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Characterization and classification of selected rice-growing soils in hilly zone of Karnataka

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Abstract
In Karnataka rice is grown under a variety of soils and wide range of rainfall and temperature. A study was carried out to characterize and classify the rice-growing soils of hilly zones of Karnataka. Two pedons each from Haliyal taluk of Uttara Kannada district and Hangal taluk from Haveri district were selected for the study. Haliyal soils (pedon 1) were deep (>120 cm), moderate, medium, sub-angular blocky in structure, dark brown (7.5YR) in colour, clay loam to silt loam in texture, strongly acidic to slightly acidic in reaction, low CEC (16.60 to 21.50 cmol (p+) kg^{-1} soil) and medium to high base saturation. Hangal soils (pedon 2) were very deep (>160cm), moderate, medium, sub-angular blocky in structure, dark brown to reddish brown or red (7.5YR- 5YR- 2.5YR) in colour, clay loam to clay in texture, strongly acidic to slightly acidic in reaction, low CEC (10.20 to 14.60 cmol (p+) kg^{-1} soil) and medium to high base saturation. Haliyal soils were classified as Aquic Haplustepts and Hangal soils as Oxyaquic Haplustalfs at subgroup level.

Keywords: rice, soil properties, characterization, hilly zone

Introduction
Soil resource characterization studies throws light on the nature and inherent potential of soil in an area, its possible agriculture land use options and management requirements for existing crop production constraints. Knowing the nature and soil responses is the foremost step in managing our resource in a sustainable manner. Characteristics of all soils are largely governed by the landforms, in which they are developed.

Rice (*Oryza sativa*) is the single largest crop cultivated in India, contributing more than 40 per cent of the country's total food grain production. Because of the wide adaptability of the crop, it being cultivated in differing climate-soil –hydrological regimes. In Karnataka, rice is grown under a variety of soils and wide range of rainfall and temperature. (Rajanna, 2010). The present investigation aims to characterize and classify the rice-growing soils in hilly zone of Karnataka for knowing its nature and potential/problems in detail.

Materials and Methods
The study was conducted in Haliyal taluk of Uttara Kannada district and Hangal taluk of Haveri district from rice-growing areas in hilly zone of Karnataka. Pedon site of Haliyal lies between 15° 19' 18.2″ N latitude and 74° 47' 14.7″ E longitude at an elevation of 559 m above MSL and area is having a hot moist sub-humid tropical climate receives an average annual rainfall of 1190.1 mm. Location of Hangal site is between 14° 45' 16.7″ N latitude and 75° 00' 58.5″ E longitude at an elevation of 592 m above MSL with a hot dry sub-humid tropical climate receives an average annual rainfall of 1054.9 mm. Geologically, the Haliyal soils are formed from Archean granitic gneiss/schist whereas soils of latter pedon is of granitic and colluvial origin.

Soil profiles were dug with a dimension of 1 m width and 1.5 m length and depth extending to either bedrock or more than 150 cm whichever is shallower. Soil profile faces were cleaned and peds exposed to facilitate examination of morphological features. Descriptions were made according to procedures outlined by AIS&LUS (1970) [1], USDA Soil Survey Manual (1962) [15]. Soil horizons were differentiated based on colour, texture, structure and gravel content and horizon wise samples collected were shade dried, ground and sieved using 2 mm sieve.

The depth wise soil samples from the study sites were analyzed for pH, electric conductivity (EC), cation exchange capacity (CEC), exchangeable cations, exchangeable sodium percentage (ESP) following standard procedures. Soil pH, EC and CEC were measured as per the procedure described by Jackson (1973) [4].

Calcium carbonate ($CaCO_3$) was analyzed by rapid titration method (Richards 1954) [10]. The soil organic carbon content determined by wet oxidation method of Walkley and Black (1934) [14]. Based on the studied characteristics soils were classified upto family level by USDA soil taxonomy (Soil Survey Staff, 1999) [8].

Results and Discussion

Morphological characteristics

Morphological description of soils done by following guidelines by USDA is presented in Table 1. Haliyal and Hangal soils from the study site are deep to very deep. Surface horizon of Haliyal was having dark brown colour both in moist and dry conditions and can be attributed to presence of organic matter (Dutta *et al*., 2016) [3]. Sub-surface horizons of Haliyal soils also exhibited 7.5YR (dark brown) hue for the soil matrix whereas that of Hangal pedon down the profile exhibited more reddish hue value ranging from 7.5YR to 5YR and 2.5YR. The colour of sub-soil horizons was dark brown (7.5YR) to reddish brown (5YR), dark reddish brown (2.5YR) and red (2.5YR 4/6) in moist as well as in dry condition. Brownish to red or reddish colour of the soil sub-surface horizons and its variations down the profile may be dependent on the release of iron, its degree of oxidation, hydration etc. (Thangasamy *et al*., 2005) [12]. Texture of the sub-surface horizons varied from clay loam to silty loam in case of pedon 1 and varied from clay loam to clay for pedon 2. In case of pedon 2 notable increase in finer fractions with the depth of the soil mainly due to eluviation and illuviation processes operated in the pedons resulting in the formation of a distinct argillic horizon in the subsurface horizons and same designated as Bt in the sub-surface horizons (Narsaiah *et al*., 2018) [6]. Structure of both the pedons in their sub-surface horizons exhibited variation from moderate, medium, sub-angular blocky to weak, medium, sub-angular blocky and massive. Consistence of the sub-surface horizons of pedon1 and pedon 2 were hard to slightly hard when dry and friable when moist. Under wet condition, consistence was moderately sticky and slightly plastic. The sub-surface horizons of the studied pedons had few very fine roots common fine to medium and few medium pores.

Physical and Chemical properties

Haliyal soils exhibited an increase in silt content with depth with content varied from 37.11 to 65.79 per cent. The clay content of Hangal soils increased with depth and ranged from 19.54 to 54.73 per cent. Pedon 2 was noticed with higher sand content in the surface horizons of the soil which could be attributed to loss of finer fractions of soils due to erosion, movement of clay to deeper horizons due to illuviation and more active chemical weathering in the lower horizons due to better availability of moisture (Basavaraju *et al.,* 2005) [2].

Soils studied are non-saline with EC ranging from 0.04 to 0.14 dS m^{-1} (Table 2). Soil reaction of the soils were strongly acidic to slightly acidic range. A decrease in pH was observed with depth can be attributed to leaching of the bases due to the existing high rainfall conditions and to some extend may be contributed from acidic parent materials (Srinivasan *et al*., 2016) [11]. Organic carbon content of pedon 1 and pedon 2 ranged from 0.16 to 1.18 and 0.38 to 1.43 per cent respectively with the highest value recorded for the surface soil layer which could be attributed to leaf-litter fall/ decay, vegetation, plant coupled with heavy rainfall (Vara Prasad Rao *et al.,* 2008) [13]. Exchangeable bases of surface horizon in the pedon 1 and 2 were in the order Ca>Mg>K>Na and Ca>Mg>Na>K respectively whereas for sub-surface horizons of pedon 1 order of exchangeable bases were Ca>Mg>K>Na and for pedon 2 order remained same for both surface as well as sub-surface layers. Sum of exchangeable bases showed an increase with the depth, ranged from 11.15 to 16.80 cmol (p+) kg^{-1} soil for pedon 1 and ranged from 5.96 to 11.85 cmol (p+) kg^{-1} soil for pedon 2. Cation exchange capacity (CEC) for pedon 1 and 2 ranged from 16.60 to 21.50 and 10.20 to 14.60 cmol (p+) kg^{-1} soil respectively. Low to moderate CEC in these soils reflects type of parent material, higher degree of weathering leading to depletion of bases and also may be due to the mixed type of kaolinitic, illitic and other clay minerals (Singh *et al*., 2013) [7]. KCl extractable acidity of the pedon 1 and 2 recorded higher for the surface and decreased with depth. $BaCl_2$-TEA acidity was observed higher for pedon 1 ranging from 13.30 to 26.30 cmol (p+) kg^{-1} soil and 5.60 to 17.20 cmol (p+) kg^{-1} soil for pedon 2. Base saturation ranged from 56.68 to 92.84 per cent for the pedon 1 whereas it ranged from 57.32 to 100.00 per cent for pedon 2. Lower value of base saturation on the surface and depth wise increase might be due to leaching of bases and accumulation in lower horizon due to appreciable rainfall received in these areas (Mahesh *et al.,* 2019) [5].

Soil classification

Haliyal soils are deep well drained with an altered B horizon or cambic horizon with higher chroma are classified under Inceptisols. At sub-order level, pedon fall under moisture regime Ustic, hence the pedon was classified as Ustepts. At great group level, pedon classified as Haplustepts. Haliyal soils showing redox depletion within 75 cm of mineral soil with presence of mottles, so classified as Aquic Haplustepts at sub-group level. Pedon 2 with very deep well drained soils with clay translocated argillic sub-surface horizons and do not have oxic, plaggen and spodic epipedon or sub-surface horizons above the clay translocated horizon, furthermore the argillic horizons have the base saturation by sum of cations of more than 35 per cent and clay illuviation is clearly identified by the existence of clay cutans with 7.5 cm or more thickened horizon and also more than one-tenth of the thickness of all the overlying horizons as thick as the sum. Hangal pedon was keyed out under Alfisols in order level. At sub-order level, the soil fall under moisture regime Ustic, hence classified as Ustalfs. The soils of the Hangal remain saturated within 100 cm of mineral soil surface for 20 or more days consecutively or 30 or more days cumulative, in normal years and hence classified as Oxyaquic Haplustalfs at sub-group level.

Table 1: Morphological characteristics of the soils study area

Horizon	Depth (cm)	Boundary	Colour		Texture	Structure	Consistency			Roots	Pores
			Dry	Moist			Dry	Moist	Wet		
Pedon 1 – Haliyal taluk, Uttara Kannada district											
Ap	0-17	c s	7.5YR 4/3	7.5YR 3/3	cl	1 C sbk	h	fr	ss & ps	f vf	c m
Bw1	17-36	c s	7.5YR 3/2	7.5YR 2.5/2	cl	2 M sbk	sh	fr	vs & ps		c f
Bw2	36-57	c s	-	7.5YR 2.5/1	c	2 M sbk		fr	ms & ps		c vf
Bw3	57-82	c s	-	7.5YR 3/2	sicl	1 M sbk		fr	ms & ps		f vf
BC	82-120		-	7.5YR 3/2	sil	Massive		fr	ms &ps		f vf
Pedon 2- Hangal taluk, Haveri district											
Ap	0-18	c s	10YR 5/3	10YR 2/2	sl	2 C sbk	h	fr	ss & ps	c vf	c f
Bt1	18-42	c s	7.5YR 4/2	7.5YR 3/2	cl	2 M sbk	h	fr	ms & ps	f vf	c f
Bt2	42-66	c s	7.5YR 3/3	7.5YR 2.5/3	c	2 M sbk	sh	fr	ms & ps		c m
Bt3	66-97	c s	5YR 4/4	5YR 3/3	c	2 M sbk	sh	fr	ms & ps		c m
Bt4	97-130	c s	2.5YR 3/4	2.5YR 3/4	c	1 M sbk		fr	ms & ps		f m
Bt5C	130-160			2.5YR 4/6	c	Massive		fr	ms & ps		f m

Table 2: Physical and chemical properties of soils of the study area

Depth (cm)	Mechanical analysis			pH (1:2.5)	E.C ($dS\ m^{-1}$)	OC %	Exchangeable bases					Extractable acidity			CEC NH_4OA_C	BS (%)
	Sand	Silt	Clay				Ca	Mg	Na	K	Total	$BaCl_2$-TEA	1.0 *N* KCl			
	2.0-0.05	0.05-0.002	<0.002										H^+	Al^{3+}		
	% of <2 mm						cmol (p+) g^{-1} soil									
Pedon 1 – Haliyal taluk, Uttara Kannada district																
0-17	26.49	44.61	28.90	5.32	0.14	1.18	6.13	4.51	0.20	0.31	11.15	26.30	0.49	0.13	16.60	67.20
17-36	24.11	38.36	37.53	5.71	0.04	0.92	6.15	5.22	0.22	0.09	11.68	20.20	0.33	0.08	20.60	56.68
36-57	20.02	37.11	42.87	5.82	0.04	0.88	9.77	4.40	0.26	0.19	14.62	19.50	0.30	0.02	21.50	67.99
57-82	13.85	55.38	30.77	6.11	0.05	0.28	11.13	3.22	0.17	0.06	14.58	16.30	0.18	0.00	17.70	82.36
82-120	7.28	65.79	26.93	6.19	0.04	0.16	12.60	4.02	0.13	0.05	16.80	13.30	0.14	0.00	18.10	92.84
Pedon 2- Hangal taluk, Haveri district																
0-18	53.76	26.70	19.54	5.19	0.06	1.43	4.68	1.12	0.09	0.06	5.96	17.20	0.57	0.14	10.40	57.32
18-42	41.55	20.04	38.41	6.16	0.04	0.92	9.18	2.50	0.09	0.04	11.81	12.00	0.34	0.08	13.40	88.14
42-66	32.53	18.30	49.17	6.31	0.04	0.74	8.60	2.87	0.09	0.06	11.61	11.40	0.20	0.00	14.60	79.55
66-97	37.66	7.61	54.73	6.42	0.04	0.42	8.64	3.04	0.09	0.08	11.85	8.30	0.12	0.00	13.80	85.86
97-130	38.54	12.94	48.52	6.35	0.04	0.38	8.01	3.23	0.11	0.10	11.45	9.50	0.18	0.00	13.30	86.08
130-160	30.34	16.25	53.41	6.28	0.04	0.95	6.81	3.64	0.09	0.09	10.62	5.60	0.25	0.00	10.20	100.0

Conclusion

Pedological approach for studying soils gives an insight on specific characteristics and problems associated with the soils. Haliyal and Hangal soils belong to hilly zone where similar agro-climatic conditions exists, even then results of this study has given evidence for differences in properties of these soils. The diversity in soils belonging to same agro-climatic conditions is brought about by variation in local topographic conditions causing erosion, leaching, sedimentation and other pedogenic processes modified by water table.

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