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Soil Morphological Properties and Classification of Hebbalagere Micro Watershed in Channagiri Taluk, Davanagere District of Karnataka, India

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ABSTRACT

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A study was undertaken to characterize and classify the soils of Hebbalagere micro watershed in Channagiri taluk, Davanagere district of Karnataka. Eleven profiles were studied for the morphological features based on soil heterogeneity. The detailed morphological descriptions of the pedons were done in the field as per the procedure outlined in Soil Survey Manual. The soils were moderately shallow to very deep in depth. The colour of red soil pedons varied from 2.5YR 2.5/3 (dark reddish brown) to 5YR 4/4 (reddish brown), whereas in black soils shown 7.5YR 3/3 (dark brown) to 10YR 4/4 (dark yellowish brown) in colour. Soil texture varied from sandy clay to clay in red soil pedons whereas in case of black soil pedons it was clay. The soil structure was weak fine sub-angular blocky to moderate medium angular blocky in the pedons under study. The consistency of soil pedons varied from slightly hard to very hard when dry, friable to the firm when moist, slightly sticky to very sticky and slightly plastic to very plastic when wet. Soils studied were classified upto family level. Taxonomically, the soils of the study area were classified under the orders Alfisols, Inceptisols and Vertisols.

Introduction

Soil morphology is the field observable attributes of the soil within the various soil horizons and the description of the kind and arrangement of the horizons (Buol *et al.*, 2003). A morphological study enables us to detect many essential characters of a soil by mere observation in the field, without analytical investigations, though such observations are of a qualitative nature only. The more common morphological features are

colour, structure, texture, consistency, inclusions, water conditions and a few others of lesser significance. Soil characterization provides the information for our understanding of the mineralogical, physical, chemical and microbiological properties of the soils on which we depend on to grow crops, grasslands and sustain forests as well as support homes and social structures. A soil characterization study is a major building block for understanding the soil, classifying it and getting the best understanding of the

environment. Soil characteristics are affected by a number of natural and human-induced factors. Hence there is a need for systemic study of soil resources characteristics for sustainable land use.

Classification is the grouping of objects in some orderly and logical manner. It is based on the properties of objects for the purpose of their identification and study. The individual soils are grouped into classes of lower category (*i.e.*, soil series), which are further grouped into classes of higher categories (*i.e.*, soil orders). The USDA Soil Taxonomy is property based and concepts are discussed as guidelines, but not as criteria. Properties include horizons and soil morphological properties. The use of definitions for horizons and characteristic diagnostic properties limit descriptions of diagnostic criteria and enhance communication. This supports an accurate natural and concise classification of the pedon. The USDA Soil Taxonomy has six levels, with 12 Orders at the highest level. It defines nine topsoil horizons, 19 subsoil horizons, and 26 and 33 diagnostic properties for organic and inorganic soils, respectively (Soil survey staff, 2003). Therefore, soil classification is helpful in identifying their potential uses, estimating their productivity and transferring agro-technology from research farms to cultivators' fields.

Materials and Methods

The study area was Hebbalagere micro watershed located in Channagiri taluk, Davangere district of Karnataka. The study area lies at latitude 13°59'53.34"N to 14°2'31.20"N and longitude 76° 0'23.62"E to 76° 1'26.83"E. The micro watershed comes under Southern transition zone (Zone 7) and climate is semi-arid with a mean annual average rainfall of 655 mm. The Hebbalagere micro watershed was surveyed using satellite imagery (IRS P6 LISS-IV and cartostat-1

quick bird imagery), cadastral map and toposheet to collect information on surface features / site characteristics like soil texture, slope, erosion and graveliness. Based on soil heterogeneity, 11 pedons were opened and studied for their morphological features. The detailed morphological descriptions of these pedons were done in the field as per the procedure outlined in Soil Survey Manual.

Soil colour of the pedons was measured both under dry and moist condition using Munsell colour chart. Other morphological characteristics studied were depth of solum, depth of each horizon, texture, structure, consistency at dry, moist and wet conditions, root distribution, coarse fragments, slickenside, quantity of conca and conir, *etc.* The morphological properties were described as per Soil Survey manual. The horizons were identified and designated according to revisions in Soil Taxonomy.

The pedons under study are classified based on morphological, physical and chemical properties according to Keys to Soil Taxonomy (Soil Survey Staff, 2014). At higher categories (order) the presence or absence of diagnostic horizons which are indications of pedogenic process were considered. At sub-order level, the moisture and temperature regimes were used. At lower categories (great group, sub-group and family), diagnostic subsurface horizons, soil depth, mineralogy, texture, soil chemical properties and drainage are considered. In Hebbalagere micro-watershed, the soils were classified up to family level.

Results and Discussion

Morphological characteristics of pedons

Soil morphological characteristics of pedons of Hebbalagere micro watershed is presented in table 1. Soils of the micro-watershed

derived from peninsular gneissic complex consisting of the granite gneiss parent rock and schist parent rock. Eleven soil pedons were selected based on soil heterogeneity and slope in the micro-watershed. Selected soil pedons fall under nearly level (0 – 1 % slope) to very gently sloping (1 – 3 % slope) and exhibited very slight to moderate erosion with moderately well to well drainage condition.

Horizon differentiation

Horizon differentiation in black soil was relatively weak compared to that of red soils in the study area. In case of black soils, the process of pedoturbation interferes with horizonation. A similar observation was made by Bhattacharjee *et al.*, (1974) in black soils of Deccan plateau. The horizon identification in black soil pedons was made mostly based on intersecting slickensides and horizontal and vertical nature of cracks.

Based on this, three to four horizons could be identified namely; self-mulching surface horizon, horizons with pressure faces and wedge shapes slicken sided sub-soil and horizons with slicken sides and carbonate nodules with varying distribution. Bhattacharyya *et al.*, (2007) studied the morphological properties of red and black soils and observed that black soils, due to their very sticky and very plastic consistency under wet condition, showed well-developed slickensides.

In case of red soil pedons, horizons were identified based on colour, texture, an abundance of coarse fragments. In the red soil, the coarse fragments were high when compared to the black soil. Rudramurthy and Dasog (2001) while studying the associated red and black soils of North Karnataka observed that red soils were characterized by redder hue, high chroma and abundance of coarse fragments in their horizons.

Soil depth

Soil depth varied from 75 cm to more than 150 cm across 11 pedons indicating that they were moderately shallow to very deep. Solum depth reflects the balance between soil formation and soil loss by erosion in any area. The variability in soil depth was due to the variation in topography and slope gradient (Singh and Mishra, 1996). They related to soil depth to physiography; shallow soils on upland pedons due to non-availability of an adequate amount of water for a prolonged period and deeper soils on lower plains due to deposition of finer particles.

Soil colour

Colour of red soil pedons varied from 2.5YR 2.5/3 (dark reddish brown) to 5YR 4/4 (reddish brown) and 7.5YR 3/3 (dark brown) to 10YR 4/4 (dark yellowish brown) in black soil pedons. The soil colour is a function of chemical and mineralogical composition and influenced by topographic position, textural makeup and moisture regimes of the soils. Essentially, the landform position is known to greatly influence the soil colour where intermittent cycles of erosion and runoff intervening not only the matrix colour but also the soil material development. The dark matrix colour of surface horizon was due to presence of high organic matter content (Tripathi *et al.*, 2006). Whereas, the sub-surface horizons had comparatively brighter colour throughout the profile, which might be due to low organic matter content and higher iron oxide. In black soils, chroma did not change along depth. This might be due to higher degree of pedoturbation.

Soil texture

Soil texture, in general, varied from sandy clay to clay. In red soil pedons, soil texture varied from sandy clay to clay whereas in case

of black soil pedons it was clay. This textural variation was ascribed to differences in composition of parent material, topography, *in-situ* weathering and translocation of clay by eluviation and age of soils (Prathibha *et al.*, 2018).

Soil structure

The structure designates the mode of arrangement of the particles and their aggregations, therefore the structural variation in soils were useful to differentiate the horizon (Landey *et al.*, 1982).

In black soil pedons, both surface and subsurface horizons had moderate medium sub-angular blocky structure to moderate medium angular blocky which was due to high clay content in black soils. Sub-angular to angular blocky structure in the sub-soil horizons was due to slicken sides formation in these soils. Dominantly, the soil structure was weak fine sub-angular blocky to moderate medium sub-angular blocky. The weak structural development was ascribed to low clay and low organic carbon content (Sitanggang *et al.*, 2006).

Soil consistency

The consistency of soil pedons varied from slightly hard to very hard when dry, friable to the firm when moist, slightly sticky to very sticky and slightly plastic to very plastic when wet. The clay content of the soil is known to play a major role in the expression of consistency.

The soils of eroded land were low in clay content due to dispersion and removal and consequently the consistency status was lower than that of the soil unaffected by the erosion. The attribute and relief were considered to have a significant bearing on soil consistency (Anjali and Hebbara, 2017).

Soil classification

The soils of the study area were classified up to family level as per Keys to Soil Taxonomy (Soil survey staff, 2014) based on the morphological, physical and chemical properties of soils. These soils were grouped into three orders viz., Alfisols, Inceptisols and Vertisols. The soils classified upto family level is presented in table 2.

The pedons morphology exhibited argillic subsurface diagnostic horizon in pedons 1, 2, 3, 4, 5, 6, 8 and 11 whereas, pedons 7, 9 and 10 evidenced the presence of cambic horizon. The significant translocation of illuvial clay from the surface horizon to the subsurface horizon qualified the subsurface horizon to be designated as an argillic horizon (Chari, 2015)

The pedons 1, 2, 3, 4, 5, 6, 8 and 11 were classified under order Alfisols as they possessed argillic horizon and base saturation more than 35 per cent. Since moisture regime was ustic, it was classified under suborder ustalfs.

The pedon 5 was classified as rhodustalfs due to 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 colors that have hue of 2.5YR or redder and value, moist, of 3 or less. Pedons 1, 2, 3, 4, 6, 8 and 11 were classified as haplustalfs since they do qualify under other ustalfs but does not have characteristics of any other great groups.

At the sub-group level, because of absence of inter-gradation with other taxa or an extra-gradation from the central concept, the pedons 2, 3, 5 and 11 were keyed out as Typic haplustalfs and Typic rhodustalfs. Pedons 1, 4, 6 and 8 were grouped under Ultic Haplustalfs as they have argillic horizon with a base saturation of less than 75 per cent throughout.

Table.1 Morphological characteristics of pedons of Hebbalagere micro watershed

Horizon	Depth (cm)	Colour		Texture	Structure	Consistency		Stickiness	Root	Special features
		Dry	Moist			Dry	Moist			
					Pedon 1					
Ap	0-20	7.5YR 4/3	7.5YR 3/3	sc	2msbk	h	fr	ms	vf-c	Micro features like cracks and clay cutons was observed
Bt ₁	20-45	7.5YR 4/3	7.5YR 3/3	sc	2msbk	h	fr	ms	vf-m	
Bt ₂	45-78	7.5YR 4/3	7.5YR 3/3	sc	2msbk	h	fr	ms	vf-c	
Bt ₃	78-110	7.5YR 4/3	7.5YR 3/3	sc	2msbk	h	fr	ms	-	
Bt ₄	110-152	7.5YR 4/3	7.5YR 3/4	sc	2msbk	h	fr	ms	-	
					Pedon 2					
Ap	0-16	5YR 2.5/2	5 YR 3/2	c	2msbk	mh	fr	ms	vf-m	Clay cutons were observed
Bt ₁	16-36	5YR 2.5/2	5YR 3/2	c	2msbk	mh	fr	ms	vf-m	
Bt ₂	36-61	5YR 2.5/2	5YR 3/3	c	2msbk	mh	fr	ms	vf-m	
Bw ₁	61-87	5YR 2.5/2	10YR 3/2	c	2msbk	mh	fr	ms	vf-m	
Bw ₂	87-99	5YR 2.5/2	10YR 3/2	c	2msbk	mh	fr	ms	-	
Bw ₃	99-130+	5YR 2.5/2	10YR 3/2	c	2msbk	mh	fr	ms	-	
					Pedon 3					
Ap	0-17	5YR 3/3	5YR 2.5/2	c	2msbk	sh	fr	ms	vf-m	Clay cutons were observed
Bt ₁	17-40	5YR 3/3	5YR 2.5/2	c	2msbk	sh	fr	ms	vf-m	
Bt ₂	40-65	5YR 3/3	5YR 2.5/2	c	2msbk	sh	fr	ms	vf-m	
Bt ₃	65-90	5YR 4/3	5YR 2.5/2	c	2msbk	sh	fr	ms	vf-m	

Horizon	Depth (cm)	Colour		Texture	Structure	Consistency		Stickiness	Root	Special features
		Dry	Moist			Dry	Moist			
					Pedon 4					
Ap	0-15	10YR 3/2	10YR 2/2	sc	2msbk	h	fi	ms	vf-c	Micro features like clay cutons were observed
Bt ₁	15-28	10YR 3/2	10YR 2/2	c	2msbk	h	fi	vs	f-c	
Bt ₂	28-75	10YR 3/2	10YR 7/1	sc	2msbk	h	fi	ms	-	
					Pedon 5					
Ap	0-15	2.5YR 3/4	2.5YR 2.5/3	c	2msbk	h	fi	ms	vf-m	Stoniness and clay cutons were observed
Bt ₁	15-30	2.5YR 3/4	2.5YR 3/4	c	2msbk	h	fi	ms	vf-m	
Bt ₂	30-50	2.5YR 3/4	2.5YR 3/3	sc	2msbk	h	fr	ms	vf-m	
Bt ₃	50-65	2.5YR 3/4	2.5YR 3/4	sc	1fsbk	h	fr	ms	vf-m	
Bt ₄	65-83	2.5YR 3/4	2.5YR 3/4	sc	1fsbk	h	fr	ms	vf-m	
BC	83-93	2.5YR 3/4	2.5YR 4/6	scl	2msbk	h	fr	ms	vf-m	
					Pedon 6					
Ap	0-20	5YR 4/4	5YR 3/3	sc	2msbk	mh	fr	ms	vf-m	Clay cutons were observed
Bt ₁	20-50	5YR 4/4	5YR 2.5/2	sc	2msbk	mh	fr	ms	vf-m	
Bt ₂	50-75	5YR 4/4	5YR 3/3	sc	2msbk	mh	fr	ms	vf-m	
Bt ₃	75-110	5YR 4/4	5YR 3/3	sc	2msbk	mh	fr	ms	-	
Bt ₄	110-160+	5YR 4/4	5YR 3/3	sc	2msbk	mh	fr	ms	-	

Horizon	Depth (cm)	Colour		Texture	Structure	Consistency		Stickiness	Root	Special features
		Dry	Moist			Dry	Moist			
					Pedon 7					
Ap	0-20	10YR 3/2	10YR 2/2	c	2mabk	h	fi	vs	vf-m	Micro features like cracking was observed
Bw₁	20-38	10YR 3/2	10YR 2/2	c	2mabk	h	fi	vs	vf-m	
Bw₂	38-60	10YR 3/2	10YR 2/1	c	2mabk	h	fi	vs	vf-c	
Bw₃	60-80	10YR 3/2	10YR 2/1	c	2mabk	h	fi	vs		
Bw₄	80-95	10YR 3/2	10YR 2/1	c	2mabk	h	fi	vs		
Bw₅	95-114+	10YR 3/2	10YR 2/1	c	2mabk	h	fi	vs		
					Pedon 8					
Ap	0-14	7.5YR 3/2	7.5YR 2.5/3	c	2mabk	mh	fr	ms	vf-m	Stoniness and clay cutons were observed
Bt₁	14-29	7.5YR 3/2	5YR 3/3	sc	2mabk	mh	fr	ms	vf-m	
Bt₂	29-49	7.5YR 3/2	5YR 3/4	sc	2mabk	mh	fr	ms	vf-m	
Bt₃	49-71	7.5YR 3/2	2.5YR 3/4	sc	2mabk	mh	fr	ms	-	
Bt₄	71-98	7.5YR 3/2	7.5YR 3/4	sc	2mabk	mh	fr	ms	-	
Bt₅	98-129+	7.5YR 3/2	7.5YR 3/4	sc	2mabk	mh	fr	ms	-	

Horizon	Depth (cm)	Colour		Texture	Structure	Consistency		Stickiness	Root	Special features
		Dry	Moist			Dry	Moist			
Pedon 9										
Ap	0-19	7.5YR 4/4	7.5YR 3/4	c	2msbk	h	fi	vs	vf-c	Micro features like cracking were observed
Bw ₁	19-40	7.5YR 4/4	10YR 3/3	c	2msbk	h	fi	vs	vf-c	
Bw ₂	40-75	7.5YR 4/4	10YR 4/4	c	2msbk	h	fi	vs	vf-c	
Bw ₃	75-110	7.5YR 4/4	10YR 3/3	c	2msbk	h	fi	vs	-	
Bw ₄	110-150	7.5YR 4/4	10YR 3/3	c	2msbk	h	fi	vs	-	
Pedon 10										
Ap	0-15	10YR 3/2	10YR 2/2	c	2mabk	h	fi	vs	vf-m	Cracking and slickensides was observed
Bss ₁	15-33	10YR 3/2	10YR 2/2	c	2mabk	h	fi	vs	vf-m	
Bss ₂	33-50	10YR 3/2	10YR 2/2	c	2mabk	h	fi	vs	vf-m	
Bss ₃	50-68	10YR 3/2	10YR 2/2	c	2mabk	h	fi	vs	vf-m	
Bss ₄	68-93	10YR 3/2	10YR 2/2	c	2mabk	h	fi	vs	vf-m	
Bss ₅	93-130+	10YR 3/2	10YR 3/3	c	2mabk	h	fi	vs	vf-m	

Horizon	Depth (cm)	Colour		Texture	Structure	Consistency		Stickiness	Root	Special features
		Dry	Moist			Dry	Moist			
Pedon 11										
Ap	0-19	7.5YR 4/4	7.5YR 3/3	sc	1msbk	mh	fr	ms	vf-m	Micro features like clay cutons were observed
Bt ₁	19-49	7.5YR 4/4	5YR 3/3	sc	2msbk	mh	fr	ms	vf-m	
Bt ₂	49-75	7.5YR 4/4	5YR 3/4	sc	2msbk	mh	fr	ms	vf-m	
Bt ₃	75-106	7.5YR 4/4	2.5YR 4/4	sc	2msbk	mh	fr	ms	-	
Bt ₄	106-128	7.5YR 4/4	2.5YR 3/3	sc	2msbk	mh	fr	ms	-	
Bt ₅	128-140+	7.5YR 4/4	2.5YR 3/4	sc	1msbk	mh	fr	ms	-	

c-clay; sc-sandy clay; scl-sandy clay loam; h-hard; mh-moderately hard; sh-slightly hard; fr-friable; fi-firm; m-moderate; sbk-sub angular blocky; abk-angular blocky; ms-moderately sticky; vs-very sticky; vf-very fine; c-coarse, m-medium.

Table.2 Taxonomical classification of soil pedons of Hebbalagere micro watershed

Pedon No.	Soil classification
1	Fine, mixed, active, Isohyperthermic, Ultic Haplustalfs
2	Fine, mixed, superactive, Isohyperthermic, Typic Haplustalfs
3	Fine, mixed, superactive, Isohyperthermic, Typic Haplustalfs
4	Fine, mixed, active, Isohyperthermic, Ultic Haplustalfs
5	Fine, mixed, active, Isohyperthermic, Typic Rhodustalfs
6	Fine, mixed, superactive, Isohyperthermic, Ultic Haplustalfs
7	Very fine, mixed, superactive, Isohyperthermic, Typic Haplustepts
8	Fine, mixed, superactive, Isohyperthermic, Ultic Haplustalf
9	Fine, mixed, superactive, Isohyperthermic, Typic Haplustepts
10	Fine, mixed, superactive, Isohyperthermic, Typic Haplusterts
11	Fine, mixed, superactive, Isohyperthermic, Typic Haplustalfs

The soils of pedon 7 and 9 were grouped under order Inceptisols, because of the presence of cambic horizon. Because of the prevailing ustic moisture regime, they were identified as ustepts under suborder. At the great group level, pedons 7 and 9 were classified as haplustepts. These pedons which exhibited no inter-gradation with other taxa or an extra-gradation from the central concept were keyed out as Typic haplustepts.

Pedon 10 was classified as Vertisols at the order level and had a weighted average of > 30 per cent clay in all the horizons down to a depth of 100 cm and possessed cracks that open and close periodically. This pedon had a layer (> 25 cm thickness) of slickensides and wedge shaped peds within 100 cm from the soil surface. At sub order level, pedon 10 was classified as ustert because of ustic moisture regime. At the great group level, keyed out as haplusterts. Because of absence of inter-gradation with other taxa or an extra-gradation from the central concept, the pedon was keyed out as Typic haplusterts.

Classification of pedons at family level was done based on particle size, mineralogical class, CEC and temperature. Pedons 1, 2, 3, 4, 5, 6, 8, 9, 10 and 11 contained more than 35

but less than 60 per cent clay (weighted average) in the control section, which led to the grouping of these pedons under fine particle size class. Pedon 7 contained more than 60 per cent clay (weighted average) in the control section and was classified as very fine particle size class.

MAST (Mean annual soil temperature) was computed by adding 3.5⁰C to the MAAT (Mean annual air temperature) which was 26⁰C in the micro-watershed. Based on this, the study area was classified under hyperthermic (MAST >22⁰C). The difference between mean summer and winter temperatures was less than 6⁰C making it isohyperthermic.

Pedons 2, 3, 5, 6, 7, 8, 9, 10 and 11 were classified as superactive active while pedons 1 and 4 were classified as active. The cation exchange activity class of above pedons was rated as superactive as the ratio of CEC to clay exceeded 0.60 while in remaining pedons it was active as the CEC to clay content ratio was between 0.4 to 0.6.

Soils of Hebbalagere micro watershed were grouped into 11 soil series like Billahalli (BLH), Chennagiri (CNG), Ganduganahankalu (GDG), Hireganguru

(HRG), Jammapura (JMP), Lakshmisagar (LKS), Mangenahalli (MGN), Pandavamatte (PDM), Rangapura Thanda (RGT), Rangapura (RGP) and Vaddanala (VDN) by considering soil depth, amount and nature of gravel, depth of occurrence of gravel layer and nature of substratum present below soil and horizon sequence.

Soils of Hebbalagere micro-watershed varied with respect to morphological, physical and chemical properties and were classified based on these at the order level as Alfisols, Inceptisols and Vertisols. Similar approach was followed by Prathibha *et al.*, (2018) in classifying the soil resources of Kavalur-1 micro-watershed in Koppal district of Karnataka.

Eleven representative soil pedons were identified in Hebbalagere micro-watershed which were characterized and classified. The soils were moderately shallow to very deep in depth. The soil texture varied from sandy clay to clay in red soils and largely clay in black soils. Irrespective of soil type, the soil structure remained largely sub angular blocky. Slickensides were observed in pedon 10. The consistency of soil pedons varied from slightly sticky to very sticky and slightly plastic to very plastic when wet. Taxonomically, the soils of the Hebbalagere micro-watershed were classified under the orders Alfisols (pedons 1, 2, 3, 4, 5, 6, 8 and 11), Inceptisols (pedons 7 and 9) and Vertisols (pedon 10).

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