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Soil Morphological Properties and Classification of Kavalur Sub-Watershed of Koppal District, Karnataka

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ABSTRACT

Soils of Kavalur sub-watershed of Koppal district of Karnataka characterized and classified. Based on soil heterogeneity, twenty two profiles were studied for the morphological features. Among them, four (pedon 1, 2, 4 and 6) and 18 (pedon 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22) soil pedons belonged to red and black soil, respectively. 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 depth of the pedons varied from moderately deep (50 - 100 cm) to very deep (>180). The colour of red soil pedons varied from 2.5 YR 2.5/3 (dark reddish brown) to 5 YR 4/4 (reddish brown) and in black soils from 7.5 YR 3/3 (dark brown) to 10 YR 5/4 (yellowish brown). Soil texture varied from sandy clay loam to clay, having weak to moderately sub angular structure with many fine roots distributed in surface horizons. 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. Slickensides were observed in pedons 5 and 8. Pressure faces were observed in pedons 5, 7, 8, 9, 10, 17, 19 and 20. Soils were classified up to Family level. Taxonomically, the soils of the study area were classified under the orders Alfisols, Inceptisols and Vertisols.

Key words: *Soil survey manual, Alfisols, Inceptisols and Vertisols.*

INTRODUCTION

Land has been a means of survival for many years and it will continue its role as a major resource on this planet. Soil is one of the most important natural resources and proper understanding of its properties is necessary for judicious and optimal use on sustainable basis. Soil characterization helps in determining a soil's potential and in identifying the constraints in crop production besides giving detailed information about soil properties[9]. The system of farming in Kavalur sub-watershed (Koppal district) is changing over years in tune with introduction of newer technologies and crops/varieties in the area as like in other parts of the State.

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Unfortunately, it is the soil which has to bear all these stresses and still we want it to be sustainable productive. It was felt imperative to characterize these soils for their fertility status and productivity functions so as to plan for their efficient use. Identification of soil problems helps to plan ameliorative measures and improve soil productivity. It is the need of the hour to manage our resources on a sustainable manner so that the changes proposed to meet the needs of development are brought out without diminishing their potential for future use. Therefore, characterization of soil resources for planning better integration of management options was considered important for enhancing and sustaining farm productivity and income in these backward areas of Koppal taluk[10]. Morphology of soil is the more powerful tool than physical and chemical properties of soil, because it is observed under natural undisturbed condition.

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. 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)[1]. Therefore, soil classification is helpful in identifying their potential uses, estimating their productivity and transferring agro-technology from research farms to cultivator's fields.

MATERIALS AND METHODS

Kavalur sub-watershed is located between 15^0 15' 35.2" and 15^0 18'30.1" N latitude and 75^0 54'56.7" and 75^0 57' 28.9" E longitude, respectively (an elevation of 463.27) in nearly level to very gently sloping land of Koppal taluk, Karnataka (India) with an objective to know the morphological properties of the soils. The watershed comes under low rainfall zone (Zone 3) and climate is semi-arid with a mean annual average rainfall of 572 mm. The length of growing period (LGP) is <90 to 120 days[14]. The Kavalur sub-watershed has both red and black soils, though the former is dominant. The major agricultural crops grown are jowar, bajra, sunflower, maize, groundnut *etc* and trree species like Bellary jali (*Prosopis juliflora*), banni (*Acacia ferugenia*) and neem (*Azadiracta indica*) were predominantly found in this area.

The Kavalur sub-watershed was surveyed survey number-wise using satellite imagery (IRS P6 LISS-IV), cadastral map and toposheet to collect information on surface features / site characteristics like soil texture, slope, erosion and graveliness. Based on soil heterogeneity, Totally 22 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[1]. 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[1]. The horizons were identified and designated according to revisions in Soil Taxonomy[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[1].

RESULT AND DISCUSSION

Twenty two soil pedons were studied in sub-watershed and soil pedons distributed across all the physiographic units of the sub-watershed. Landscape slope was nearly level (0-1 % slope) to gently undulating (1-3 % slope) and exhibit slight to severe erosion having moderately well drainage condition. Pedons were classified into three categories upland (pedon 1, 5, 6, 7, 12 and 17), midland (pedon 2, 8, 10, 11, 13, 15, 16, 18, 21 and 22) and lowland pedons (pedon 3, 4, 9, 14, 19 and 20). The depth of low land pedon was comparatively more than that of midland and upland pedons. The results of the present study were in accordance with findings of Raju *et al*.[12]. The detailed descriptions of the soils of pedons were given below.

MORPHOLOGICAL PROPERTIES OF PEDONS

Morphological properties of pedons of Kavalur sub-watershed presented in table 1.

HORIZON DIFFERENTIATION

Horizon differentiation in black soil was relatively weak compared to that of red soils in the study area. The horizon identification in black soil pedons are made mostly based on intersecting slickensides and the horizontal and vertical nature of cracks. Pedon 5 and 8 of Kavalur sub-watershed exhibited these properties. In case of red soil pedons, horizons were identified based on colour, texture, abundance of coarse fragments. In the red soil, the coarse fragments were high when compared to the black soil. Similar observations were also made by Vinay[20] in Bhanapur micro-watershed of Koppal district, Karnataka.

SOIL DEPTH

The soils of the study area were moderately deep to very deep. Pedons 10, 12, 13, 15, 17, 18, 20, 21 and 22 were deep (100 - 150 cm), pedons 1, 2, 3, 4, 5, 6, 7, 9, 11, 16 and 19 were very deep (>180) and pedon 14 was moderately deep (50 - 100 cm) in nature. Solum depth reflects the balance between soil formation and soil loss by erosion in any area. Soil depth varied from 85 cm to more than 150 cm across pedons indicating that they were moderately deep to very deep. The variation of depth in relation to physiography, is mainly because of non-availability of adequate amount of moisture for prolonged period on upland soils associated with removal of finer particles and their deposition at lower pediplain have resulted in shallow soils in uplands and deeper soils in lowland physiographic units. The results obtained in the present study are in agreement with the findings of Ramprakash and Rao[13].

SOIL COLOUR

Colour of red soil pedons varied from 2.5 YR 2.5/3 (dark reddish brown) to 5 YR 4/4 (reddish brown) and 7.5 YR 3/3 (dark brown) to 10 YR 5/4 (yellowish brown) in black soil pedons. This variation in colour is a function of chemical and mineralogical composition, topographic position, textural make up and moisture regimes of the soils. The results of the present study were in accordance with findings of Thangasamy *et al*.[19]. The dark matrix colour of surface horizon was due to presence of high organic matter content. 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. Similar observation was made by Mohan[6] and Pulakeshi *et al.*[11].

SOIL TEXTURE

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 sandy clay loam to clay. This variation in texture was mainly because of difference in deposition of finer fractions[4]. According to Nayak *et al.*[8] texture variation is mainly due to differences in physiography.

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 might be due to higher clay content in the sub surface horizons when compared to surface horizons. 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. These results were in accordance with Murthy *et al.*[7] observed sub-angular blocky structure in the soils of Tungabhadra catchment. Similarly, Sumithra *et al.*[18] reported that the dominant structure observed was moderate, medium, sub-angular blocky structure in soils of Timanhal micro-watershed, Koppal district of Karnataka, which was a reflection of their sandy loam and sandy clay to clay loam in texture, similar observations were also made by Singh and Agarwal[17].

SOIL CONSISTENCY

Consistency 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. The clay content of soil is known to play a major role in the expression of consistency. The attribute and relief were considered to have significant bearing on soil consistency[5]. This physical behavior of soils was not only due to the textural make up but also due to type of clay minerals present in these soils[19] and Dasog and Patil[3].

Special features like effervescence with dil. HCl was observed in pedons. All pedons (except pedons 1, 2, 3, 4 and 6) showed effervescence which increased with depth. The differences in reaction to HCl were due to variation in lime content of these soils. The lime content was more in black soils than red soils. Slickensides were observed in pedons 5 and 8 due to high clay content, their very sticky and very plastic consistency leads to development of slickensides and pressure faces in pedons 5, 7, 8, 9, 10, 17, 19 and 20 are presented in Table 1. The results of the present study were in accordance with findings of Bhattacharyya *et al.*[2] studied the morphological properties of red and black soils and observed that black soils, due their very sticky and very plastic consistency under wet condition, showed well developed slickensides.

SOIL CLASSIFICATION

In Kavalur sub-watershed, the soils were classified up to Family level. The soils were classified based on morphological, physical and chemical properties according to Soil Taxonomy[1]. 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 conditions were considered. Taxonomically, the soils of the study area were classified under the orders Alfisols, Inceptisols and Vertisols. The taxonomic classification of soil pedons up to family level in Kavalur sub watershed is presented in Table 2.

Table 2: Classification of soil pedons

Pedon	Soil classification
1,2	Fine, mixed, active, isohyperthermic, Typic rhodustalf
3	Fine, mixed, superactive , isohyperthermic, Typic haplustepts
4, 6	Fine loamy, mixed, superactive, isohyperthermic, Typic rhodustalf
5	Fine, smectite, superactive, isohyperthermic, Typic haplusterts
8	Clayey, smectite, superactive, isohyperthermic, Vertic haplusterts
7, 9, 11, 12, 13, 16, 17, 18, 20, 22	Clayey, Mixed, superactive, isohyperthermic, Vertic haplustepts
14	Fine loamy, mixed, superactive, isohyperthermic, Lithtic haplustepts
21	Clayey, mixed, superactive, isohyperthermic, Calcic haplustepts
10, 15	Clayey, mixed, active, isohyperthermic, Typic haplustepts
19	Clayey, mixed, active, isohyperthermic, Vertic haplustepts

The soils of Kavalur sub-watershed belonged to three soil orders namely Alfisol, Inceptisol and Vertisol.

Soil pedons 1 and 2 were grouped under the order- Alfisols, suborder-ustalfs, great group- rhodustalf, subgroup-Typic rhodustalf and Family- fine mixed active isohyperthermic. Soil pedons 4 and 6 were grouped under the order- Alfisols, suborder-ustalfs, great group- rhodustalf, subgroup-Typic rhodustalf and Family- fine-loamy mixed superactive isohyperthermic. Soil pedon 5 was grouped under the order- Vertisols, suborder- usterts, great group- haplusterts, subgroup-Typic haplusterts and Family- fine mixed superactive isohyperthermic. Soil pedon 8 was grouped under the order- Vertisols, suborder- usterts, great group- haplusterts, subgroup-Vertic haplusterts and Family- clayey smectite superactive isohyperthermic. Soil pedons 7, 9, 11, 12, 13, 16, 17, 18, 20 and 22 were grouped under the order- Inceptisols, suborder-ustepts , great group- haplustepts, subgroup- vertic haplustepts and Family- clayey mixed superactive isohyperthermic.

Soil pedon 14 was grouped under the order-Inceptisols, suborder-ustepts , great group-haplustepts, subgroup- Lithtic haplustepts and Family- fine loamy mixed superactive isohyperthermic. Soil pedon 21 was grouped under the order- Inceptisols , suborder-ustepts , great group- haplustepts, subgroup- Calcic haplustepts and Family- clayey mixed superactive isohyperthermic. Soil pedons 10 and 13 were grouped under the order-Inceptisols, suborder- ustepts, great group-haplustepts, subgroup- Typic haplustepts and Family- clayey mixed active isohyperthermic. Soil pedon 19 was grouped under the order- -Inceptisols, suborder- ustepts, great group-haplustepts, subgroup- Vertic haplustepts and Family- clayey mixed active isohyperthermic.

At the family level, the soil properties such as particle size, mineralogical class, CEC and temperature were considered as criteria for further classification. Pedons 8 and 5 showed smectite mineralogy, the remaining pedons had the mixed mineralogy. Pedons 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 20, 21 and 22 were classified as superactive while remaining pedons 1, 2, 10, 15 and 19 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).

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 pedons 1, 2, 4 and 6 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 pedons 1, 2, 4 and 6 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 colours that have hue of 2.5YR or redder and value, moist, of 3 or less.

The soils of pedon 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22 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 6, 10 and 15 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. Pedon 21 was classified as calciustepts because of presence of free carbonates of more than 12 per cent (control section). At the sub-group level, this pedon was classified as calcic haplustepts.

Pedons 5 and 8 were 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.

Classification of pedons at family level was done based on particle size, mineralogical class, CEC and temperature. Pedons 1, 2, 3, and 5 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. Pedons 4, 6 and 14 contained more than 18 per cent but less than 35 per cent clay (weighted average) in the control section and was classified as fine loamy.

Soils of Kavalur sub-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 Similar attempts were made to classify soils of North Karnataka, of course in different areas *viz*., Rudramurthy and Dasog[15] in red and black soil areas, Vinay *et al*.[20] in Bhanapur micro-watershed, Ram *et al.*[13] in Raichur and Pulakeshi *et al.*[11] in Matangi village. The soils belonged to Alfisols, Inceptisols and Vertisols.

Table 1: Morphological characteristics of the soils of pedons in Kavalur sub -watershed

Horizon	Depth (cm)	Colour matrix		Texture	Structure	Consistency			Roots	Boundary	Special features
		Dry	Moist			Dry	Moist	Wet			
Pedon 1											
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 2											
Ap	0-25	2.5YR 4/4	2.5YR 3/3	Scl	1msbk	sh	fr	ss & sp	mft	cs	
Bt	25-47	2.5YR 3/4	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	151-180+	Weathered granite gneiss									
Pedon 3											
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	163-180+	Weathered parent rock (granite gneiss)									
Pedon 4											
Ap	0-24	5YR 4/4	5YR 4/3	Scl	1msbk	sh	fr	ss &sp	mft	cs	Slight effervescence was observed with dil. HCl at depth between 24-74 cm, strong effervescence was observed at 173-180+ depths
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	
Bt_4	173-180+	2.5YR 3/3	2.5YR 2.5/3	Sc	1msbk	sh	vfr	ms &ms	-	-	
Pedon 5											
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
Bw_1	20-82	10YR 3/1	10YR 3/1	C	2mabk	vh	fr	ms &mp	fft	cs	
Bw_2	82-148	-	10YR 3/1	C	2mabk	vh	fi	vs & vp	ffp	cs	
Bss	148-180+	-	10YR 2/1	C	2mabk	vh	fi	vs & vp	-	-	
Pedon 6											
Ap	0-18	5YR 4/4	5YR 4/4	Sl	1msbk	h	fr	ss &sp	mft	cs	

Bt_1	18-44	2.5YR 3/4	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 7											
Ap	0-20	10YR 3/1	10YR 3/2	C	2msbk	h	fr	ms &mp	mft	cs	2 cm wide Cracks, 23-28 cm deep was observed on surface, Pressure faces was observed at depth 20cm onwards, Effervescence was observed with dil.HCl.
Bw_1	20-63	-	10YR 3/1	C	2msbk	h	fr	ms &mp	mft	cs	
Bw_2	63-97	-	10YR 3/1	C	2msbk	h	fr	ms & mp	ffp	cs	
Bw_3	97-133	-	10YR 2/1	C	2msbk	h	fr	ms & mp	-	cs	
BC	133-180+	-	2.5Y 4/2	C	2msbk	h	fr	ss & sp	-	-	
Pedon 8											
Ap	0-30	10YR 3/1	10YR 3/1	C	2msbk	sh	fr	ms &mp	mft	cs	3 – 4 cm wide Cracks, 45 cm deep was observed on surface, Pressure faces was observed at depth 30-66 and 94-150cm, slickenside at 66 -94 cm depth, Effervescence was observed with dil.HCl.
Bw_1	30-66	10YR 3/1	10YR 2/1	C	2mabk	h	fr	ms &mp	mft	cs	
Bw_{ss}	66-94	10YR 3/1	10YR 2/1	C	2mabk	vh	fi	vs & vp	fft	cs	
Bw_2	94-150	10YR 3/1	10YR 2/1	C	2msbk	h	fr	ms & mp	-	cs	
BC	150-180+	2.5Y 5/3	2.5Y 4/3	C	2msbk	h	fr	ss & sp	-	-	
Pedon 9											
Ap	0-15	10YR 4/1	10YR 3/1	C	2msbk	h	fr	ms & mp	mft	cs	4-5 cm wide Cracks, more than 50 cm deep was observed on surface, Pressure faces was observed at depth 48-87 cm and Effervescence was observed with dil.HCl
Bw_1	15-48	10YR 3/1	10YR 2/1	C	2mabk	h	fr	ms & mp	mft	cs	
Bw_2	48-87	10YR 4/1	10YR 3/1	C	2mabk	h	fr	ms & mp	ffp	cs	
Bw_3	87-106	10YR 4/2	10YR 3/2	C	2msbk	h	fi	ss & sp	-	cs	
BC	106-180	10YR 4/3	10YR 4/3	C	2msbk	h	fi	ss & sp	-	-	
Pedon 10											
Ap	0-9	10YR 3/2	10YR 3/2	Sc	2msbk	sh	fr	ms & mp	mft	cs	Pit site was sand mulched. So, there is a lot of surface graveliness, Pressure faces was observed at depth 33-64 cm, Effervescence was observed with dil.HCl.
Bw_1	9-33	10YR 3/1	10YR 2/1	C	2msbk	h	fr	ms & mp	mft	cs	
Bw_2	33-64	-	10YR 4/3	C	2mabk	h	fr	ss & sp	ffp	cs	
BC	64-98	-	10YR 5/4	C	2mabk	h	fr	ss & sp	-	cs	
Ck	98-140+	Weathered parent rock									
Pedon 11											
Ap	0-26	10YR 3/1	10YR 2/1	C	1msbk	h	fr	ms & mp	mft	cs	Pressure faces was observed at depth 26-64, Strong effervescence was observed with dil.HCl in all depths
Bw	26-64	10YR 2/1	10YR 3/1	C	2msbk	h	fr	ms & mp	mft	cs	
BC	64-112	10YR 4/2	10YR 4/3	C	2msbk	vh	fi	ss & sp	ffp	cs	
Cr	92-143	Weathered parent rock (granite gneiss)									
Pedon 12											
Ap	0-11	10YR 4/1	10YR 2/1	C	2msbk	h	fr	ms & mp	mft	cs	5 cm wide Cracks, more than 50 cm

Bw	11-32	10YR 4/1	10YR 3/1	C	2msbk	h	fr	ms & mp	mft	cs	deep was observed on surface and Strong effervescence was observed with dil.HCl in all depths
BC	32-68	-	2.5Y 4/2	C	2msbk	h	fi	ss & sp	ffp	cs	
C	68-110	Weathered parent rock (granite gneiss)									
Pedon 13											
Ap	0-9	10YR 4/1	10YR 2/1	C	2msbk	h	fr	ms & mp	mft	cs	2 cm wide Cracks, 20-25 cm deep was observed on surface and Strong effervescence was observed with dil.HCl in all depths
Bw	9-30	10YR 3/1	10YR 3/1	C	2msbk	h	fr	ms & mp	fft	cs	
CBk	30-62	2.5Y 5/2	2.5Y 4/2	Sc	0msbk	h	l	ss & sp	-	cs	
Crk	62-120	Weathered parent rock (granite gneiss)									
Pedon 14											
Ap	0-11	10YR 4/1	10YR 3/1	C	1msbk	sh	fr	ms & mp	mft	cs	Strong effervescence was observed with dil.HCl in all depths
Bw	11-30	10YR 4/1	10YR 3/1	C	1msbk	sh	fr	ms & mp	mft	cs	
Cr	30-85	Weathered parent rock (granite gneiss)									
Pedon 15											
Ap	0-12	5YR 4/6	5YR 3/4	Sc	1msbk	sh	fr	ms & mp	mft	cs	Slight effervescence was observed with dil.HCl in 0-12, 12-41 and 112-162 cm depths
Bt_1	12-41	2.5YR 4/6	2.5YR 3/4	Sc	1msbk	sh	fr	ms & mp	mft	cw	
Bt_2	41-67	2.5YR 4/4	2.5YR 4/6	Sc	1mabk	h	fr	vs & vp	ffp	cw	
BC	67-112	2.5YR 4/4	2.5YR 3/4	Scl	1msbk	h	fr	ss & sp	-	cs	
Cr	112-162	Weathered parent rock (granite gneiss)									
Pedon 16											
Ap	0-20	10YR 3/1	10YR 3/1	C	2msbk	sh	fr	ms & mp	mft	cs	3 – 4 cm wide Cracks, more than 35 cm deep was observed on surface and slight effervescence was observed with dil.HCl in all depths
Bw_1	20-46	-	10YR 3/1	C	2msbk	h	fr	ms & mp	mft	cs	
Bw_2	46-73	-	10YR 2/1	C	2mabk	sh	fr	vs & vp	ffp	cs	
BC	3-101	-	2.5Y 5/4	C	2msbk	sh	fr	ss & sp	ffp	cs	
Cr	101-164	Weathered parent rock (granite gneiss)									
Pedon 17											
Ap	0-24	10YR 3/1	10YR 3/1	C	2msbk	h	fr	ms & mp	mft	cs	3 cm wide Cracks, 40 cm deep were observed on surface, Pressure faces was observed at depth 24-51 and Effervescence was observed with dil.HCl and increased with depth.
Bw_1	24-51	10YR 4/1	10YR 3/1	C	2msbk	h	fr	ms & mp	mft	cs	
Bw_2	51-74	-	10YR 3/1	C	2msbk	h	fr	ms & mp	ffp	cw	
Cr	74-130	Weathered parent rock (granite gneiss)									
Pedon 18											
Ap	0-18	10YR 4/1	10YR 3/1	C	2msbk	h	fr	ms & mp	mft	cs	2 cm wide Cracks, more than 20 cm deep was observed on surface, and Strong effervescence was observed
Bw_1	18-39	-	10YR 3/1	C	2msbk	h	fr	ms & mp	mft	cs	
BC	39-62	-	2.5Y 4/1	Scl	2msbk	h	fr	ss & sp	ffp	cw	

Crk	62-114	Weathered parent rock (granite gneiss)									with dil.HCl in all depths
Pedon 19											
Ap	0-35	10YR 4/1	10YR 3/1	C	1msbk	sh	fr	ms & mp	mft	cs	4 cm wide Cracks, 45 cm deep was observed on surface, last layer was buried layer consist of sand accumulation, Pressure faces were observed at lower depths and Strong effervescence was observed with dil.HCl
Bw_1	35-90	-	10YR 2/1	C	2msbk	h	fr	vs & vp	mft	cs	
Bw2	90-119	-	10YR 3/1	Scl	2msbk	sh	vfr	ss & sp	fft	cs	
Bw3	119-171	-	10YR 3/1	C	2msbk	h	fr	ms & mp	ffp	cs	
Bw4	171-193	10YR 3/1	10YR 2/1	C	2msbk	h	fr	ms & mp	ffp	cs	
C	193-200	Sand accumulation									
Pedon 20											
Ap	0-19	10YR 4/1	10YR 3/1	C	1msbk	h	fr	ms & mp	mft	cs	2 cm wide Cracks, more than 25 cm deep was observed on surface, Pressure faces was observed at depth 39-127cm and Effervescence was observed with dil.HCl.
Bw_1	19-39	10YR 3/1	10YR 3/2	C	2msbk	h	fr	ms & mp	ccc	cs	
Bw2	39-127	10YR 2/1	10YR 2/2	C	2msbk	vh	fi	vs & vp	ccc	cs	
Bw3	127-154	10YR 4/1	10YR 4/2	C	2msbk	h	fr	ms & mp	ccc	cs	
Bw4	154-180+	10YR 3/1	10YR 2/1	C	2msbk	h	fr	ms & mp	-	-	
Pedon 21											
Ap	0-21	2.5Y 4/1	2.5Y 4/2	C	1msbk	h	fr	ms & mp	mft	cs	Strong effervescence was observed in all depths
Ck1	21-57	-	-	-	-	-	-	-	ffp	cs	
Ck2	57-122	-	-	-	-	-	-	-	-	-	
Pedon 22											
Ap	0-16	10YR 3/1	10YR 2/1	C	1msbk	sh	vfr	ms & mp	mft	cs	5 cm wide Cracks, more than 24 cm deep was observed on surface and Strong effervescence was observed with dil.HCl in all depths
Bw	16-49	10YR 2/1	10YR 2/1	C	2msbk	h	fr	ms & mp	ffp	cs	
Ck	49-110	-	-	-	-	-	-	-	-	-	

CONCLUSION

The soils were moderately deep to very deep in depth and varied from dark reddish brown to yellowish brown in colour. Soils under the study were predominantly sub-angular blocky in structure, friable (wet) in consistency, the cracks were observed in the surface of most of the profile area and the pressure faces, slicken sides and concentration of calcium were observed in the lower depths of most of the profiles. The texture varies from sandy clay loam to clay in texture. Based on morphological, physical and chemical properties of soils, soils were classified as per "Keys to Soil Taxonomy" (Soil Survey Staff, 2014) up to family level. The soils of Kavalur sub-watershed belonged to three soil orders namely Alfisol, Inceptisol and Vertisol. The soil mapping will help in better planning and efficient use of natural resources towards achieving higher crop productivity and production.

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