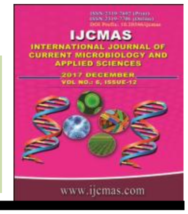
Int.J.Curr.Microbiol.App.Sci (2017) *6*(12): 319-329

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 12 (2017) pp. 319-329**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2017.612.038

Characterisation and Classification of Soil Resources of Kumachahalli Micro-Watershed in Chamarajanagar, Karnataka, India

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Keywords

Soil characterization, Soil classification, Soil resources, Soil taxonomy, Pedons.

Article Info

Accepted:
04 October 2017
Available Online:
10 December 2017

A B S T R A C T

A study was undertaken to characterize and classify the soil resources of Kumachahalli micro-watershed in Chamarajanagar district of Karnataka. Sixteen profiles were studied for the morphological, physical and chemical properties. Seven representative pedons covering all the soil types were selected and classified. Soils were very shallow, deep and moderately deep in depth. The colour of the soils in the pedons varied from dark red to dark reddish brown. Soils were loamy sand, sandy loam, sandy clay loam and clayey in texture. The structure was fine granular to sub-angular blocky throughout the profile. The consistency was very friable in surface horizon and friable in sub-surface horizons under both dry and moist conditions. Soil reaction of the pedons varied from near neutral to moderately alkaline in nature. In valley lands, the soil reaction was neutral to slightly alkaline. The electrical conductivity of all the pedons was negligible. Calcium and magnesium are dominant exchangeable cations followed by sodium and potassium. Soils studied were classified up to family level according to revisions in Soil Taxonomy. Major proportion of the soils in the micro-watershed belonged to the order Alfisols and Inceptisols.

Introduction

The natural resources of any country are the national treasure and proper planning is prerequisite for best possible utilization with limited means available. Therefore, sustainable management practices can't be ignored to preserve the production potential of agricultural lands. Land evaluation for the suitability of specified land use using a scientific procedure is essential to assess the potential and constraints of a given area for agricultural purposes. Presently, the detrimental effects of land use on the environment and sustainability of agricultural production systems have became an issue which needs to be analysed critically and addressed carefully. The problems of declining soil fertility, stagnant yield level and unfettered soil erosion are associated with intensive agriculture in industrialized countries; while over exploitation of natural resources and scarcity of inputs like chemical fertilizers denote intensive agriculture in the developing countries. In the recent past, concepts of watershed based holistic development has emerged as one of the potential approaches, which can lead to higher productivity and sustainability in agricultural production. 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, acidity, salinity *etc*.) which can be utilized for the planning and development. Detailed soil survey was undertaken to characterize and classify soils of Kumachahalli micro-watershed. System of farming in this area has changed gradually during last many years, hence, it was felt imperative to characterise these soils.

Materials and Methods

The investigation was carried out in Kumachahalli micro-watershed (Harve sub-watershed, Chamarajanagar taluk, Chamarajanagar district) which is situated at 18 km from Chamarajanagar town in between 11^0 51' 27.00" and 11^0 52' 35.02" North latitude and 76^0 46' 31.95"and $76^0$48' 41.84" East longitude covering an area of about 407 ha bounded by Kumachahalli, Lakkuru, Shyanadrahalli and Hooradhahalli villages. Out of 407 ha, 9 ha is coming under water bodies and habitation. Location map of the study area has been shown in Figure 1.

The climate is semi-arid with an average rainfall of 769 mm. Parent material in the study area is granite-gneiss. The area is under Ustic moisture regime and Isohyperthermic temperature regime. Soil survey was done by using the merged data of Cartosat-1 (PAN) and Resourcesat-2 (LISS IV) MX in the form of digital and geo-coded false colour composites (FCC) which were analysed in GIS environment along with cadastral maps. These inputs were used for surface characterization, detailed soil profile studies and soil sample collection.

After intensive traversing, the representative areas for transect study were located across the slope at right angles to the contours and covers most of the variations observed in a landform. In each selected transect, profiles were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravels and stones *etc.* Random soil profiles were opened in areas which were not covered in the transect to bring all the possible variability of the study area. Seven representative profiles were studied in detail for their morphological and physical characteristics. 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.

Field equipments used for work during soil profile studies and grid sampling are profile digging tools, Munsell soil colour chart, magnifying lens, measuring tape, wash bottle with dilute HCl, sieves, shovel, cloth bags etc. Global positioning system (GPS) instrument was utilized for correct location of the pedons and also for collecting surface soil samples to study the spatial variability of soils. Light table was used for visual interpretation of satellite data. Soil samples were analysed using laboratory facilities of the department and the data are presented in this paper.

Results and Discussion

Characterisation of soils

Morphological characters of all the pedons are shown in Table 1. The soils were reddish brown (5YR 3/4) to dark reddish brown (5YR 3/3) in pedons 1, 2, 3, 4 and 6 whereas in pedon 5 the colour of soil was deep and dark red (2.5 YR 3/2) to deep and weak red (2.5

YR 4/2) and pedon 7 soils were very dark brown (10 YR 3/3) to dark greyish brown (10 YR 3/2). There was not much variation in the soil colour with depth in all the pedons. 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 structure was fine granular to sub-angular blocky throughout the profile. The Fine weakly developed structure are found in the surface and well developed are found down the pedon. The consistence of all the pedon soils varied from slightly hard to hard when dry, friable to firm when moist, slightly sticky to very sticky and slightly plastic to very plastic when wet.

Total sand content varied from 30 to 82.5 per cent and it was more in the surface compared to sub-surface horizons. The clay content in different pedons in surface horizon ranged from 10.5 to 52 per cent. The sub-surface horizons exhibited higher clay content as compared to surface horizons. Silt content ranged from 5 to 26.5 per cent.

It exhibited an irregular trend with depth. Among all the pedons, pedon 7 had higher clay content in both surface and subsurface layer. Bulk density of the pedon samples varied from 1.26 to 1.78 Mg m^{-3} followed a common pattern of increasing with increasing depth but in case of pedon 6 soils decreased with depth. Soil reaction (pH) increased with depth from 7.76 to 8.11 and higher value was noticed in Bt2 horizon in pedon 2 (Table 2).

The pH of pedon 4 soils ranged from 7.62 to 6.89 with higher value in surface horizon. Irregular trend with depth was found in pH and varied from 6.98 to 7.8 in case of pedon 7. Organic carbon content in surface horizons ranged from 2 to 8 g kg^{-1} and in subsurface horizon it varied from 2 to 6 g kg^{-1}. The organic carbon content was very low and it was 2.0 g kg^{-1} throughout the profile in pedon 1. The organic carbon content of pedon 2 soils decreased with depth from 7.0 (Ap) to 5.0 (Bt2) g kg^{-1}. Organic carbon of pedon 5 soils decreased down the profile with a range from 6.0 to 3.0 g kg^{-1}.The exchangeable bases in all the pedons were in order of $Ca^{+2}>Mg^{+2}>Na^{+}>K^{+}$ on the exchange complex (Table 3).

From the distribution of Ca^{+2} and Mg^{+2}, it is evident that Ca^{+2} shows the strongest relationship with all the species, comparing these ions ($Mg^{+2,}$ K^{+} and Na^{+}) it was clear that Mg^{+2} was present in low amount than Ca^{+2}. Cation exchange capacity of the pedons varied both location and depth-wise. Higher CEC was observed in Bt2 horizon. Pedon 7 had higher CEC in both surface and subsurface layer.

The soils of the study area has recorded high base saturation. Among all the pedons, pedon 2 had higher BS per cent in both surface and subsurface layer.

Classification of soils of the micro-watershed

At the highest category (Order), the presence or absence of diagnostic horizons, which are indications of pedogenic processes, are considered. At sub-order level, the moisture and temperature regimes were used.

At lower categories (great group, family *etc.*) mineralogy, texture, soil chemical properties and drainage are considered. Two orders were identified namely Alfisols and Inceptisols.

Six pedons *i.e.* pedon 1 to pedon 6 were classified as "Alfisols" at order level and pedon 7 classified under the "Inceptisols" at order level. Classification of soils is given in Table 4.

Table.1 Physico-chemical properties of the pedons

Horizon	Depth (cm)	Boundary	Diagnostic Horizon	Colour	Gravel (Vol.%)	Texture	Structure	Consistency
Pedon 1								
Ap	0-15	as	Ochric	5YR3/4	40	ls	2 f gr	l frsssp
Bt	15-35	cs	Argillic	2.5YR3/4	50	scl	1 m sbk	shfrsssp
BC	35-65	cw	-	2.5YR3/3	60	scl	1 m sbk	shfrsssp
Pedon 2								
Ap	0-15	as	Ochric	5YR 3/4	5	sl	1 m sbk	vfrsssp
Bt1	15-34	cs	Argillic	2.5YR3/4	<5	c	2 m sbk	frmsmp
Bt2	34-56	cw	Argillic	2.5YR3/4	<5	c	2 m sbk	frmsmp
Pedon 3								
Ap	0-14	cs	Ochric	5YR 4/4	15	scl	1 m sbk	Shfrsssp
Bt	14-39	cs	Argillic	2.5YR3/4	15	sc	2 m sbk	Frmsmp
Pedon 4								
Ap	0-15	as	Ochric	7.5YR3/5	30	ls	0c gr	l lsopo
Bt1	15-50	cw	Argillic	2.5YR3/5	70	scl	1 m sbk	shfrmsmp
Bt2	50-120	cw	Argillic	2.5YR4/3	60	scl	1 m sbk	shfrmsmp
Pedon 5								
Ap	0-20	as	Ochric	2.5YR3/3	40	sl	0 c gr	lvfrsssp
Bt1	20-40	gs	Argillic	2.5YR5/4	15	scl	1 m sbk	shfrmsmp
Bt2	40-100	gw	Argillic	2.5YR3/2	10	sc	1 m sbk	shfrmsmp
BC	100-120	cw	-	2.5YR4/2	15	sc	1 m sbk	shfrmsmp
Pedon 6								
Ap	0-17	as	Ochric	7.5YR3/4	20	ls	0 c gr	l lsopo
Bt1	17-48	cs	Argillic	5YR 3/4	10	sl	1 m sbk	Vfrsssp
Bt2	48-82	cw	Argillic	5YR 3/3	5	sc	2m sbk	frmsmp
Pedon 7								
Ap	0-17	as	Ochric	10YR 3/3	5	sc	2msbk	Shfrmsmp
Bw1	17-36	cs	Cambic	10YR 3/3	-	c	2msbk	Shfrmsmp
Bw2	36-69	gs	Cambic	10YR 3/2	-	c	2msbk	Shfrmsmp
Bw3	69-107	gs	Cambic	10YR 3/2	-	c	2msbk	Shfrmsmp

Table.2 Physico-chemical properties of the pedons

Horizon	Depth (cm)	Particle size distribution (%)			pH	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	BD ($Mg\ m^{-3}$)
		Sand	Silt	Clay				
Pedon 1								
Ap	0-15	82.50	7.00	10.5	7.05	0.06	2.01	1.58
Bt	15-35	65.00	5.00	30.00	7.15	0.06	2.01	1.69
BC	35-65	64.00	9.50	26.5	7.26	0.04	2.01	1.78
Pedon 2								
Ap	0-15	70.5	15.50	14.00	7.76	0.17	7.02	1.26
Bt1	15-34	32.00	26.50	41.50	7.84	0.15	6.15	1.28
Bt2	34-56	30.00	23.00	47.00	8.11	0.13	5.03	1.52
Pedon 3								
Ap	0-14	62.00	15.50	22.50	8.24	0.20	8.01	1.36
Bt	14-39	61.00	3.00	36.00	8.39	0.16	6.11	1.43
Pedon 4								
Ap	0-15	73.00	15.00	12.00	7.62	0.07	3.09	1.32
Bt1	15-50	55.00	10.00	35.00	6.87	0.07	3.09	1.36
Bt2	50-120	50.00	10.00	40.00	6.89	0.06	2.15	1.56
Pedon 5								
Ap	0-20	70.00	12.00	18.00	8.56	0.13	6.05	1.34
Bt1	20-40	60.00	9.00	31.00	8.43	0.16	6.05	1.35
Bt2	40-100	52.00	13.00	35.00	8.00	0.15	5.08	1.37
BC	100-120	50.00	12.00	38.00	8.37	0.22	3.12	1.48
Pedon 6								
Ap	0-17	71.00	18.00	11.00	6.58	0.05	2.11	1.55
Bt1	17-48	70.00	14.00	16.00	6.41	0.04	2.11	1.5
Bt2	48-82	54.00	6.00	40.00	6.38	0.04	2.11	1.33
Pedon 7								
Ap	0-17	60.00	9.00	28.00	6.98	0.09	4.02	1.26
Bw1	17-36	45.00	9.00	46.00	7.35	0.06	2.11	1.28
Bw2	36-69	41.00	12.00	47.00	7.80	0.14	2.11	1.29
Bw3	69-107	38.00	10.00	52.00	7.34	0.06	2.11	1.32

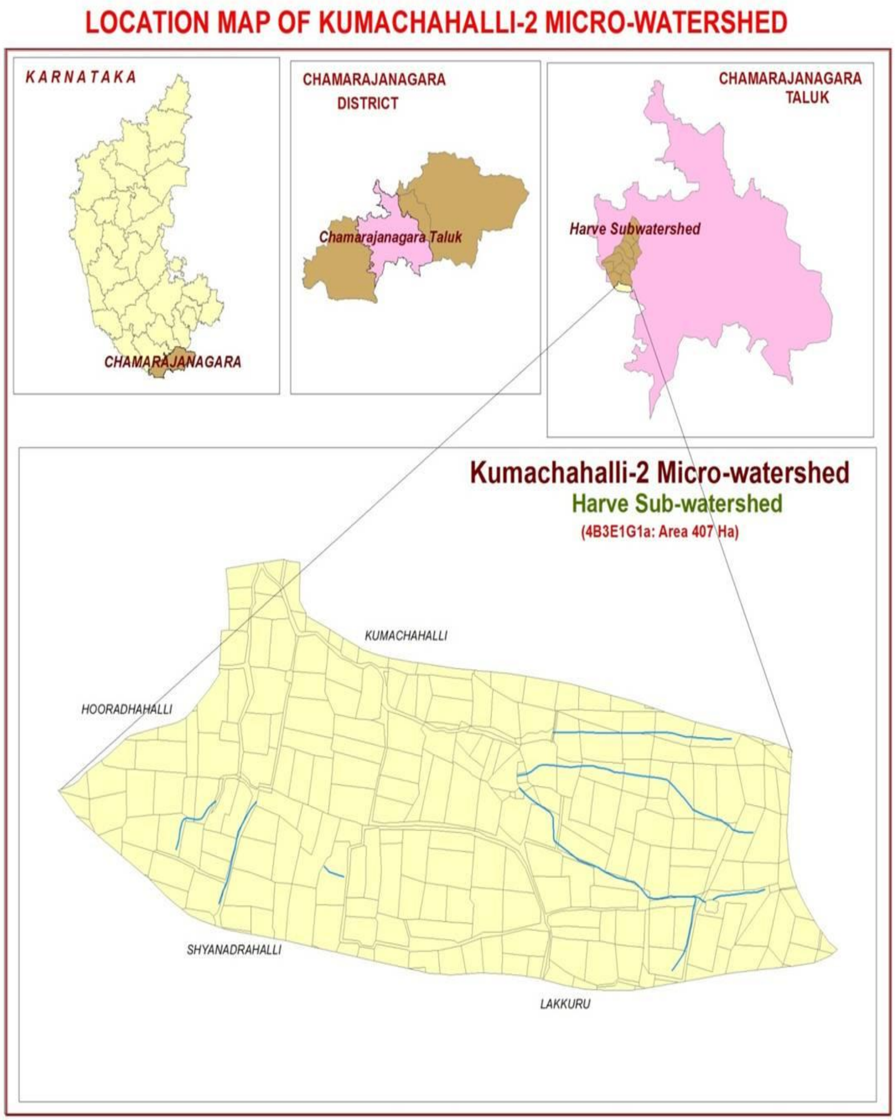
Table.3 Ion exchange properties of pedons

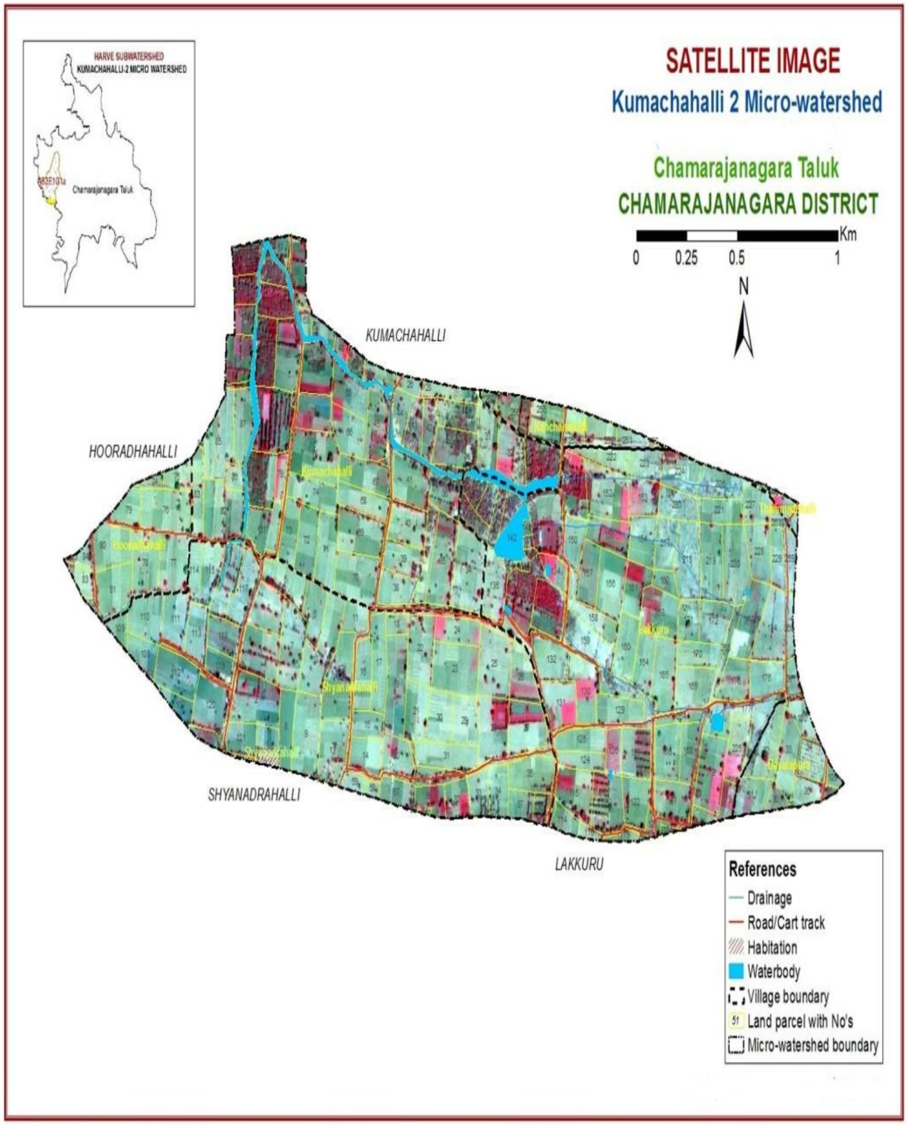
Horizon	Depth (cm)	Exchangeable bases (cmol(p+) kg^{-1})				CEC (cmol(p+) kg^{-1})	BS (%)	CEC/ Clay ratio
		Ca	Mg	K	Na			
Pedon 1								
Ap	0-15	7.90	3.70	0.05	0.01	12.65	92.17	1.21
Bt	15-35	6.40	5.30	0.07	0.02	13.01	90.63	0.44
BC	35-65	6.40	5.30	0.07	0.02	13.01	90.63	0.50
Pedon 2								
Ap	0-15	5.60	7.00	0.09	0.01	13.81	92.17	0.98
Bt1	15-34	11.20	9.40	0.10	0.01	22.60	91.64	0.55
Bt2	34-56	15.40	7.60	0.13	0.01	24.60	94.06	0.53
Pedon 3								
Ap	0-14	8.90	1.90	0.03	0.05	12.00	90.67	0.54
Bt	14-39	17.60	0.20	0.03	0.06	21.00	85.20	0.59
Pedon 4								
Ap	0-15	6.00	3.70	0.01	0.01	7.50	89.60	0.62
Bt1	15-50	7.30	3.20	0.05	0.01	12.30	85.86	0.35
Bt2	50-120	5.70	3.70	0.05	0.01	11.25	84.47	0.28
Pedon 5								
Ap	0-20	9.80	2.60	0.04	0.01	14.50	85.87	0.81
Bt1	20-40	7.40	7.60	0.10	0.02	17.20	87.91	0.56
Bt2	40-100	13.60	8.60	0.12	0.03	25.50	87.65	0.73
BC	100-120	19.10	8.10	0.11	0.01	31.40	87.00	0.83
Pedon 6								
Ap	0-17	3.20	0.50	0.07	0.01	4.80	78.75	0.44
Bt1	17-48	3.50	1.40	0.02	0.01	6.70	73.59	0.42
Bt2	48-82	8.10	2.30	0.03	0.01	14.10	74.05	0.36
Pedon 7								
Ap	0-17	11.70	15.70	0.21	0.05	31.70	87.26	0.84
Bw1	17-36	21.50	6.90	0.09	0.02	30.51	93.44	0.67
Bw2	36-69	19.00	5.50	0.08	0.02	29.70	82.83	0.64
Bw3	69-107	25.70	12.30	0.16	0.04	40.20	95.03	0.78

Table.4 Classification of soils of the Micro-watershed

Pedon	Soil series	Family	Sub group	Great group	Suborder	Order
1	Lakkuru (S_2)	Loamy skeletal, mixed, super active, Isohyperthermic Typic Rhodustalfs	TypicRhodustalfs	Rhodustalfs	ustalfs	Alfisols
2	Thammadihalli(S_7)	Fine, mixed, active, Isohyperthermic, Typic Rhodustalfs	TypicRhodustalfs	Rhodustalfs	ustalfs	Alfisols
3	Shyanandrahalli-1 (S_1)	Fine, mixed, acive, Isohyperthermic Lithic Rhodustalfs	Lithic Rhodustalfs	Rhodustalfs	ustalfs	Alfisols
4	Kumachahalli 1 (S_4)	Clayey skeletal, mixed, active, Isohyperthermic,Typic Rhodustalfs	TypicRhodustalfs	Rhodustalfs	ustalfs	Alfisols
5	Horadahalli(S_5)	Loamy skeletal, mixed, superactive, Isohyperthermic,TypicRhodustalfs	TypicRhodustalfs	Rhodustalfs	ustalfs	Alfisols
6	Kumachahalli 3 (S_3)	Fine loamy, mixed semi active, Isohyperthermic, Typic Haplustalfs	TypicHaplustalfs	Haplustalfs	ustalfs	Alfisols
7	Shyanandrahalli-2 (S_6)	Fine, mixed, super active Isohyperthermic, Vertic Haplustepts	VerticHaplustepts	Haplustepts	ustepts	Inceptisols

Fig.1 Location map and cadastral map of Kumachahalli micro-watershed of Chamarajanagar district





Characterisation of soils

Morphological properties

The variations in soil colour might be due to the differences in content and hydration of iron oxide and variation in mineral suites coupled with other prevailing pedological features (Shamsudheen *et al.*, 2005). The soils were dark reddish brown (5YR 4/4) to dark red (2.5YR 3/4), it may be due to variation in organic matter and texture (Noshadi *et al.*, 2013). Dark brown (7.5YR 3/5) colour in the surface horizon to dark red (2.5YR 3/5) and red (2.5YR 4/3) in the sub-surface horizons may be attributed to the presence of non-hydrated iron oxides, indicating well drained nature of these soils. The variations in soil texture may be due to differences in parent material, physiography, in situ weathering and translocation of clay (Basavaraju *et al.*, 2005). The fine weakly developed structure in the surface and well developed down the pedon could be due to finer materials received from higher topographic positions and higher rate of weathering. Similar results were also reported by Sireesha and Naidu (2013). The coarse, structure less, granular structure in surface horizon and weak to moderate sub-angular blocky structure in sub-surface horizon was due to the increase in clay content. The change in the consistency may be due to the increase in the clay content.

The consistence of all the pedon soils varied from slightly hard to hard when dry, friable to firm when moist, slightly sticky to very sticky and slightly plastic to very plastic when wet. The sub-surface horizons exhibited higher clay content as compared to surface horizons due to the illuviation process occurring during soil development. The clay increased while sand and silt decreased with depth due to illuviation of clay. Similar results were obtained by Sharma *et al.*, (2002). Bulk density of the pedon samples followed a common pattern of increasing with increasing depth. It was attributed to the pressure of the overlying horizons and diminishing amounts of organic matter (Marathe *et al.*, 2003). But in case of pedon 6 soils bulk density decreased with depth due to increment in the clay (Sitanggang *et al.*, 2006).

Chemical properties

Soil reaction (pH) increased with depth and higher value was noticed in Bt2 horizon in all the pedons (Table 2). It may be due to process of illuviation, where leaching down of bases takes place which is deposited in the sub surface layer. Thangasamy *et al.*, 2005 reported that the variation in soil pH is associated with parent material, rainfall and topography. Soils of all the pedons were non-saline in nature. This may be due to free drainage conditions, which removed the released bases by percolation or by drainage water. These results were in conformity with the findings of Kumar (2011). The organic carbon content was very low and it might be due to the decomposition of organic matter under high temperature regime in the study area.

Higher organic carbon content observed in the surface horizon, indicating the maturity of the profile developed on very stable landform (Nalina *et al.*, 2016). From the distribution of Ca^{+2} and Mg^{+2}, it is evident that Ca^{+2} shows the strongest relationship with all the species, comparing these ions ($Mg^{+2,}$ K^{+} and Na^{+}) The low value of exchangeable monovalents as compared to divalents was due to preferential adsorption of divalents than monovalents. Cation exchange capacity increased with depth which may be related to the higher clay content down the profile. Similar results were obtained by Sharma and Anil Kumar (2003). High base saturation in pedons indicating low degree of leaching showed tendency to increase with depth (Sitanggang *et al.*, 2006).

Classification of soils

Pedon 1 and 5 were classified under order Alfisols due to presence of Argillic endopedon and ochric epipedon. The base saturation was more than 35 per cent throughout the profile. At Suborder level it was ustalfs due to presence of ustic moisture regime. Rhodustalfs were keyed out at The "Isohyperthermic" temperature regime was because of the reason that mean annual soil temperatures of >22°C and the difference between the mean summer and mean winter temperatures were <5°C and classified as super active as the ratio of CEC to percent clay was more than 0.60. The Pedon 2 classified as Fine, mixed, active, Iso hyperthermic, Typic Rhodustalfs. Active because the CEC to clay ratio was between 0.40 to 0.60. pedon 3 classified as Fine, mixed, active, Iso hyperthermic Lithic Rhodustalfs. Family of lithic Rhodoustalfs due to lithic contact within 100 cm of mineral soil surface. The particle size class is fine as clay is more than 35 per cent and less than 60 per cent in the control section. Pedon 4 as Clayey skeletal, mixed, active, iso hyperthermic, Typic Rhodustalfs. Pedon 6 classified as fine loamy, mixed semi active, Isohyperthermic, Typic Haplustalfs. The Argillic horizon did not exhibit a hue of 2.5YR and moist value of 3. Hence, this pedon grouped as "Haplustalfs" at great group level and was semi active because the CEC to clay ratio was between 0.24 and 0.40. Pedons7 was classified as "Inceptisols" at order level due to cambic endopedon and at sub order level keyed out as "Ustepts" because of Ustic soil moisture regime. The base saturation is more than 60 per cent at a depth between 0.25 to 0.75m from the soil surface. These characters indicated that these pedons represented the central concept of ustepts. So, the pedon is grouped under "Haplustepts" at great group level. At Great group level, Ustepts were classified under "Haplustepts" as they were not qualified for other great groups. This pedon was Classified as super active as CEC to clay ratio was >0.60.

Acknowledgements

The Author is thankful to the Indian Council of Agriculture Research, New Delhi for providing excellence exposure during the course of investigation. The author is in shortage of words to express his heartfelt gratitude to University of Agricultural Sciences, Bangalore for the facilities provided in order to complete this investigation in timely manner with a dashing fashion so that it can have its utility in the grassroot level.

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How to cite this article:

Pinki Seth, T. Chikkaramappa, Rajeswari Das and Navya, N.C. 2017. Characterisation and Classification of Soil Resources of Kumachahalli Micro-Watershed in Chamarajanagar, Karnataka, India. *Int.J.Curr.Microbiol.App.Sci.* 6(12): 319-329.
doi: https://doi.org/10.20546/ijcmas.2017.612.038