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Soil morphological properties and classification of kavalur-1 micro-watershed of Koppal district, Karnataka

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Abstract
The Kavalur-1 micro-watershed of Koppal district, Karnataka was systematically surveyed using satellite imagery (IRS P6 LISS-IV), cadastral map and topo-sheet. Eighteen typical soil pedons representing varied physiographic features were identified and examined for their morphological features. Among them, eight (Pedon 1, 3, 4, 5, 9, 12, 13 and 18) and 10 (pedon 2, 6, 7, 8, 10, 11, 14, 15, 16 and 17) soil pedons represented respectively, the black and red soil areas. The detailed morphological descriptions of the pedons were done in the field as per the procedure outlined in Soil Survey Manual. The results revealed that the pedons were deep (100 - 150 cm) to very deep (>180) and varied in colour from reddish brown (2.5 YR 4/4) to dark reddish brown (5 YR 3/4) in case of red soils and dark grayish brown (10 YR 4/2)) to brown (10 YR 5/3) in case of black soils. Soil texture varied from sandy clay loam to clay and showed weak to moderate sub-angular structure. Consistence of soil pedons varied from slightly hard to very hard when dry, very friable to firm when moist, slightly sticky to very sticky and slightly plastic to very plastic when wet. Taxonomically, the soils of the study area were classified under the orders Alfisols, Inceptisols and Vertisols.

Keywords: kavalur-1 micro-watershed, soil survey manual, alfisols, inceptisols and vertisols

Introduction
Soil is a valuable resource and a critical component in many of the environmental and economic issues facing today's society. The inherent ability of soils to supply nutrients for crop growth and maintenance of soil physical conditions to optimize crop yields is the most important component of soil fertility that virtually determines the productivity of agricultural system.

A thorough and proper understanding of morphological characteristics and classification of soils (Basavaraju *et al*., 2005) [2] gives greater insight into the dynamics of the soil and also suggests land use plan to protect our finite soil resource to achieve sustainable crop production. The main objectives of this investigation were to characterize the soils of the area, to classify the soils according to the Soil Taxonomy System (Anon., 2014) [1] and to provide basic information about the soils for agricultural development. Detailed soil survey is useful in deciding sustainable agricultural land use options. It also provides adequate information in terms of land form, slope, land use as well as characteristics of soils (*viz.*, texture, depth, structure, stoniness, drainage *etc.*) which can be utilized for the planning and development (Pinki *et al.*, 2017) [10].

Classification *per se* 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. They are termed as differentiating characteristics as they differentiate and serve to separate one class from the others. For classifying the individuals of a large and widely varying population, such as soils, it is useful to group individuals into classes and further into higher classes. 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). Therefore, soil classification is helpful in identifying their potential uses, estimating their productivity and transferring agro-technology from research farms to cultivators' fields.

Material and Methods
Kavalur-1 micro-watershed having an area of 463.57 ha is located between 15° 16' 35" and 15° 17' 40" N latitude and 75° 57′ 30″ and 75° 54′ 55″ E longitude in Koppal district (Zone -3, northern dry zone) of Karnataka, India. The average elevation of the micro-watershed is 551.7 m above MSL. The length of growing period (LGP) is <90 to 120 days (Ramamurthy *et al.*, 2009) [11]. The Kavalur-1 micro-watershed has both red and black soils, though the former is

dominant. The climate is semi-arid with a mean annual average rainfall of 572 mm.

The micro-watershed was surveyed survey number-wise using satellite imagery (IRS P6 LISS-IV), cadastral map and toposheets to collect information on surface features / site characteristics like soil texture, slope, erosion and graveliness. Based on soil heterogeneity, the polygons were drawn on the cadastral map indicating surface features. Pooling information from polygon maps, the transects were drawn on the satellite imagery from ridge to valley covering larger heterogeneity. Totally 18 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 (Anon., 2014) [1]. The colour of distinct horizons of pedons was measured both under dry and moist conditions using Munsell colour chart. Other morphological characteristics recorded included 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 (Anon., 2014) [1].

Based on the morphological, physical and chemical properties, the soils were classified up to family level by following Keys to Soil Taxonomy, Soil Survey Staff (Anon., 2014) [1].

Results and Discussion

Eighteen soil pedons representing different physiographic units of the micro-watershed were marked and sampled to assist morphological characterization. Eight of them (pedon 1, 3, 4, 5, 9, 12, 13 and 18) represented red soil areas while ten (pedon 2, 6, 7, 8, 10, 11, 14, 15, 16 and 17) were from black soil areas. Landscape slope was nearly level (0-1 % slope) to gently undulating (1-3 % slope) and exhibited slight to severe erosion and moderately well drained conditions.

Morphological properties of pedons

Horizon differentiation

Horizon differentiation in black soil was relatively weak compared to that of red soils. This was attributed to the process of pedo-turbation interfering with horizonation. Similar observation was made by Bhattacharjee *et al*. (1974) [3] in black soils of Deccan plateau. The horizon identification in black soil pedons are made mostly based on intersecting slickensides and the horizontal and vertical nature of cracks. Pedon 9 of Kavalur-1 micro-watershed exhibited these properties. In case of red soil pedons, horizons were identified based on colour, texture, abundance of coarse fragments.

Soil depth

The soils of the study area were deep to very deep. Pedons 4, 8, 11 were deep (100 - 150 cm); pedons 1, 2, 3, 5, 6, 7, 9, 10, 12, 13, 14, 15, 16, 17 and 18 were very deep (>180) in nature (Table 1). Solum depth reflects the balance between soil formation and soil loss by erosion in any area which in turn are governed by topography and slope. Soil depth varied from 110 cm to more than 150 cm across 18 pedons indicating lesser erosion intensities in the area. Similar observations were also made by (Singh and Mishra, 1996) [14].

Table 1: Morphological characteristics of red and black soil pedons in Kavalur-1 micro-watershed

Horizon	Depth (cm)	Colour matrix		Texture	Structure	Consistency			Roots	Boundary	Special features
		Dry	Moist			Dry	Moist	Wet			
Red soil pedons											
Pedon 2											
Ap	0-19	5YR 4/4	5YR 4/3	scl	1msbk	sh	fr	ms & mp	mft	cs	Animal activity in Bt horizon
Bt	19-49	2.5YR ¾	2.5YR 3/3	Sc	1msbk	sh	vfr	ms & mp	fft	cs	
CB	49-88	2.5YR 4/4	2.5YR 3/4	scl		sh	vfr	ss & sp		cs	
Cr	88-140+	Weathered parent rock (Schist)									
Pedon 6											
Ap	0-27	10YR 4/3	10YR 3/3	c	2msbk	sh	fr	ms & mp	mft	cs	
Bw	27-82	-	7.5YR 3/3	c	2msbk	h	fr	ms & mp	fft	cs	
Bt_1	82-112	5YR 4/3	5YR 3/3	sc	2msbk	vh	fr	ms&ms		cs	
Bt_2	112-180+	5YR 4/4	5YR ¾	sc	2msbk	vh	fr	ms&ms			
Pedon 7											
Ap	0-21	5YR 4/4	5YR 4/3	sc	1msbk	sh	vfr	ms & mp	mft	cs	
Bt_1	21-70	2.5YR ¾	2.5YR 3/3	sc	2msbk	sh	fr	ms & mp	mft	cs	
Bt_2	70-115	5YR 4/4	5YR 4/4	sc	1msbk	sh	fr	ms & mp	fft	cs	
Bt_3	115-141	2.5YR 5/6	2.5YR 4/6	sc	1msbk	sh	fr	ms & mp		cs	
BC	141-180	5YR 5/6	5YR 4/4	sc	1msbk	sh	fr	ss & sp		cs	
Pedon 8											
Ap	0-18	5YR 4/3	5YR 3/2	sc	1msbk	h	fr	ms & mp	mft	cs	
Bt	18-52	2.5YR 3/2	2.5YR 3/2	sc	2msbk	h	fr	ms & mp	fft	cw	
BC	52-89	2.5YR 5/6	2.5YR 4/6	scl	2msbk	sh	vfr	ms & mp		cs	
C	89-152	Weathered granite-gneiss									
Pedon 10											
Ap	0-18	5YR 4/4	5YR 4/4	sc	1msbk	h	fr	ss & sp	mft	cs	
Bt_1	18-44	2.5YR ¾	2.5YR 3/3	sc	2msbk	h	fr	ms & mp	mft	cs	
Bt_2	44-95	2.5YR 4/6	2.5YR 3/6	sc	1msbk	h	fi	ms & mp	fft	cs	
BC	95-180+	2.5YR 4/6	2.5YR 4/6	scl	1msbk	h	fr	ms & mp			
Pedon 11											
Ap	0-20	2.5YR 4/6	2.5YR 3/4	sc	1msbk	sh	fr	ss & sp	mft	cs	
Bt	20-91	2.5YR ¾	2.5YR 3/6	Scl	1msbk	h	fr	ms & mp	fft	cs	
Cr	91-110	Weathered granite-gneiss									

Pedon 14										
Ap	0-19	5YR 4/4	5YR 3/4	scl	1msbk	sh	vfr	ms & mp	mft	cs	
Bt_1	19-83	2.5YR 4/4	2.5YR 3/6	sc	1msbk	sh	vfr	ms & mp	fft	cw	
Bt_2	83-103	5YR 4/4	5YR ¾	sc	1msbk	sh	vfr	ms & mp		cs	
Cr	103-175+	Weathered granite-gneiss									
Pedon 15										
Ap	0-24	5YR 4/4	5YR 4/3	scl	1msbk	sh	fr	ss & sp	mft	cs	Conca was observed between 173 to 180+cm depth
Bt_1	24-74	2.5YR 4/6	2.5YR 3/4	scl	2msbk	h	fr	ss & sp	fft	cs	
Bt_2	74-129	-	2.5YR 3/3	Scl	2msbk	sh	fr	ss & sp	ffp	cs	
Bt_3	129-173	2.5YR 4/4	2.5YR 3/3	scl	1msbk	sh	vfr	ss & sp		cs	
Bk	173-180+	2.5YR 3/3	2.5YR 2.5/3	sc	1msbk	sh	vfr	ms&ms			
Pedon 16										
Ap	0-26	5YR 4/4	5YR 4/3	sc	1msbk	h	fr	ms & mp	mft	cs	
Bt_1	26-81	2.5YR 3/2	2.5YR 3/2	sc	2mabk	vh	fr	ms & mp	mft	cs	
Bt_2	81-139	2.5YR 3/3	2.5YR 2.5/3	sc	2mabk	vh	fr	ms & mp	ffp	cs	
Bt_3	139-180	2.5YR 4/4	2.5YR 3/4	sc	1msbk	sh	fr	ms & mp			
Pedon 17										
Ap	0-25	2.5YR 4/4	2.5YR 3/3	scl	1msbk	sh	fr	ss & sp	mft	cs	
Bt_1	25-47	2.5YR ¾	2.5YR 3/3	sc	1msbk	sh	fr	ms & mp	mft	cs	
BC	47-82	2.5YR 4/6	2.5YR 3/4	scl	1msbk	sh	fr	ss & sp	fft	cs	
CB	82-151	2.5YR 4/6	2.5YR 4/6	sl	1msbk	sh	fr	ss & sp		cs	
C	151-186+	Weathered granite gneiss									
Black soil pedons										
Pedon 1										
Ap	0-28	10YR 4/2	10YR 4/2	c	2msbk	h	fr	ms & mp	mft	cs	8-10cm wide cracks, 26cm deep was observed on surface and slight effervescencewas observed in all depths
Bw_1	28-53	10YR 4/2	10YR 3/2	c	2msbk	h	fr	ms & mp	ffp	cs	
Bw_2	53-94	10YR 4/2	10YR 3/2	c	2msbk	vh	fi	ms & mp		cw	
Bw_3	94-162	-	10YR 2/1	c	2mabk	vh	fi	vs &vp		cs	
BC	162-180+	-	10YR4/2	c	2msbk	vh	fr	ms & mp			
Pedon 3										
Ap	0-25	10YR 4/2	10YR 3/2	c	1msbk	sh	fr	ms & mp	mft	cs	3cm wide and 22cm deep cracks was observed on surface and effervescence with dil. HCl was increased with depths
Bw_1	25-53	10YR 4/1	10YR 3/1	c	2msbk	h	fr	ms & mp	fft	cs	
Bw_2	53-74	10YR 3/1	10YR 3/2	c	2mabk	vh	fi	vs &vp		cs	
Bw_3	74-97	10YR 4/1	10YR 4/2	sc	1msbk	sh	vfr	ms & mp		cs	
BCk	97-135	10YR 5/3	10YR 5/4	sc	2msbk	vh	fi	ms & mp		cs	
C	135-180	Weathered parent rock (Schist)									
Pedon 4										
Ap	0-23	10YR 4/2	10YR 3/2	c	1msbk	sh	fr	ms & mp	mft	cs	Conca, was observed in 45-120cm depth
Bw_1	23-45	10YR 3/1	10YR 3/2	c	1msbk	h	fr	ms & mp	mft	cs	
Crk	45-150	Weathered parent rock (Schist) with $CaCO_3$ concretions									
Pedon 5										
Ap	0-22	10YR 4/2	10YR 3/2	c	2msbk	sh	fr	ms &mp	mft	cs	Strong effervescence with dil. HCl was observed between 0 to 120 cm depths
Bw_1	22-58	-	10YR 3/1	c	2msbk	h	fr	ms &mp	fft	cs	
Bwk	58-120	-	10YR 2/1	c	2msbk	h	fr	ms &mp		cs	
Ck	120-180	Weathered parent rock (Schist) with $CaCO_3$ concretions									
Pedon 9										
Ap	0-20	10YR 4/2	10YR 3/2	c	2msbk	h	fr	ms & mp	mft	cs	Pressure faces was observed at depth 20-82 cm and slickenside at 148-189 cm depth
Bss_1	20-82	10YR 3/1	10YR 3/1	c	2mabk	vh	fr	ms & mp	fft	cs	
Bss_2	82-148		10YR 3/1	c	2mabk	vh	fi	vs &vp	ffp	cs	
Bss_3	148-189		10YR 2/1	c	2mabk	vh	fi	vs &vp			
Pedon 12										
Ap	0-29	5YR 4/4	5YR 3/3	sc	2msbk	sh	fr	ms & mp	mft	cs	strong effervescence was observed at 99-130cm depth
Bw_1	29-76	10YR 2/1	10YR 2/1	c	2mabk	vh	fi	vs &vp	fft	cs	
Bw_2	76-99	10YR 4/1	10YR 4/1	c	1msbk	sh	vfr	ms & mp		cs	
BCk_1	99-130	-	-	sc	0msbk	sh	vfr	ss & sp		cs	
BCk_2	130-170	-	-	c	0msbk	sh	vfr	ms & mp		cs	
Pedon 13										
Ap	0-29	10YR 3/3	10YR 3/2	sc	1msbk	sh	fr	ms & mp	mft	cs	Conca was observed between 55-180+cm depths
Bw_1	29-55	10YR 4/2	10YR 3/2	c	2msbk	h	fr	ms & mp	fft	cw	
Bw_2	55-90	10YR 4/2	10YR 3/2	c	2msbk	h	fr	ms & mp	fft	cs	
BCk	90-118	10YR 4/2	10YR 4/2	sc	1msbk	sh	fr	ms & mp		cs	
Crk	118-180+	Weathered parent rock (Schist) with $CaCO_3$ concretions									
Pedon 18										

Ap	0-22	7.5YR 3/3	7.5YR 3/3	c	2msbk	h	fr	ms & mp	mft	cs	
Bw_1	22-54	7.5YR 4/3	7.5YR 3/3	c	2msbk	vh	fr	ms & mp	fft	cs	
Bw_2	54-80	7.5YR 4/3	7.5YR 3/3	c	2msbk	vh	fr	ms & mp		cs	
Bw_3	80-99	10YR 4/2	10YR 3/2	c	2msbk	vh	fr	ms & mp		cs	
Bw_4	99-163	10YR 2/1	10YR 2/1	c	1mabk	vh	fr	ms & mp		cs	
C	163-200	Weathered parent rock (Schist)									

Soil colour

The colour of red soil pedons varied from 2.5 YR 4/4 (reddish brown) to 5 YR 3/4 (dark reddish brown) while the colour of black soil pedons varied from 10 YR 4/2 (dark grayish brown) to 10 YR 5/3 (brown) Table 1. This gradation in soil colour is ascribed to varied chemical and mineralogical composition, topographic position, textural make up and moisture regimes of the soils. The results of the present study are in accordance with findings of Thangasamy *et al*. (2005) [16].

Soil texture

The soil texture, in general, varied from sandy clay loam to clay. In red soil pedons, soil texture varied from sandy loam to sandy clay loam 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 (Geetha and Naidu, 2013) [6].

Soil structure

The soil structure was weak medium sub-angular blocky in the surface horizon and it became moderate medium sub-angular blocky with increased depth in red soil pedons. This change in structure with depth was due to higher clay content in the sub surface horizons when compared to surface horizons. The weak structural development was ascribed to low clay and low organic carbon content (Sitanggang *et al.*, 2006) [15]. In black soil pedons, both surface and subsurface horizons had moderate medium sub-angular blocky structure. This was due to high clay content and non-movement of clay in black soils.

Soil consistency

The soil consistency of pedons varied largely among soil types, depths and also spatially. It varied from slightly hard to very hard when dry, very friable to firm when moist, slightly sticky to very sticky and slightly plastic to very plastic when wet. The consistency became more harder, firm, sticky and plastic with increasing depth owing to progressive increase in clay content with depth. The land attribute and relief were reported to have significant bearing on soil consistency (Mahapatra *et al.*, 2000) [7].

Among special features, the degree of effervescences increased with depth evidencing progressive increase in free lime content with depth. This was attributed to the dominance of calcification process in black soils and then illuvial movement of colloidal lime to lower depths with percolating water. Pressure faces (20 to 80 cm depth) and slickensides (148-189) were observed in pedon 9 (Table 1). Bhattacharyya *et al*. (2007) [4] studied the morphological properties of both red and black soils and observed well developed slickensides in black soil pedons and ascribed it to their very sticky and very plastic consistency under wet condition.

Soil classification

In Kavalur-1 micro-watershed, the soils were classified up to Family level. The soils were classified based on morphological, physical and chemical properties according to Soil Taxonomy. At higher categories (*i.e.*, 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 conditions were considered.

At the family level, the soil properties such as particle size, mineralogical class, CEC and temperature were considered as criteria for further classification. Pedons 1, 3 and 9 have smectite mineralogy, except pedons 2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17 and 19. Pedons 1, 2, 3, 4, 5, 9, 12, 13, 10, 11, 14, 15 and 18 were classified as superactive while remaining pedons 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 (Anon., 2014) [1].

All the pedons belonged to isohyperthermic soil temperature regime as the difference between mean summer and winter temperature was less than 6^0C. MAST (Mean annual soil temperature) was computed by adding 3.5^0C to the MAAT (Mean annual air temperature) which was 24^0C in the micro-watershed. Based on this, the study area was classified under hyperthermic (MAST >22 ^{0}C) (Sehgal, 1996). The difference between mean summer and winter temperatures was less than 6 ^{0}C making it isohyperthermic.

The pedon's morphology exhibited argillic subsurface diagnostic horizon in pedons 2, 6, 7, 8, 10, 11, 14, 15, 16 and 17 whereas, pedons 1, 3, 4, 5, 12, 13 and 18 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 by Manjunatha Chari (2015) [8]. Based on these observations, the pedons 2, 6, 7, 8, 10, 11, 14, 15, 16 and 17 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 rhodustalfs. The pedons 2, 8, 10, 15, 16 and 17 were 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 6, 7, 11 and 14 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 were keyed out as Typic haplustalfs and Typic rhodustalfs.

The soils of pedon 1, 3, 4, 5, 12, 13 and 18 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 4 and 18 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. Pedons 1 and 3 were classified as vertic haplustepts as they possessed cracks within 125 cm of the mineral soil surface. Pedons 5, 12 and 13 were classified as calciustepts because of presence of free carbonates of more than 15 per cent (control section). At the sub-group level, this pedon was classified as Typic calciustepts.

Pedon 9 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.

Soil pedons 2, 10 and 15 were grouped under the order- Alfisols, suborder-ustalfs, great group- rhodustalf, subgroup-Typic rhodustalf and Family- fine-loamy mixed superactive isohyperthermic (Table 2). Soil pedons 8, 16 and 17 were grouped under the order- Alfisols, suborder-ustalfs, great group- rhodustalf, subgroup-Typic rhodustalf and Family-fine mixed active isohyperthermic. Soil pedons 6 and 7 were grouped under the order- Alfisols, suborder-ustalfs, great group- haplustalf, subgroup-Typic haplustalf and Family- fine mixed active isohyperthermic. Soil pedons 11 and 14 were grouped under the order- Alfisols, suborder-ustalfs, great group- haplustalf, subgroup-Typic haplustalf and Family-fine-loamy mixed superactive isohyperthermic. Soil pedons 1 and 3 were grouped under the order- Inceptisols, suborder-ustepts, great group- haplustepts, subgroup- vertic haplustepts and Family- fine mixed superactive isohyperthermic.

Soil pedons 5, 12 and 13 were grouped under the order- Inceptisols, suborder- ustepts, great group- calciustepts, subgroup- Typic calciustepts and Family- fine mixed superactive isohyperthermic. Soil pedons 4 and 18 were grouped under the order- Inceptisols, suborder- ustepts, great group- haplustepts, subgroup-Typic haplustepts and Family-fine mixed superactive isohyperthermic. Soil pedon 9 was grouped under the order- Vertisols, suborder- usterts, great group- haplusterts, subgroup-Typic haplusterts and Family-fine mixed superactive isohyperthermic. The summary of soil classification of Kavalur-1 micro-watershed is presented in Table 2. An area of 235 ha (50.65 % TGA) and 179 ha (38.58 % TGA) was comes under red and black soil type respectively (Fig. 1).

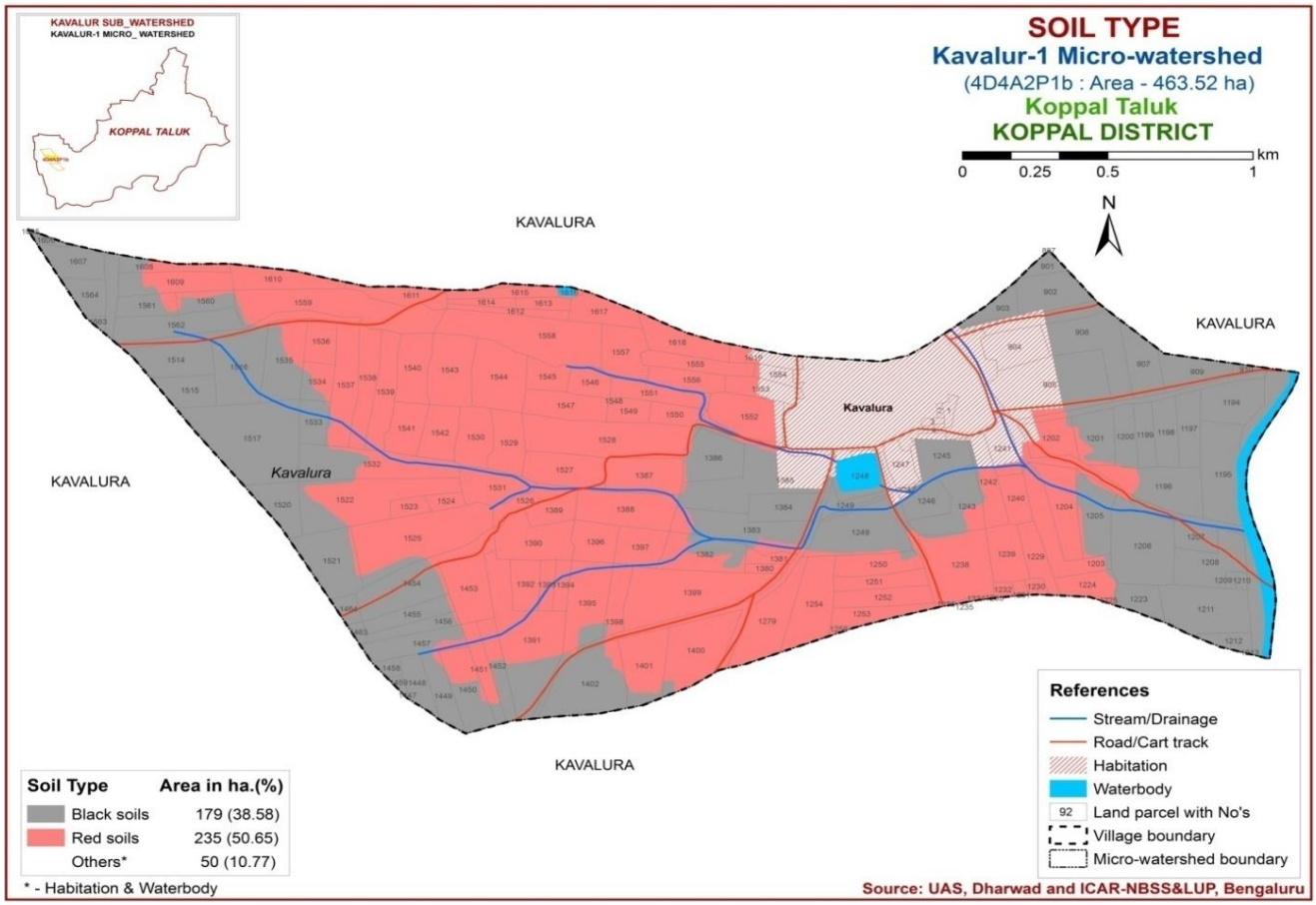

Fig 1: Soil types of Kavalur-1 micro-watershed

Soil mapping units

In Kavalur-1 micro watershed, 23 soil mapping units (KVR-1 to KVR-23) were identified based on physiography and soil characteristic and mapped as phases of series with the help of the ArcGIS software (Fig. 2). The mapping legend is presented as KVR-1-mB2. It includes the name of the series (e.g., KVR- Kavalur), surface texture (m- clay), slope (B = 1-3 %) of the land and erosion status (2 = moderate).

Similar approach was followed in classifying and mapping soils by many others (Murthy *et al.*, 1972; Dent and Young, 1981). The legend design or the kinds of mapping units for any given soil was determined by nature, procedure and kind of survey (Rourke, 1981) [12].

Table 2: Classification of soil pedons

Pedon	Soil classification
2,10,15	Fine loamy, mixed, superactive, isohyperthermic, Typic rhodustalf
8,16,17	Fine, mixed, active, isohyperthermic, Typic rhodustalf
6,7	Fine, mixed, active, isohyperthermic, Typic haplustalf
11,14	Fine loamy, mixed, superactive, isohyperthermic, Typic haplustalf
1,3	Fine, smectite, superactive, isohyperthermic, Vertic haplustepts
5,12,13	Fine, mixed, superactive, isohyperthermic, Typic calciustepts
4,18	Fine, mixed, superactive, isohyperthermic, Typic haplustepts
9	Fine, smectite, superactive, isohyperthermic, Typic haplusterts

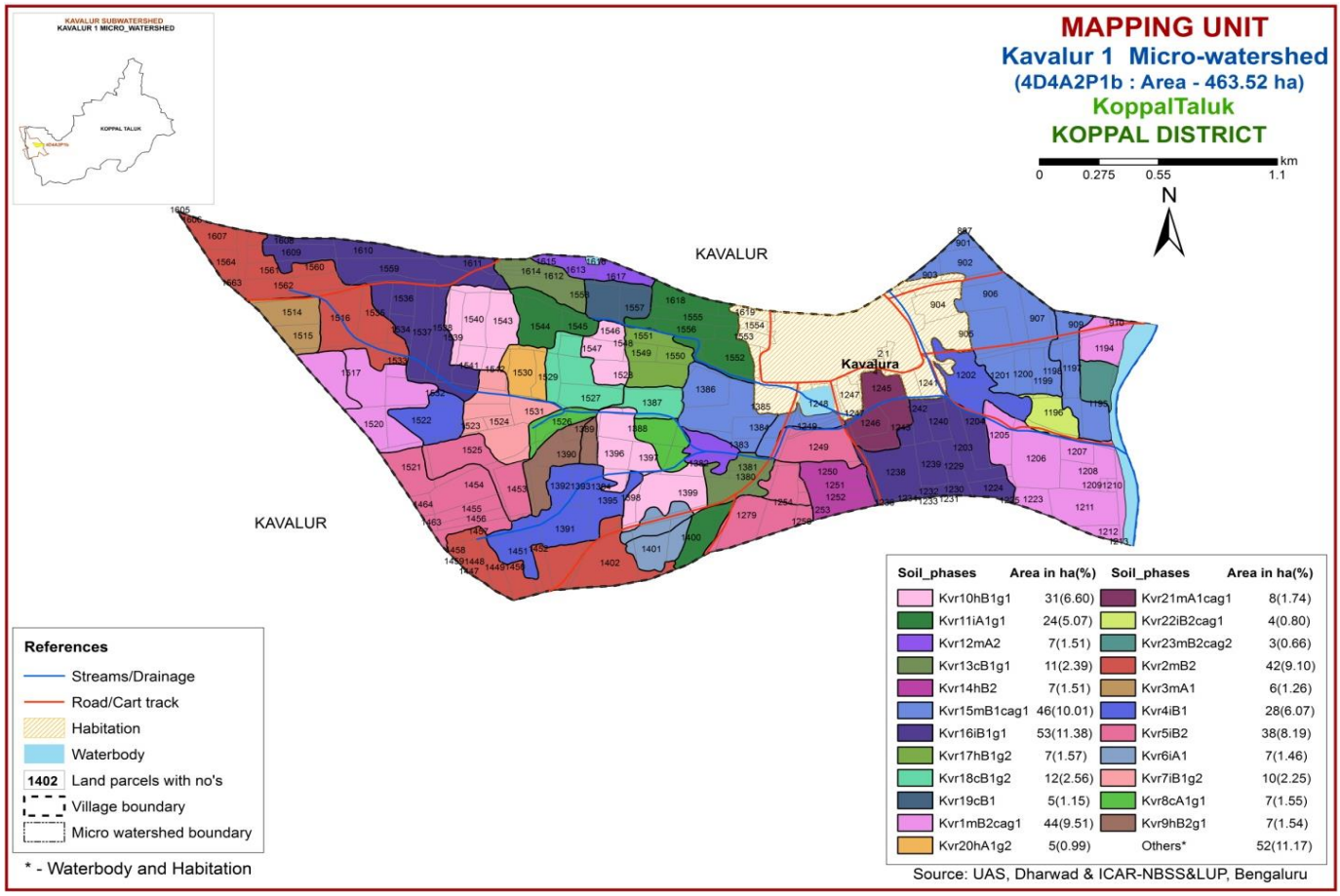

Fig 2: Mapping units of Kavalur-1 micro-watershed

Conclusions

Eighteen representative soil pedons were identified in Kavalur-1 micro-watershed and characterized and classified. The micro-watershed was dominated by red soils (represented by 10 pedons). Irrespective soil type, the soil pedons were deep (100 - 150 cm) to very deep (>180 cm) showing no constraint of soil depth for cultivation. The soil texture varied from sandy clay loam to sandy clay in red soils and largely clay in black soils. Irrespective of soil type, the soil structure remained largely subangular blocky. Slickensides and pressure faces were observed in pedon 9. Taxonomically, the soils of the Kavalur-1 micro-watershed were classified under the orders Alfisols (pedons 2, 6, 7, 8, 10, 11, 14, 15, 16 and 17), Inceptisols (pedons 1, 3, 4, 5, 12, 13 and 18) and Vertisols (pedon 9).

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