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Characterization and classification of soil resources of Shirol West-1 micro-watershed

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Abstract: A study was undertaken to characterize and classify the soil resources of Shirol West-1 micro-watershed in Gadag district of Karnataka. Twenty three profiles were studied for the morphological, physical and chemical properties. Eight representative pedons covering all the soil types were selected and their properties and classification is discussed in this paper. The soils were very shallow to very deep in depth, very dark grayish brown to very dark grey in black soils, whereas red soils shown reddish brown to dark reddish brown in colour. Soils under the study were predominantly sub-angular blocky in structure, clay in texture, alkaline reaction with non salinity and organic carbon content was low to medium. Calcium and magnesium were the dominant exchangeable cations followed by sodium and potassium. Soils studied were classified up to family level according to revisions in Soil Taxonomy using morphological, physical and chemical properties. Major proportion of the soilsin the micro-watershed belonged to the order Vertisols, Inceptisols and Entisols.

Keywords: Soil characterization, Soil classification, Soil resources, Soil survey

Introduction

The natural resources of any country are the national treasure and need proper planning to make best use of them. Therefore, sustainable management practices are urgently needed all over the world to preserve the production potential of agricultural lands. Efficient management and maintenance of soil health is the key to accomplish sustained high productivity, food security and environment safety. Yadav (2003) reported that per capita arable land in India decreased from 0.34 ha in 1950-51 to 0.15 ha in 2000-01 and is expected to shrink to 0.08 ha in 2005. No possibility of further horizontal expansion in the cultivated area seems to exist. It has been also reported that 57 per cent of the total geographical area in India is suffering from various types of land degradation problems.

Soil survey constitutes a valuable resource inventory linked with the survival of life on the earth. It provides an accurate and scientific inventory of different soils, their kind and nature, and extent of distribution so that one can make prediction about their character sand potentialities. 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, acidity, salinity *etc.*) which can beutilized for the planning and development. Keeping this in mind, a rapid reconnaissance soil survey of the area was carried to characterize and classify soils in Shirol West-1 micro-watershed in Gadag district of Karnataka for sustainable land use planning using geo-referred false colour composite image of IRS-P6, LISS-III and Survey of India (SOI) topomaps.

Material and methods

The selected Shirol West-1 micro-watershed lies 40 km away from Gadag (Fig. 1). The micro-watershed is located between 15^0 15' 6.2" and 15^0 16' 34.7" N latitude and 75^0 34' 2.5" and 75^0 35' 59.2" E longitude, with an average elevation ranged from 678 to734 m above Mean Sea Level (MSL). The climate is semi-arid type with mean annual maximum temperature of 32.8ºC and mean annual minimum temperature of 19.1ºC. The area receives a mean annual rainfall of 671 mm and having nearly level to undulating topography with frequent mound like features. Schist is the parent rock in the study area. The area is under Ustic moisture regime and isohyperthermic temperature regime. Soil survey was carried out during March 2015 using IRS P6 LISS-III data, survey of India toposheet and cadastral map of the village. After intensive traversing, 23 pedons were studied depending upon soil heterogeneity. Morphological characters like colour, structure, consistency and physico-chemical properties like bulk density, water holding capacity, pH, electrical conductivity, organic carbon, cation exchange capacity, etc., were studied for the profile samples. The soils were classified at family level according to revisions in soil taxonomy (Soil Survey Staff, 2014). After correlating for the above referred properties of pedons, eight representative pedons were selected and presented in the paper.

Results and discussion

Brief morphological features of the pedons are presented in Table 1.The soils were dark grayish brown (10 YR 4/2) to very dark gray (10 YR 3/1) in surface horizon and yellowish brown (10 YR 5/4) to very dark brown (10 YR 2/2) in subsurface horizon of all the pedons, except pedons 4, 15 and 18 soils were dark brown (7.5 YR 3/2) to very dark brown (7.5 YR 2.5/2) in surface and subsurface horizon, whereas in pedon 12, 13 and 14 soils were reddish brown (5 YR 4/4) to dark reddish brown (5 YR 3/4) in colour. There was not much variation in the soil colour with

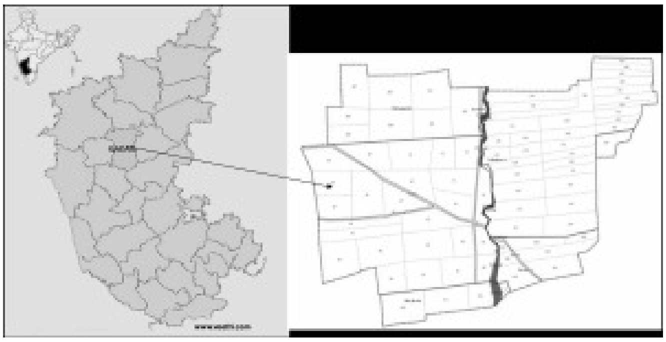

Table 1. Soil morphological characteristics of the pedons in Shirol West-1 micro-watershed

Pedon No.	Horizon	Depth (cm)	Colour		Texture	Structure	Consistency			Root	Boun -dary	Special features
			Dry	Moist			Dry	Moist	Wet			
Pedon 1	Ap	0-20	10 YR 3/2	10 YR 2/2	c	2 m sbk	h	fr	vs &vp	ff	gw	Pressure faces were observed from 20-33 cm. Strong effervesces with dilute HCl, many and fine sized prominent $CaCO_3$ concretions were observed from 20-33cm
	Bk	20-33	10 YR 3/2	10 YR 2/2	c	2 m sbk	h	fr	vs &vp	ff	gw	
	Crk	33-120+	Paralithic contact with schist									
Pedon 5	Ap	0-20	10 YR 3/2	10 YR 3/2	c	2 m sbk	h	fr	vs &vp	fm	cw	Strong effervesces with dilute HCl, many and fine sized prominent $CaCO_3$ concretions were observed from 0-31cm.
	AC	20-31	10 YR 4/3	10 YR 5/4	c	m sbk	sh	fr	ss&sp	ff	cw	
	Cr	31-68+	Paralithic contact with schist									
Pedon 6	Ap	0-19	10 YR 3/2	10 YR 3/2	c	2 m sbk	h	fr	vs &vp	ff	cw	Strong to violent effervesces with dilute HCl, common to many and fine sized prominent $CaCO_3$ concretions were observed from 0-39 cm.
	ACk	19-39	10 YR 4/3	10 YR 5/4	c	1 m sbk	sh	fr	ss&sp	ff	gw	
	Cr	39-80+	Weathered parent rock (schist).									
Pedon 9	Ap	0-26	10 YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	vs &vp	ff	cw	Slight effervesces with dilute HCl, many and fine sized prominent $CaCO_3$ concretions were observed from 0-26 cm.
	Bw	26-64	10 YR 3/1	10 YR 2/2	c	2 m sbk	sh	fr	vs &vp	ff	cw	
	Cr	64-92+	Paralithic contact with schist									
Pedon 14	Ap	0-26	5 YR 4/3	5 YR 3/4	c	2 m sbk	sh	fr	ms & mp	ff	cs	-
	Cr	26-96+	Paralithic contact with schist									
Pedon 16	Ap	0-22	10 YR 3/3	10 YR 3/2	c	2 m sbk	h	fr	vs &vp	cf	gw	Wide and deep cracks up to 40 cm. Prominent slicken sides were observed from 53-90 cm slight to strong effervesces with dilute HCl, few and fine sized prominent $CaCO_3$ concretions were observed from 0-124 cm.
	Bw_1	22-53	10 YR 3/2	10 YR 3/2	c	2 m sbk	h	fr	vs &vp	ff	gw	
	B_2ss	53-90	10 YR 3/2	10 YR 3/2	c	2 m sbk	h	fr	vs &vp	-	cs	
	Crk	90-124+	Weathered parent rock (schist).									
Pedon 22	Ap	0-24	10 YR 3/1	10 YR 2/2	c	2 m sbk	h	fr	vs &vp	mc	gw	-
	AC	24-65	10 YR 3/1	10 YR 3/1	c	2 m sbk	h	fr	vs &vp	mc	Cs	
	Cr	65-126+	Weathered parent rock (schist).									
Pedon 23	Ap	0-25	10 YR 3/2	10 YR 3/2	c	2 m sbk	h	Fr	vs &vp	ff	cw	Wide and deep cracks up to 60 cm. Prominent slicken sides were observed from 25-158 cm. Slight effervesces with dilute HCl, common to few and fine sized prominent $CaCO_3$ concretions were observed from 0-112 cm
	Bss_1	25-68	10 YR 3/1	10 YR 3/1	c	2 m sbk	h	fr	vs &vp	ff	gw	
	Bss_2	68-112	10 YR 3/1	10 YR 3/1	c	2 m sbk	h	fi	vs &vp	ff	gw	
	Bss_3	112-158	10 YR 3/1	10 YR 2/2	c	2 m sbk	h	fi	vs &vp	-	cs	
	Cr	158-198+	Weathered parent rock (schist).									

depth in all the pedons except in pedon 11. The black soil pedons dominant colour was dark grayish brown to very dark grayish brown due to the clay-humus complex in the presence of lime. The dark matrix colour was due to presence of high organic matter content in the surface horizons (Tripathi *et al.,* 2006). In red soil pedons, hue was yellowish (5 YR). Pedons at higher positions were red while those on lower locations were black which also indicated the gradation in the colour from higher topographic positions to the lower topographic units (Mini *et al.,* 2007). The soils exhibited moderate medium sub-angular blocky structure in all the pedons in the surface and subsurface horizon, except pedon 6 and 5 subsurface horizon are weak medium sub-angular blocky, whereas in pedon 7, 8 and 18 soils were strong medium sub-angular blocky in structure. The structure designates the mode of arrangement of the particles and their aggregation, therefore the structural variation in soils was useful to differentiate the horizon.

The dry consistency of all pedon soils were hard in surface and subsurface horizon, except pedon 5 and 6 are slightly hard in subsurface horizon (AC), whereas pedons 9, 10, 12, 13, 14 and 15 were slightly hard in surface and subsurface horizon. Moist consistency of surface and subsurface horizon soils were friable in almost all pedons, where as in pedon11 and 23 subsurface horizons are firm in nature. Very sticky and very plastic consistency was observed in almost all pedons, except in pedon 6 and 10 subsurface horizons are slightly sticky and slightly plastic. All the horizons which of pedon 12, 13 and 14 were found to be moderately sticky and moderately plastic in consistency (wet). Increase in stickiness and plasticity may be due to high clay content (Tripathi *et al.,* 2006). Many to few and fine sized roots were observed in all the pedons of surface and subsurface horizons, whereas in 3, 4 and 22 pedon horizons many and coarse to medium size roots were observed. Wide and deep cracks were observed up to 60 cm depth and prominent slicken sides were noticed in subsurface horizons of pedons 2, 3, 7, 8, 11, 16, 18, 20 and 23. Abundant accumulation of calcium carbonate concretions were observed in all pedons except pedons 7, 11, 12, 13, 14 and 22. Physical characteristics of the soil are presented in Table 2. A perusal of the data on particle size distribution in soil srevealed that, all the soils are clay in texture according to the USDA textural triangle.

All the soils were clay in texture and the clay content increase throughout the depth in all the pedons which could be attributed to several processes like illuviation of the finer fraction to the lower depth. Similar results were quoted by Pulakeshi *et al.* (2014) for the soils of Mantagani village of Haveri district in Karnataka. The distribution of silt content did not follow definite trend in the pedons under study. Generally,

Table 2. Physical characteristics of the soils of pedons in Shirol West-1 micro-watershed

Pedon No.	Horizon	Depth (cm)	Coarse fragments (>2 mm)	Coarse sand (2- 0.25 mm)	Fine sand (0.25-0. 005 mm)	Total sand (2.0-0. 005 mm)	Silt (0.05 -0.002 mm)	Clay (<0.002 mm)	MWHC	BD (Mgm^{-3})
			(……………………………..%...)							
Pedon 1	Ap	0-20	6.21	15.4	04.4	19.8	18.6	61.5	52.69	1.36
	Bk	20-33	5.80	25.8	02.7	28.5	12.3	59.2	51.33	1.42
	Crk	33-120+	Paralithic contact with schist							
	Cr	18-80+	Paralithic contact with schist							
Pedon 5	Ap	0-20	8.36	19.2	09.3	28.5	26.4	45.2	58.20	1.38
	AC	20-31	7.68	25.8	04.6	30.4	13.8	55.8	60.26	1.39
	Cr	31-68+	Paralithic contact with schist							
Pedon 6	Ap	0-19	7.20	14.6	14.3	28.9	28.3	42.8	60.90	1.39
	ACk	19-39	6.84	22.5	11.4	33.9	15.7	50.4	65.25	1.39
	Cr	39-80+	Weathered parent rock (schist).							
Pedon 9	Ap	0-26	7.20	06.9	11.0	17.9	22.8	59.3	68.49	1.31
	Bw	26-64	5.40	05.6	06.5	12.1	37.5	50.4	67.20	1.36
	Cr	64-92+	Paralithic contact with schist							
Pedon 14	Ap	0-26	14.78	19.6	08.1	27.7	17.1	55.2	52.29	1.45
	Cr	26-96+	Paralithic contact with schist							
Pedon 16	Ap	0-22	7.20	03.4	23.0	26.4	18.6	55.0	49.71	1.34
	Bw_1	22-53	6.54	03.8	10.2	14.0	24.8	61.2	57.14	1.37
	B_2ss	53-90	3.42	03.1	11.1	14.2	20.0	65.8	58.07	1.41
	Crk	90-124+	Weathered parent rock (schist).							
Pedon 22	Ap	0-24	10.28	14.4	15.7	30.1	27.8	42.1	55.44	1.31
	AC	24-65	6.48	12.4	15.4	27.8	25.1	47.1	58.42	1.36
	Cr	65-126+	Weathered parent rock (schist).							
Pedon 23	Ap	0-25	3.24	08.0	09.8	17.8	17.7	64.5	55.10	1.25
	Bss_1	25-68	2.76	09.1	04.7	13.8	20.8	65.4	56.62	1.28
	Bss_2	68-112	1.86	08.2	04.9	13.1	19.5	67.4	60.97	1.33
	Bss_3	112-158	1.42	06.7	05.6	12.3	18.5	69.2	61.22	1.35
	Cr	158-198+	Weathered parent rock (schist).							

fine sand per cent decreased with depth in all pedons, except in pedon 3 the fine sand per cent increased upto B_2ss horizon and decreased thereafter, but in pedon 7 the fine sand per cent showed irregular trend. The distribution of coarse sand and total sand content did not follow definite trend in the pedons under study. High clay and silt content in some of the pedons of study area may be due to their formation on the transported parent material. Similarly, the illuvation process also affected the vertical distribution of silt and sand content.

Maximum water holding capacity of pedons in the surface layer ranged from 51.52 to 68.49 per cent and in subsurface horizons varied between 51.33 to 68.98 per cent. MWHC increased from surface to the lower horizons and followed the trend in clay variation in pedons of these results are in line with those of Thangasamy *et al.* (2005) in soils of Sivagiri village in Chittoor district of Andhra Pradesh. In black soil pedons, the bulk density varied from 1.24 to 1.46 Mg per m^3. In general, the bulk density of the lower solum was more than the upper solum. This could be attributed to clogging of pores by dispersed clays in sub-soil layers and reduction of organic carbon with depth. Similar results were quoted by Pulakeshi *et al.* (2014) for the soils of Mantagani village of Haveri district in Karnataka.

In soil pedons, pH ranged from neutral to strongly alkaline. High pH in black soil pedons was due to their calcareous nature and the accumulation of bases in the solum as they were poorly leached. Increase in soil pH with depth was evident in some of the pedons,which may be ascribed to increasing content of exchangeable and soluble sodium and calcium. The pH was high at surface and then showed decreasing trend with depths in some other pedons. This may be attributed to high base status of these horizons resulting from the recycling of bases through the addition of crop residues. In red soil pedons, large amount of bases have been leached out of the solum leaving behind iron and aluminium oxides and hence the pH in red soil pedons waslow compared to their black soil counter parts. The increase in soil reaction down the slope could be due to leaching of bases from higher topography and getting deposited at lower elevations (Sitanggang *et al.,* 2006).

Electrical conductivity was more in black soil pedons, which indicate that black soil pedons were less leached. In soils EC ranged from 0.12 to 0.91dS m^{-1} and 0.14 to 0.45 dS m^{-1} in subsurface and surface horizon, respectively, indicate non-saline nature of soils (Table 3). These soils did not show any specific relationship of EC with depth. This may be due to free drainage conditions, which removes the bases by the percolating and drainage water. These results are in confirmation with the findings of Sumithra *et al.* (2013) in soils of Timanhal micro-watershed, Kushtagi taluk of Karnataka. The free $CaCO_3$ is an accumulation of precipitated calcium carbonate in the solum. This generally happens due to a negative precipitation-evapotranspiration (PET) balance and some geological

Table 3. Chemical properties of the soils of pedons in Shirol West-1 micro-watershed

PedonNo.	Horizon	Depth (cm)	pH (1:2.5)		EC(1:2.5) in water (dSm^{-1})	O.C.(g kg^{-1})	Free $CaCO_3$(%)
			Water	KCl			
Pedon 1	Ap	0-20	8.26	6.63	0.29	4.2	8.5
	Bk	20-33	7.74	6.65	0.91	3.3	28.5
	Crk	33-120+	Paralithic contact with schist				
Pedon 5	Ap	0-20	8.31	6.24	0.31	3.9	19.0
	AC	20-31	8.29	6.28	0.19	3.6	17.5
	Cr	31-68+	Paralithic contact with schist				
Pedon 6	Ap	0-19	8.32	6.27	0.17	3.9	16.0
	ACk	19-39	8.27	6.47	0.16	2.7	20.5
	Cr	39-80+	Weathered parent rock (schist).				
Pedon 9	Ap	0-26	8.02	6.10	0.21	3.3	10.5
	Bw	26-64	8.14	6.20	0.21	3.0	10.0
	Cr	64-92+	Paralithic contact with schist				
Pedon 14	Ap	0-26	8.09	6.38	0.14	4.2	10.0
	Cr	26-96+	Paralithic contact with schist				
Pedon 16	Ap	0-22	8.30	6.49	0.45	3.6	12.5
	B_1w	22-53	8.39	6.48	0.22	3.0	12.5
	B_2ss	53-90	8.15	6.27	0.29	2.7	11.5
	Crk	90-124+	Weathered parent rock (schist).				
Pedon 22	Ap	0-24	8.13	6.10	0.17	6.9	10.5
	AC	24-65	8.18	6.17	0.17	4.5	07.0
	Cr	65-126+	Weathered parent rock (schist).				
Pedon 23	Ap	0-25	8.38	6.35	0.16	6.9	12.5
	Bss_1	25-68	8.35	6.50	0.16	5.4	14.5
	Bss_2	68-112	8.45	6.51	0.24	2.4	09.5
	Bss_3	112-158	8.60	6.58	0.30	2.1	14.0
	Cr	158-198+	Weathered parent rock (schist).				

properties (parent material). The calcium carbonate content in surface layers ranged from 5.5 to 19.0 per cent and in subsurface layers, it ranged from 5.5 to 28.5 per cent. The organic carbon content ranged from 3.0 to 6.9 g kg^{-1} in surface layer and 2.1 to 5.4 g kg^{-1} in the subsurface horizons. The organic carbon content of surface soil was greater than subsurface soil in all the pedons and it decreased with depth. This was attributed to the addition of farmyard manure and plant residues to surface horizons which resulted in higher organic carbon content in surface horizons than that of lower horizons. These observations are in accordance with results of Basavaraju *et al.* (2005) in soils of Chandragiri Mandal of Chittor district of Andhra Pradesh.

The dominant cations on the clay complex were calcium followed by magnesium, sodium and potassium. The exchangeable calcium and magnesium in surface soils ranged from 26.7 to 44.0 cmol (p^+) per kg and 9.8 to 18.0 cmol (p^+) per kg, respectively (Table. 4). In subsurface soils, Ca and Mg ranged from 30.8 to 42.9 cmol (p^+) per kg and 10.8 to 18.1 cmol (p^+) per kg, respectively. The exchangeable sodium content ranged from 2.18 to 5.20 cmol (p^+) per kg in surface horizons and 2.76 to 5.78 cmol (p^+) per kg in subsurface horizons and varied with profile depth. The soils under investigation contained exchangeable potassium in quantities less than 1 cmol (p^+) per kg and the values exhibited a decreasing trend with depth in few pedons. The exchangeable potassium content ranged from 0.20 to 0.62 cmol (p^+) per kg in surface horizons and 0.31 to 0.65 cmol (p^+) per kg in subsurface horizons. The low value of exchangeable monovalents compared to divalents may be due to leaching of monovalents than divalent. These results are in line with the findings of Thangasamy *et al.* (2005) in Sivagiri micro-watershed of Chittoor district in Andhra Pradesh. The exchangeable sodium percentage ranged from 4.48 to 8.03 per cent in surface horizons and 4.42 to 8.50 per cent in subsurface horizon (Table. 4). A lower ESP (<15) throughout the depth in soils clearly indicated that these soils are non sodic in nature. Exchangeable sodium percentage values did not follow definite trend throughout the depth in all pedons. A measure of relative amounts of exchangeable sodium in comparison with the total cations in the soil are dependent on factors such as type of minerals, concentration of electrolytes and status of soluble cations.

Soils were classified according to the revision in US Soil Taxonomy. Pedons 2, 3, 7, 8, 11, 16, 18, 20 and 23 were classified as Vertisols at order level as these pedons did not have lithic or paralithic contact within 50 cm of soil surface and had a weighted average of >30 per cent clay in all the horizons down to a depth of 1 m and had a cracks that open and close periodically. These pedons have a layer of a > 25 cm thick, with an upper boundary within 100 cm of mineral soil surface that had slicken sides. The pedons belonging to Vertisols key out as Ustert at suborder level as they have cracks in normal year that are 5 mm or more through a thickness of 25 cm or more within 50 cm of mineral

Table 4. Exchangeable cationsproperties of the soils ofpedons in Shirol West-1 micro-watershed

PedonNo.	Horizon	Depth (cm)	Ca	Mg	Na	K	CEC	BS	ESP
		(……………………cmol (p^+) kg^{-1}…………………)(……..%.........)							
Pedon 1	Ap	0-20	44.0	11.2	3.28	0.52	64.85	90.97	5.05
Bk	20-33	42.0	10.8	2.76	0.55	62.39	89.93	4.42	
Crk	33-120+Paralithic contact with schist								
Pedon 5	Ap	0-20	40.8	10.8	4.10	0.51	63.54	88.46	6.45
AC	20-31	41.6	11.6	4.02	0.48	62.88	91.76	6.39	
Cr	31-68+Paralithic contact with schist								
Pedon 6	Ap	0-19	38.8	12.8	4.13	0.42	61.89	90.76	6.67
ACk	19-39	39.6	13.5	4.38	0.58	65.98	87.99	6.63	
Cr	39-80+Weathered parent rock (schist).								
Pedon 9	Ap	0-26	38.2	10.5	4.47	0.52	59.87	89.67	7.46
Bw	26-64	39.7	11.8	4.67	0.52	60.23	94.12	7.75	
Cr	64-92+Paralithic contact with schist								
Pedon 14	Ap	0-26	23.1	5.24	2.16	0.42	36.8	84.02	5.86
Cr	26-96+Paralithic contact with schist								
Pedon 16	Ap	0-22	42.2	13.4	4.42	0.21	63.78	94.43	6.93
B_1w	22-53	37.8	12.8	4.78	0.32	60.23	92.47	7.93	
B_2ss	53-90	36.6	14.0	3.64	0.36	60.20	90.69	6.04	
Crk	90-124+Weathered parent rock (schist).								
Pedon 22	Ap	0-24	40.5	15.4	3.87	0.35	66.80	90.00	5.79
AC	24-65	39.5	14.3	4.63	0.37	63.81	92.14	7.25	
Cr	65-126+Weathered parent rock (schist).								
Pedon 23	Ap	0-25	40.8	14.8	4.80	0.46	65.12	93.45	7.37
Bss_1	25-68	41.7	14.5	5.30	0.48	67.40	91.95	7.86	
Bss_2	68-112	40.5	17.4	5.78	0.47	67.94	94.42	8.50	
Bss_3	112-158	40.2	18.1	5.00	0.35	68.90	93.25	8.12	
Cr	158-198+Weathered parent rock (schist).								

soil surface for 90 or more cumulative days per year. Whereas, pedon key out as Haplusterts at great group level as they do not have salic, gypsic or calcic horizons and at subgroup level classified as Typic Haplusterts, it did not qualify for other subgroup under Haplusterts.

Pedons 1, 6, 9 and 10 were classified into Inceptisols owing to the absence of any other diagnostic horizon other than cambic horizon. As the moisture regime is Ustic and classified as Ustepts at suborder level. Pedons 1, 6 and 10 have calcic horizon and lithic contact within 50 cm, were classified as Calciustepts and Lithic Calciustepts at great group and subgroup level, respectively. Whereas, pedon 9 classified as Typic Haplustepts at subgroup level. Pedons 4, 5, 12, 13, 14, 15, 17, 19, 21 and 22 were classified as Entiosols, because there was no evidence of development of pedogenic horizons and followed none of the criteria established for sub-orders in the order Entisols. So it was classified as Orthents. At great group level these pedons classified as Ustorthents due to the prevailing soil moisture regime as "Ustic". All Pedons, under Entisols had a lithic contact with in depth of 50 cm except pedon 22. Whereas, pedon 22 was classified as Typic Ustorthents at subgroup level and remaining are classified as Lithic Ustorthents at subgroup level.

All the soils under study had isohyperthermic temperature regime, since, the mean summer and winter temperatures differ by less than 6^0C and mean annual temperature exceeds 22^0C. The cation exchange activity class of pedons under study was super active, where CEC to clay content ratio exceeds 0.60 and the particle size class of pedons under study were very fine (60 % clay content), fine (>35 to <60 % clay content) and if clayey (more than 35 per cent clay content) (Soil Survey Staff, 2014). At family and series level, the pedons under study are classified and presented in table 5.

Table 5. The overall classification of selected pedons are given below.

Pedon No.	Soil classification
2, 3, 8, 11, 18, 20 and 23	Very fine, smectitic, super active, isohyperthermic, TypicHaplustert.
7 and 16	Fine, smectitic, super active, isohyperthermic, TypicHaplustert
6 and 10	Clayey, smectitic, super active, isohyperthermic, Lithic Calciustepts
1	Very fine, smectitic, super active, isohyperthermic, Lithic Calciustepts
9	Fine, smectitic, super active, isohyperthermic, TypicHaplustepts
22	Fine, smectitic, super active, isohyperthermic, TypicUstorthents
4, 5, 15, 17, 19 and 21	Clayey, smectitic, super active, isohyperthermic, Lithic Ustorthents
12, 13 and 14	Clayey, mixed, super active, isohyperthermic, Lithic Ustorthents

The studied soils were very shallow to very deep in depth, very dark grayish brown to very dark grey in black soils, whereas red soils shown reddish brown to dark reddish brown in colour, sub-angular blocky in structure, clay in texture, alkaline reaction with non-saline soils and organic carbon content was low to medium. Calcium and magnesium were the dominant exchangeable cations followed by sodium and potassium. Soils studied were classified up to family level according to revisions in Soil Taxonomy using morphological, physical and chemical properties. Major proportion of the soils in the micro-watershed belonged to the order Vertisols, Inceptisols and Entisols.

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