17.3 17.3 17.3 17.3 10.7 10.7 19.7	14.9 17.4 17.4 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 19.1 10.7 10.7 11.7.8 10.7 10.7 19.7 19.7	14.9 17.4 17.4 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 19.7 10.7 11.3 11.3 11.3 11.3 11.3 11.3 11.7	14.9 17.4 17.4 18.1 18.1 18.1 18.1 18.1 18.1 18.1 19.7 10.7 117.3 117.3 17.3 17.3 17.3 17.3 17.3 17.3 10.7 19.7 18.0	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
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8.12		9.01			11.37	7.77		7.03	7.03 6.44	7.03 6.44 7.31	7.03 6.44 7.31	7.03 6.44 7.31 18.56	7.03 6.44 7.31 7.31 18.56 13.21	7.03 6.44 6.43 7.31 7.31 18.56 13.21 12.40	7.03 6.44 6.44 7.31 7.31 18.56 13.21 12.40 12.40 16.05	7.03 6.44 6.44 7.31 18.56 18.56 18.56 13.21 12.40 12.40 16.05 17.76	7.03 6.44 6.44 7.31 7.31 18.56 18.56 13.21 12.40 15.40 17.76 3.58	7.03 6.44 6.44 7.31 7.31 18.56 13.21 12.40 12.40 12.40 12.40 3.58	7.03 6.44 6.44 7.31 7.31 18.56 13.21 12.40 12.40 12.40 3.58 9.56	7.03 6.44 6.44 7.31 7.31 18.56 13.21 13.21 12.40 12.40 17.76 3.58 3.58 10.72	7.03 6.44 6.44 7.31 7.31 18.56 13.21 12.40 12.40 17.76 3.58 9.56 11.16	7.03 6.44 6.44 7.31 7.31 18.56 13.21 17.40 17.40 17.40 17.40 17.40 17.40 17.40 17.40 17.40 17.40 17.40 17.40 17.40 17.40 17.40 11.15	7.03 6.44 6.44 7.31 7.31 18.56 13.21 12.40 12.40 12.40 3.58 3.58 9.56 11.16 11.15 8.30	7.03 6.44 6.44 7.31 7.31 18.56 13.21 12.40 12.40 12.40 17.76 3.58 3.58 10.72 11.15 8.30 6.79
	6.04	7.44			12.60	8.94		8.71	8.71 7.89	8.71 7.89 8.56	8.71 7.89 8.56	8.71 7.89 8.56 17.73	8.71 7.89 8.56 17.73 10.53	8.71 7.89 8.56 8.56 17.73 10.53 12.50	8.71 7.89 8.56 8.56 17.73 17.73 10.53 12.50 15.02	8.71 7.89 8.56 8.56 17.73 17.73 12.50 15.02 17.65	8.71 7.89 8.56 8.56 17.73 10.53 10.53 12.50 15.02 15.02 17.65	8.71 7.89 8.56 8.56 17.73 10.53 10.53 10.53 12.50 15.02 17.65 17.26	8.71 7.89 8.56 8.56 17.73 10.53 10.53 10.53 15.02 15.02 17.26 8.82	8.71 7.89 8.56 8.56 17.73 17.73 17.65 17.65 17.65 17.26 8.82 8.82 15.07	8.71 7.89 8.56 8.56 17.73 17.73 17.65 17.65 17.65 17.26 8.82 8.82 8.82 15.07	8.71 7.89 8.56 8.56 8.56 17.73 10.53 10.53 17.65 17.65 17.65 17.26 17.26 17.26 17.26 17.26 17.26	8.71 7.89 8.56 8.56 17.73 10.53 10.53 10.53 17.65 17.65 17.26 17.26 17.26 17.26 17.26 9.98	8.71 7.89 8.56 8.56 17.73 17.73 17.50 17.02 17.65 17.65 17.26 17.26 17.26 17.26 15.07 12.29 9.98 9.98
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38.33		35.56			14.14	28.75	75 31	40.04	22.69	22.69 21.01	22.69 21.01	22.69 21.01 18.38	22.04 22.69 21.01 18.38 26.11	22.69 22.69 21.01 18.38 26.11 25.54	22.69 22.69 21.01 18.38 26.11 26.11 25.54 22.48	22.04 22.69 21.01 18.38 26.11 25.54 25.54 22.48 15.26	22.04 22.69 21.01 26.11 25.54 25.54 25.54 25.54 25.54 25.54 15.26 15.26	22.69 22.69 21.01 21.01 26.11 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.54 25.59 25.59 25.59 25.59 21.01	22.69 22.69 21.01 21.01 25.54 25.54 25.54 25.54 15.26 15.26 12.92 37.45	22.69 22.69 21.01 26.11 26.11 25.54 25.54 25.54 15.26 15.26 15.26 12.92 12.92 37.45 27.47	22.69 22.69 21.01 21.01 26.11 25.54 25.54 25.54 15.26 15.26 15.26 12.92 12.92 27.47 27.47 20.99	22.69 22.69 21.01 21.01 26.11 25.54 25.54 25.54 25.54 15.26 15.26 15.26 15.26 15.26 15.26 25.48 25.48 25.48 25.48 25.48 25.48 25.48 25.48 25.48 25.48 25.48 25.48 25.54 25.55 25.54 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.55 25.54 25.555	22.69 22.69 21.01 21.01 25.54 25.54 25.54 15.26 12.92 12.92 27.47 20.99 23.96 25.97	22.04 22.69 21.01 21.01 26.11 25.54 25.54 15.26 15.26 12.92 27.47 27.47 27.47 27.47 27.47 27.97 25.97 22.83
13.02		11.19			17.83	12.42	14.01		13.14	13.14 13.02	13.14 13.02	13.14 13.02 17.09	13.14 13.02 17.09 18.58	13.14 13.02 17.09 18.58 15.06	13.14 13.14 13.02 17.09 17.09 18.58 15.06 13.01	13.14 13.02 13.02 17.09 18.58 13.01 8.01	13.14 13.02 13.02 13.02 13.02 17.09 18.58 13.01 8.01 12.00	13.14 13.02 13.02 13.02 13.01 18.58 15.06 13.01 88.01 12.00	13.14 13.02 13.02 13.02 13.02 13.01 15.06 15.06 13.01 8.01 12.00 17.38	13.14 13.02 13.02 13.02 13.02 13.02 15.06 15.06 15.06 13.01 8.01 12.00 17.38 22.74	13.14 13.02 13.02 13.02 13.02 13.02 15.06 15.06 13.01 8.01 13.01 8.01 17.38 17.38 17.38 17.38 19.37	$\begin{array}{c c} \hline 13.14 \\ \hline 13.02 \\ \hline 13.02 \\ \hline 13.02 \\ \hline 13.01 \\ \hline 13.01 \\ \hline 8.01 \\ \hline 13.01 \\ \hline 8.01 \\ \hline 13.01 \\ \hline 8.01 \\ \hline 13.01 \\ $	$\begin{array}{c} 13.14\\ 13.02\\ 13.02\\ 17.09\\ 18.58\\ 15.06\\ 13.01\\ 13.01\\ 13.01\\ 13.01\\ 12.00\\ 12.00\\ 19.58\\ 19.58\\ 19.62\\ \end{array}$	$\begin{array}{c c} \hline 13.14 \\ \hline 13.02 \\ \hline 13.02 \\ \hline 13.01 \\ \hline 15.06 \\ \hline 13.01 \\ \hline 13.01 \\ \hline 19.37 \\ \hline 19.58 \\ \hline 19.58 \\ \hline 19.62 \\ \hline 20.11 \\ \hline \end{array}$
48.65		53.25	ı	(68.03	58.83	60.65	1	64.17	64.17 65.97	64.17 65.97 (8)	64.17 65.97 (8) 64.54	64.17 65.97 (65.97 (64.54 64.54 55.31	64.17 65.97 8) 64.54 64.54 59.40	64.17 65.97 (65.97 (8) (8) (64.54 (64.54) (64.51) (64.51)	64.17 65.97 65.97 64.54 64.54 55.31 59.40 64.51 76.73	64.17 65.97 65.97 8) 64.54 55.31 55.31 55.31 55.31 76.73 75.08	64.17 65.97 65.97 8) 64.54 55.31 59.40 64.51 76.73 75.08 77.08	$\begin{array}{c} 64.17\\ 65.97\\ 65.97\\ \hline \\ 65.97\\ \hline \\ 65.31\\ \hline \\ 55.31\\ \hline \\ 75.08\\ \hline \\ 75.08\\ \hline \\ 75.08\\ \hline \\ 75.17\\ \hline \end{array}$	$\begin{array}{c} 64.17\\ 65.97\\ 65.97\\ 89\\ 64.54\\ 55.31\\ 59.40\\ 59.40\\ 76.73\\ 76.73\\ 75.08\\ 77.08\\ 77\\ 79.79\\ 49.79\\ 49.79\end{array}$	64.17 65.97 65.97 65.97 65.97 65.97 64.54 55.31 55.31 59.40 64.51 76.73 76.73 75.08 75.08 79.65 59.65	$\begin{array}{c} 64.17\\ 65.97\\ 65.97\\ 89\\ 64.54\\ 55.31\\ 55.31\\ 55.31\\ 76.73\\ 76.73\\ 75.08\\ 77.08\\ 75.08$	$\begin{array}{c} 64.17\\ 65.97\\ 65.97\\ 8)\\ \hline \\ 8)\\ \hline \\ 64.51\\ 76.73\\ 75.08\\ 75.08\\ 775.08\\ 775.08\\ 775.08\\ 775.08\\ 775.08\\ 776.73\\ 76.73\\ 76.73\\ 756.46\\ 556.46\\ $	$\begin{array}{c} 64.17\\ \hline 65.97\\ \hline 65.97\\ \hline 65.97\\ \hline 65.31\\ \hline 59.40\\ \hline 64.51\\ \hline 64.51\\ \hline 59.40\\ \hline 75.08\\ \hline 75.08\\ \hline 75.08\\ \hline 75.08\\ \hline 54.41\\ \hline 54.41\\ \hline 54.41\\ \hline 57.05\\ \hline 57.05\\ \hline \end{array}$
20 76	0/-UC	76-91	91-91+	RG-SR /P2	0-18	18-41	41-68	1	68-88	68-88 88-110	68-88 68-110 SD- BLP/R	68-88 68-88 88-110 88-110 SD- BLP/R 0-12	68-88 68-88 88-110 88-110 SD- BLP/R 0-12 12-30	68-88 68-810 88-110 88-110 80-12 0-12 12-30 30-58	68-88 68-110 88-110 88-110 88-110 0-12 0-12 12-30 12-30 58-97	68-88 68-88 88-110 88-110 88-110 50-12 12-30 12-30 12-30 30-58 58-97 97-125	68-88 68-810 88-110 SD- BLP/R 0-12 12-30 12-30 30-58 58-97 97-125 97-125	68-88 68-810 88-110 88-110 80-12 0-12 12-30 30-58 97-125 97-125 125-150 HG- HSD/F	68-88 68-110 88-110 88-110 80-12 12-30 12-30 12-30 12-30 97-125 125-150 125-150 HG-HSD/F 0-15	68-88 88-110 88-110 88-110 88-110 12-30 12-30 12-30 12-30 97-125 97-125 125-150 HG-HSD/R HG-HSD/R	68-88 88-110 88-110 88-110 88-110 12-30 12-30 30-58 58-97 58-97 58-97 97-125 97-125 97-125 125-150 HG- HSD/R HG- HSD/R 35-75 35-75	68-88 68-88 88-110 88-110 88-110 0-12 12-30 30-58 58-97 97-125 97-125 97-125 125-150 125-150 0-15 15-35 75-106	68-88 68-88 68-810 88-110 105-125 115-35 35-75 35-75 106-128 <th106-128< th=""> <th106-128< th=""> <th106-128<< td=""><td>68-88 68-88 68-88 68-88 68-810 88-110 88-110 88-110 88-110 910<!--</td--></td></th106-128<<></th106-128<></th106-128<>	68-88 68-88 68-88 68-88 68-810 88-110 88-110 88-110 88-110 910 </td
	Bt3	BC	Cr	Pedon-7 (H	Ap	Bt1	Bt2		Bt3	Bt3 Bt4	Bt3 Bt4 Pedon-8 (H	Bt3 Bt4 Pedon-8 (H Ap	Bt3 Bt4 Pedon-8 (H Ap Bt1	Bt3 Bt4 Pedon-8 (H Ap Bt1 Bt2	Bt3 Bt4 Pedon-8 (H Ap Bt1 Bt2 Bt3	Bt3 Bt4 Pedon-8 (H Ap Bt1 Bt2 Bt3 Bt4	Bt3 Bt4 Pedon-8 (H Ap Bt1 Bt2 Bt2 Bt4 Bt4	Bt3 Bt4 Bt4 Fedon-8 (H Pedon-8 (H Bt1 Bt1 Bt2 Bt3 Bt4 Prodon-9 (C Pedon-9 (C	Bt3 Bt4 Pedon-8 (H Ap Bt1 Bt2 Bt3 Bt4 Bw Bw Ap	Bt3 Bt4 Pedon-8 (H Ap Bt1 Bt2 Bt3 Bt4 Bw Bw Pedon-9 (C Ap	Bt3 Bt4 Pedon-8 (H Ap Bt1 Bt4 Bt4 Bw1 Bw1 Bw1 Bw2	Bt3 Bt4 Pedon-8 (H Ap Bt1 Bt2 Bt4 Bt4 Bw2 Bw2 Bw3 Bw3	Bt3 Bt4 Bt4 Pedon-8 (H) Ap Ap Bt1 Bt2 Bt3 Bt4 Bt4 Bt3 Bt4 Bt4 Bt4 Bt4 Bt4 Bt4 Bt4 Bt4 Bt4 Bt4 Bw1 Bw1 Bw3 Bw3 Bw4 Bw4	Bt3 Bt3 Bt4 Edon-8 (H) Ap Bt1 Bt2 Bt2 Bt3 Bt4 Bw1 Bw2 Bw2 Bw4 Bw4 Bw4

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Table

					Lvohon	م مامام م	atione				Daco	CoCC		
Horizon	Depth	Ηd	EC	S OC	Ca	Mg	Na	К	Sum	CEC	Saturation	equivalent	Exch.	CEC/
	(CIII)	1	(III cn)	(0/)		[cm0	$d(p+)kg^{-1}$				(%)		Ca/Mg	CIAY ratio
Pedon 1 (V	PD-T4/P1)												1 auto	14110
Ap	0-8	5.08	0.06	0.40	1.62	0.57	0.01	0.11	2.30	4.30	53.51	I	2.84	0.67
A2	8-17	4.70	0.02	0.60	1.76	0.55	0.01	0.05	2.37	4.00	59.21	I	3.20	0.49
С	17-91	ı												
Pedon-2 (C	GD-BLP/R	(2)												
A	0-16	6.45	0.06	0.45	14.47	5.33	0.14	0.08	20.02	24.23	82.62	ı	2.71	0.68
Btl	16-33	6.77	0.06	0.33	9.76	8.77	0.17	0.07	18.77	21.32	88.03	ı	1.11	0.96
Cr	33-79	1												
Pedon-3 (B	MH-BLP/F	۲7) ۲7)												
Ap	0-12	6.49	0.12	0.84	6.03	3.26	0.17	0.20	9.66	10.09	95.72	1	1.85	0.40
Bt1	12-31	6.84	0.11	0.66	7.31	4.27	0.12	0.12	11.82	11.54	100.00	I	1.71	0.35
Bt2	31-46	7.02	0.11	0.63	5.09	3.18	0.11	0.09	8.48	11.02	76.90	ı	1.60	0.45
Bt3	46-63	7.11	0.10	0.45	7.73	3.84	0.28	0.09	11.95	12.20	97.90	ı	2.01	0.37
Cr	63-75													
Pedon-4 (R	MD-U1/A)	-												
Ap	0-14	4.65	0.04	0.68	1.39	0.52	0.01	0.10	2.02	3.50	57.62	I	2.67	0.43
Bt1	14-37	4.82	0.03	0.64	4.36	1.56	0.05	0.07	6.03	8.30	72.67	I	2.79	0.28
Bt2	37-96	5.1	0.02	0.4	3.85	1.25	0.06	0.06	5.22	7.80	66.91	I	3.08	0.31
С	96-124	ı												
Pedon-5 (B	LP-HSD-R	.1)												
Ap	0-10	5.42	0.07	0.68	3.22	1.45	0.01	0.10	4.78	5.70	83.85	I	2.22	0.44
Bt1	10-30	5.79	0.03	0.68	6.16	2.55	0.02	0.03	8.77	8.70	100.00	I	2.42	0.32
Bt2	30-51	6.14	0.03	0.36	6.54	2.48	0.04	0.04	9.10	9.00	100.00	I	2.64	0.38
BC	51-77	6.5	0.03	0.48	7.90	3.21	0.04	0.03	11.18	11.00	100.00	I	2.46	0.53
Cr	+77-77+	ı												
Pedon-6 (N	(BD-BLP/	R1)												
Ap	0-10	6.80	0.23	1.33	4.06	3.00	0.20	0.77	8.03	9.78	82.15	I	1.35	0.26
Bt1	10-24	6.07	0.20	0.89	3.45	2.67	0.36	1.23	7.71	10.61	72.64	I	1.29	0.29
Bt2	24-50	6.44	0.07	0.46	2.96	1.92	0.49	1.19	6.55	10.61	61.74	I	1.54	0.24
Bt3	50-76	6.63	0.07	0.34	2.26	1.02	0.07	0.13	3.48	4.78	72.72	I	2.22	0.12
BC	76-91	6.77	0.08	0.22	4.69	1.74	0.06	0.09	6.58	8.53	77.22	1	2.70	0.24

Cr	91-91+	ı												
Pedon-7 (F	IRG-SR /P.	2)												
Ap	0-18	7.88	0.13	0.76	9.67	2.09	0.03	0.13	11.92	9.80	100.00	0.98	4.63	0.69
Btl	18-41	6.60	0.06	0.48	9.53	3.80	0.03	0.08	13.43	14.10	95.28		2.51	0.49
Bt2	41-68	6.41	0.04	0.56	8.24	2.85	0.16	0.06	11.31	12.00	94.23	,	2.89	0.47
Bt3	68-88	6.44	0.04	0.36	8.76	2.89	0.23	0.06	11.94	13.10	91.12		3.03	0.58
Bt4	88-110	6.45	0.04	0.32	8.38	2.45	0.20	0.05	11.07	12.80	86.52		3.42	0.61
Pedon-8 (F	ISD-BLP/	R8)												
Ap	0-12	7.82	0.10	0.80	6.06	4.03	0.35	0.12	10.55	10.61	99.44		1.50	0.58
Bt1	12-30	689	0.08	0.53	6.84	4.48	0.12	0.07	11.50	13.10	87.78	ı	1.53	0.50
Bt2	30-58	6.91	0.05	0.55	6.74	4.44	0.09	0.08	11.35	12.69	89.48		1.52	0.50
Bt3	58-97	6.94	0.05	0.49	5.45	3.50	0.10	0.07	9.11	10.92	83.46		1.56	0.49
Bt4	97-125	7.09	0.08	0.27	3.63	2.52	0.09	0.05	6.30	7.18	87.82	ı	1.44	0.47
Bw	125-150	7.37	0.09	0.29	3.42	2.52	0.14	0.05	6.12	7.28	84.12	1	1.36	0.56
Pedon-9 (C	HG- HSD/	R7)												
Ap	0-15	8.02	0.20	2.14	17.16	7.55	0.15	0.45	25.00	21.90	100.00	3.18	2.27	0.58
Bw1	15-35	7.81	0.15	1.33	15.64	5.04	0.12	0.12	20.92	17.40	100.00	1.10	3.10	0.63
Bw2	35-75	7.62	0.06	0.6	9.08	4.41	0.11	0.09	13.68	12.20	100.00	0.73	2.06	0.58
Bw3	75-106	7.69	0.05	0.32	9.58	5.57	0.17	0.10	15.41	13.50	100.00	0.86	1.72	0.56
Bw4	106-128	7.86	0.05	0.36	9.56	5.54	0.29	0.12	15.50	14.60	100.00	1.22	1.73	0.56
Bw5	128-150	7.92	0.04	0.44	8.62	4.68	0.31	0.12	13.73	12.40	100.00	0.86	1.84	0.54
Bw6	150-160	7.94	0.07	0.4	9.76	5.53	0.39	0.13	15.81	14.00	100.00	1.35	1.76	0.51

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order. VPD soils have less than 35% (by volume) rock fragments and texture of loamy fine sand or coarser in all layers within the particle-size control section have been in Psaments grouped as at sub-order level. Owing to ustic moisture regime, soils were classified as Ustipsaments at great group level. Except the soils of VPD series, other soils were placed under Alfisols at order level as these pedons have argilic sub-surface horizon. The presence of base saturation more than 35% throughout the depth of the soil horizons and ustic moisture regime, The soils of CGD HSD and CHG were classified as Haplustalfs at great group level, because these soils do not have either duripan or rhodic features. In addition to this, soils of HSD services exhibited the base saturation (by sum of cations) of less than 75 percent throughout and hence placed Ultic at sub group level where as typing pedons of CGD and CHG services did not exhibit any integration with other taxa or an extra gradation from the central concept and hence these have been placed as Typic Haplustalfs (Table 4).

The typifying pedons of BMH, RMD, BLP, MBD, HRG soil series were classified as Rhodustalfs because of occurrence of sub-horizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 per cent colours that have hue of 2.5YR or redder and value, moist, of 3 or less. Similarly at sub group level, these soils did not exhibit any integration with other taxa nor deviated from central concept of Rhodustalfs are placed in Typic Rhodustalfs whereas soils of series MBD have been grouped as Kanhaplic Rhodustalfs (Table 4) because of CEC less than 24 c mol (p+)kg⁻¹ clay.

The pedons representing VPD CGD, BLP, HRG, CHG series had the fine earth fraction less than 75 mm in diameter, 15 per cent or more (by weight) particles with a diameter of 0.1 to 75 mm in fine earth fraction, less than 18 per cent clay by weight are placed under coarse loamy particle-size class. The soils of MBD series possessed more than 35 per cent clay with 35 per cent or more (by volume) rock fragments so these were classified placed under the clayey-skeletal particle-size class.

The soils of BMH and HSD series had more than 18 per cent but less than 35 per cent clay (weighted

average) in the control section, hence keyed out as fineloamy, whereas soils of RMD series contained more than 18 percent and less than 35 per cent clay along with 35 percent or more (by volume) rock fragments are placed under loamy-skeletal.

The soils of VPD, MBD, HRG, HSD, and CHG series were classified as active at cation exchange activity classes because the ratio of CEC to per cent clay (by weight) was between 0.40 to 0.60. The pedons belonging to BMH, RMD, and BLP Soil series were classified as semi active because CEC to clay ratio was between 0.20 to 0.40, whereas soils of CGD series was classified as active because the CEC to clay ratio was more than 0.60. The temperature regime of the area was classified as isohyperthermic.

Conclusion

The soils of the area in Ramanara district, Karnataka were strongly acidic to slightly alkaline in reaction (non saline) and had medium to high OC content and low to medium CEC. These soils were classified as Typic Ustipsamments, Kanhaplic Rhodustalfs, Typic Rhodustalfs, Ultic Haplustepts and Typic Haplustepts, at sub-group level. The main constraints were depth, slope, excessive drainage and low water holding capacity in upland soils.

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Received: August, 2022 Accepted: December, 2022