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Characterization and Classification of Soils of Tumkur District, Karnataka Based on Organic Carbon Stocks as an Index of Land Degradation

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Abstract

The detailed reconnaissance soil survey was carried out in Tumkur district of Karnataka to characterize, classify and study organic carbon stocks of degradation vulnerable soils during 2021-2023 using remote sensing, GIS and field studies. Satellite imageries (Sentinal -2) of three-seasons were used along with soil map to delineate the degraded soils through visual image interpretation. Using this as base map, resource characterization was done. Thirteen soil pedons were studied from Tumkur district covering major soils. Four representative pedons (Kurubarahalli, Koratagere; Huliyurdurga, Kunigal; Chinnenahalli, Sira and Hosahalli forest, Gubbi) to study characterization and classification of soils of Tumkur district, Karnataka based on organic carbon. The granite, gneissic and schistose landform, with dykes and laterized parent material give rise to well, somewhat excessive or moderately well drained soils. The soils were generally deep, non-gravelly to very gravelly with sandy clay loam to clayey texture. Moderately acid to moderately alkaline Specify with low to high organic carbon content were observed. CEC/clay ratio ranged from 0.14 to 0.70 and base saturation varied from 46.31 to 79.98 per cent. The available water holding capacity ranged from 42.84 to 77.55 mm m^{-1} with highest organic carbon stock in Hosahalli forest of Gubbi (9.82 kg m^{-3}) and the least in Kurubarahalli village of Koratagere (1.93 kg m^{-3}) upto 150 cm. The major taxa of the soil identified at sub-group level of soil taxonomy were Rhodic Kanhaplustalfs, Typic Rhodustalfs, Rhodic Kandiustalfs and Fluventic Haplustepts. Use of remote sensing and GIS techniques along with field studies is ideal for assessing land qualities of Tumkur district. This can help in identifying and encountering problems created by land degradation processes over a period of time along with exposure to adverse climatic conditions, land management and other anthropogenic interventions for ensuring sustainable management of land with enhanced productivity.

Keywords : Index of land degradation, Organic carbon stocks, Remote sensing, Classification of soils

The land resources of the country are its most precious and sacred endowment. It is the most valuable resource for the production of food, fibre, fuel and many other vital goods required to meet human and animal needs. However, it is facing serious threats of deterioration due to inexorable human pressure and utilization incompatible with its capacity. Land degradation is considered one of the most severe global problems worldwide. The Millennium Ecosystem Assessment defined land degradation as the reduction in the capacity of the land to perform ecosystem goods, functions and services that support society and development. Both economic loss and ecological degradation may be considered and measured against the capacity to satisfy human needs.

As the world population is increasing day by day, to feed this augmenting population, food production is also increasing with the limited land availability, which is leading to intensive cultivation and indiscriminate use of chemical fertilizers (Srinivas and Krishnamurthy, 2017). In Karnataka, about 27.4 per cent of total geographical area is degraded mainly by water erosion, salt-affected land and other anthropogenic activities. However, to meet the requirement of this food grains for the population of next decade, the current production has to be increased by nearly 50 per cent. This increase has to come from increased productivity. The higher yield in future would be harvested from the vertical rather than horizontal expansion of net cropping area (Prashanatha and Chikkaramappa, 2017). Hence, management of this soil is very important. So, we have taken Tumkur district of Karnataka, falling under three major agro-climatic zones *i.e.,* central dry zone, southern dry zone and eastern dry zone to study the soil characteristics, classification and soil organic carbon stock in land degradation vulnerable soils of Tumkur district.

Material and Methods

Tumkur district constituting the study area is situated in south-eastern part of Karnataka state and lies between 12° 45" and 14° 30" North latitudes and 76° 15" and 77° 45" East longitudes. The district, administratively divided into ten taluks, has a total area of 10,64,755 ha. It is bound by the Anantapur district of Andhra Pradesh on the North-East, Kolar and Bangalore districts on the East, Mandya district on the South, Chitradurga district on the North and Chickmagalur and Hassan districts on west (Fig. 1).

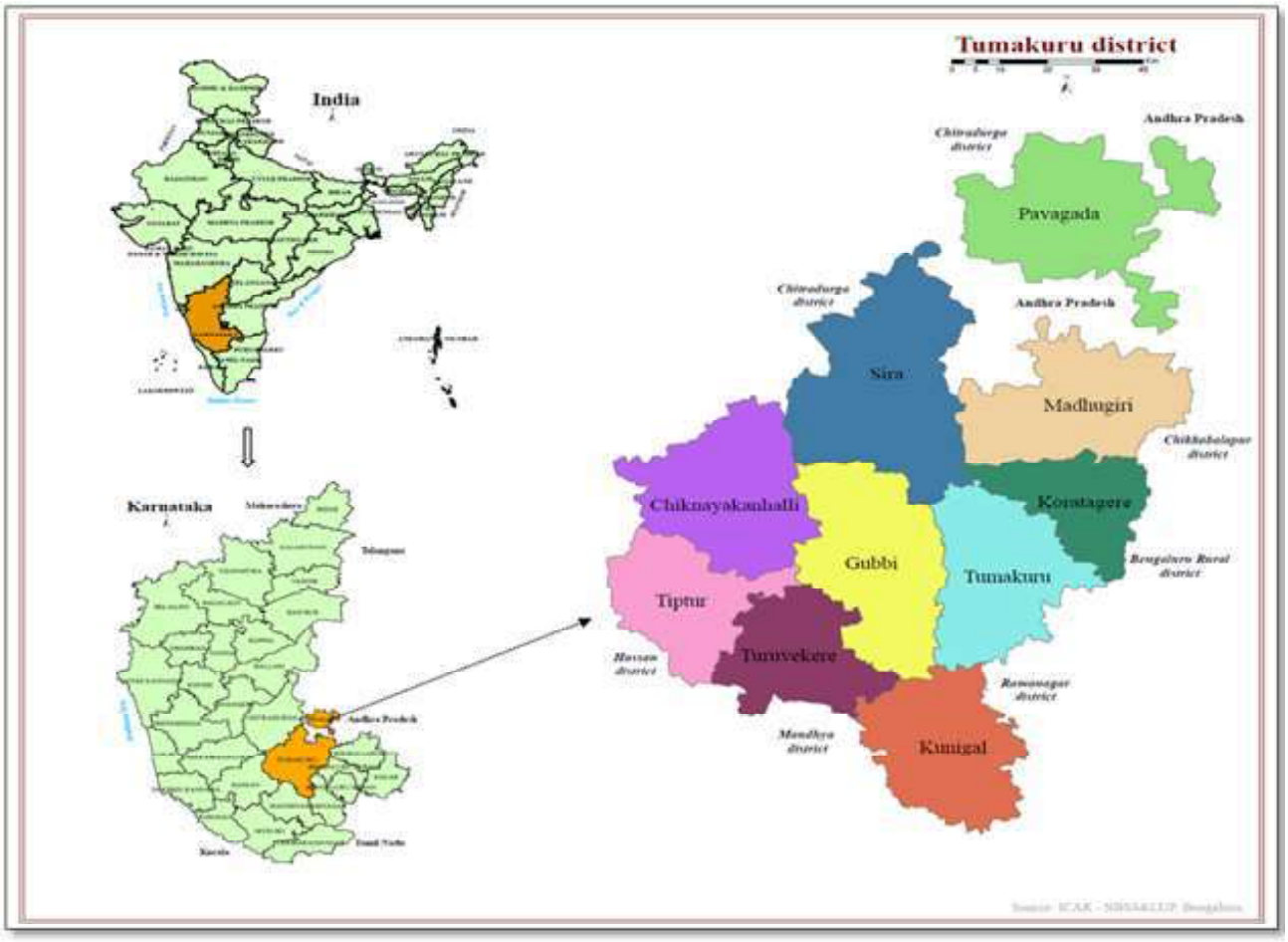

Fig. 1 : Map of study area

The district is divided into ten taluks: Tumkur, Gubbi, Kunigal, Turuvekere, Chikkanayakanahalli, Tiptur, Sira, Madhugiri, Pavagada and Koratagere. Among ten taluks Pavagada, Sira, Madhugiri, Chikka nayakanahalli, Koratagere and Tiptur fall under central dry zone, Gubbi and Tumkur fall under eastern dry zone and Turuvekere and Kunigal fall under southern dry zone. The granite, gneissic and schistose landform, with dykes and laterized parent material give rise to well, somewhat excessive or moderately well drained soils.

Image Interpretation and Ground Truth Studies

For delineation and mapping of land degradation classes, satellite imageries (Sentinal - 2) of three seasons *i.e*., summer, winter and rainy season of 2021 were extracted from Google Earth pro. In Google Earth pro, navigate to the area of interest (Tumkur), add the shape files and extracted the required image of different seasons. Using the interpretation key prepared, land degradation classes were delineated by using ArcGIS and visual image interpretation procedures. Using ArcGIS software, digital data was processed and transformed for improved image contrast and to generate photo-products for subsequent interpretation. The imagery was georeferenced with a sub-pixel accuracy using first order polynomial transformation and false colour composite of the image was generated. Satellite imageries was used to identify and delineate the degraded soils *i.e*., water erosion (slight, moderate and severe), salt affected (slight, moderate and severe), mining, forest, river, water bodies and habitation using image interpretation keys such as variations in texture, colour, tone etc., with the help of Bhuvan and Google Earth images for identification. The land degradation map was finalized based on the ground truth observations, visual interpretations and available ancillary data.

Soil Survey, Mapping and Classification

Detailed reconnaissance soil survey was carried out. The district is covered by survey of India toposheet (1:50000) of 57C/ 6 to 16, 57D/ 13, 57F/ 3, 7, 8, 11 and 12, 57G/1 to 7, 57H/1 and 2, respectively. Field traversing was done for ground truth and to identify the location for profile study. It helped in gathering information on different types of soil degradation such as sheet erosion, poor drainage, soil salinity and alkalinity, slope, problems related to water percolation and vegetal degradation etc. Site was selected based on type, extent and severity of degradation. The sampling sites which are representative of the area were chosen on the basis major soil type. A profile was dug on the dimension of 1.5 x 1.5 x 1.5 m. and the orientation of the profile should be in such a manner that a face got well-lit and easy for demarcation of the horizons. Demarcation was done on the basis of texture, structure and colour and the details like depth, texture, colour, consistency, rock fragments, presence of mottles and structure were recorded and studied according to standard proforma (USDA, 2000) of soil profile description. Thirteen pedons were studied from Tumkur district, out of that four pedons are selected based on soil organic carbon stocks (Table 1). Two pedons from central dry zone (Kurubarahalli, Koratagere, Chinnenahalli, Sira) one pedon from eastern dry zone (Hosahalli forest, Gubbi) and one pedon southern dry zone (Huliyurdurga, Kunigal).

Climate of the Tumkur is hot moist semi-arid tropical with mean average annual rainfall of 687.9 mm in 45

TABLE 1

Location of selected soil pedon of Tumkur district, Karnataka

Location	Agroclimatic zone	Taluk
13° 30’ 53.4” N latitude 77° 05’ 04.5” E longitude	Central dry zone	Kurubarahalli, Koratagere
13° 35’ 23.3” N latitude 77° 00’ 28.8” E longitude	Central dry zone	Chinnenahalli, Sira
13° 16’ 43.6” N latitude 77° 57’ 38.4” E longitude	Eastern dry zone	Hosahalli forest, Gubbi
12° 50’ 16.6” N latitude 77° 02’ 06.8” E longitude	Southern dry zone	Huliyurdurga, Kunigal

days. The rainfall was observed from 13th week to 49th week with peak precipitation in September. But during end of June and beginning of July dry spell is observed for two to three weeks. Hence, there is a need of water conservation and life-saving irrigation for protected cultivation. The highest annual mean rainfall was observed in Kunigal (828.98 mm) and lowest was observed in Sira (625.45 mm). The mean annual temperature was recorded high during April and May with temperature more than 27ºC in central dry zone, but in eastern and southern dry zone, temperature recorded was below 27ºC. The mean summer soil temperature and mean winter soil temperature are less than 6ºC, thus qualifying the soil temperature regime as iso-hyperthermic.

The horizon wise soil samples were collected, processed and analyzed using standard analytical methods and soils were classified (Soil survey staff, 2022). The soil organic carbon stock was calculated using bulk density, organic carbon, depth and gravel content (Grossman *et al*., 2001).

Results and Discussion

Site Characteristics of Selected Pedons

The elevation was ranging from 712 to 861 m. above mean sea level with Kurubarhalli of Koratagere pedon studied from 861 m. above mean sea level. These are studied from nearly low land to moderately sloping hills of Bangalore plateau with slopes ranging from 0 to 1 per cent to 5 to 10 per cent and slight to severe erosion was observed. Moderately well drained in Huliyurdurga of Kunigal to well-drained condition was observed in other three pedons. The granite and granitic gneiss are the major parent material.

Morphological Characteristics

The thickness of solum varied from 55 to 145 cm (moderately deep to very deep). The pedon occurring in moderately slopping hills was moderately deep but the pedon in nearly low land was recorded deep below which water saturated horizon was observed (Table 3). The soil's hue ranged from 2.5YR to 7.5YR with value 3 to 4 and chroma 2 to 6, respectively. the colour varied from dark reddish brown to very dark grayish brown colour. The variation is soil colour depend on chemical and mineralogical composition of parent material, textural constituent of soils, together with topographic position and moisture regime (Sireesha and Naidu, 2013).

The lower hue value might be due to presence of red mottles in lower horizons might be due to alternate oxidation and reduction process (Jondhale and Jagdish Prasad, 2006). The chroma of 2 in the lower horizons of pedon 4 revealed gleiing due to water saturation (Bhattacharyya *et al*., 2009). The soil had texture of sand to clay. In surface and sub-surface horizons, the pedons exhibited weak to moderate, fine to medium, granular to sub angular blocky with massive structure in C horizons. Higher clay and organic matter content influence the soil structure formation (Gurav *et al*.,

Table 2

Site characteristics of selected pedons of Tumkur district, Karnataka

Pedon No./ Name	Elevation (m)	Rainfall (mm)	Physiography	Slope (%)	Drainage	Erosion	Parent Material
P1 - Kurubarahalli Koratagere	861	763.31	Moderately sloping hills and Bangalore plateau	5-10	Well drained	Severe	Granite and granitic colluvium
P2 - Chinnenahalli Sira	740	625.45	Undulating plateau summit and Bangalore plateau	1-3	Well drained	Slight	Granite
P3 - Hosahalli forest Gubbi	805	788.64	Undulating upland and Bangalore plateau	3-5	Well drained	Moderate	Granite gneiss and Granite
P4 - Huliyurdurga Kunigal	712	828.98	Nearly low lands of Bangalore plateau	0-1	Moderately Well drained	Slight	Granite and Alluvium

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TABLE 3

Morphological characteristics of selected pedons of Tumkur district, Karnataka

Horizon	Depth (cm)	Boundary	Colour		Texture	Structure	Consistence			Root	Pores
			Dry	Moist			Dry	Moist	Wet		
P1 - Kurubarahalli, Koratagere											
Ap	0-9	aw		5YR 3/4	scl	1 F gr		vfr	ms&ps	m vf	m c, m
Bt1	9-28	cw		2.5YR 3/4	sc	2 Fgr		vfr	ms&ps	c vf	c m, c
Bt2C	28-55			5YR 4/4	sc	1 Fgr/m		vfr	s & p	f vf	c c
Cr	55-60+			5YR 5/4	s	m		vfr	s0& p0		
P2 - Chinnenahalli, Sira											
Ap	0-22	as		7.5YR 3/4	scl	1 Fsbk		fr	ss& ps	m vf	c m
Bt1	22-36	as		5YR 3/4	sc	1 M sbk		fi	ms&mp	f vf	c f,vf
Bt2	36-63	aw		2.5YR 3/4	sc	1 Msbk		fi	s & p	f vf	c f
BC	63-105	cw	2.5YR 4/4	2.5YR 3/4	sc	1Msbk/m	sh	fr	ss& ps		f c,f
CB	105-124		5YR 3/6	5YR 3/4	scl	2 Csbk/m	h	fr	ms& ps		f f
CrB	124-154+		5YR ¾	5YR 3/4	sc	m	h	fr	ss&ps		f m
P3 - Hosahalli forest, Gubbi											
A	0-14	as	2.5YR 4/4	2.5YR 3/4	sc	2 F sbk	sh	fr	ms& ps	m f	c m
Bt1	14-44	cs	2.5YR 4/6	2.5YR 3/6	c	2 M sbk	sh	fr	s &mp	m c, m f	c f
Bt2	44-75	as	2.5YR 3/4	2.5YR 3/4	c	1 M sbk	sh	fr	s & p	c f	c f
Bt3	75-104	cs	2.5YR 4/4	2.5YR 4/4	c	1M sbk/m	h	fr	s & p		f f
Bt4C	104-145	cw	2.5YR 3/4	2.5YR 3/4	c	1M sbk/m	vh	fi	ms& ps	f c	f f
Bt5C	145+	cw	2.5YR 3/6	2.5YR 3/6		m	eh	fi	vs& vp		f c
P4 - Huliyurdurga, Kunigal											
Ap	0-12	as		7.5YR 3/2	c	1 Fsbk		fr	vs&ps	f vc	m m
A2	12-29	cs		10YR 3/2	c	2 Fsbk		fi	ms& ps		f f
Bw	29-63	cs		2.5YR 4/2	c	1M sbk		fi	ms& ps		f vf
BC1	63-87			10YR 4/3	ls	1M sbk		vfr	s0 & p0		f m
BC2	87-106			7.5YR 4/4	s	1 F sg		vfr	s0 & p0		f c
	106 +	Water saturation									

(Boundary: a- abrupt, c- clear; s- smooth, w- wavy Colour: YR- yellowish red hue Texture: s- sand, ls- loamy sand, scl- sandy clay loam, sc- sandy clay, c- caly; Structure: 1- weak, 2- moderate; F- fine, M- medium, C- coarse; gr- granular, sbk- sub-angular blocky structure, m- massive; Consistency: Dry: h- hard, sh- slightly hard, vh- very hard, eh-extremely hard; Moist: fr-friable, vfr- very friable, fi- firm; Stickiness: so- non-sticky, ss- slightly sticky, ms- moderately sticky; Plasticity: po -non-plastic, ps- slightly plastic; Root/ pores: Quantity: f- few, c- common, m- many, Size: m- medium, c- coarse, f- fine, vf- very fine)

2017). This indicates the arrangement of soil particles and their aggregation. The consistency slightly hard to extremely hard under dry condition, friable to very friable and firm under moist condition and non-sticky and non-plastic to very sticky and very plastic under wet condition. These increase in consistency of soil not only depend on clay content, but also minerology of clay. Many to few with very fine to very coarse roots and varied pores were observed.

Physical Characteristics

The total sand, silt and clay was uneven with depth in all the pedons and ranged from 34.08 to 88.79, 6.91 to 18.25 and 5.13 to 49.60 per cent, respectively (Table 4). This variation might be due to irregular illuviation of finer size particles along with percolating water and due to irregular weathering might have led to this result (Vasundhara *et al*., 2017). Gravel content was ranging from 10 to 90 per cent and increased with depth due to reduced weathering with increasing depth and gravel content was not noticed in Kunigal pedon (P4). Bulk density of soil which depend on soil texture and organic matter content. In surface bulk density ranged from 1.39 to 1.66 Mg m^{-3} and in sub-surface 1.40 to 1.70 Mg m^{-3}. The soil moisture content (SMC) ranged from 18.09 to 39.41 mm at field capacity and 6.70 to 20.76 mm under permanent wilting point with available water holding capacity ranging from 42.84 to 77.55 mm m^{-1}. The heterogeneity of parent material,

TABLE 4

Physical characteristics of selected pedons of Tumkur district, Karnataka

Horizon	Depth (cm)	Sand	Silt	Clay	Gravel %	Texture	BD (Mg m^{-3})	FC (mm)	PWP (mm)	AWC	
			(%)							mm	mm/m
P1 - Kurubarahalli, Koratagere											
Ap	0-9	57.17	18.25	24.58	20	gscl	1.41	21.63	12.46	9.17	42.84
Bt1	9-28	52.60	12.31	35.09	30	gc	1.48	24.89	13.75	11.14	
Bt2C	28-55	49.47	13.39	37.14	30	gsc	1.59	23.91	13.47	10.44	
Cr	55-60+	87.57	7.30	5.13	90	egs	1.45	23.49	11.4	12.09	
P2 - Chinnenahalli, Sira											
Ap	0-22	63.46	12.42	24.12	10	scl	1.42	19.63	9.28	13.33	68.15
Bt1	22-36	45.44	16.99	37.57	50	vgsc	1.59	36.32	17.43	18.89	
Bt2	36-63	47.67	11.63	40.70	10	sc	1.52	39.41	18.65	20.76	
BC	63-105	53.45	9.38	37.17	70	egsc	1.54	37.98	20.76	17.22	
CB	105-124	63.47	12.19	24.34	30	gscl	1.58	34.16	16.78	17.38	
CrB	124-154+	74.67	6.91	18.42	80	egsc	1.54	26.93	12.88	14.05	
P3 - Hosahalli forest, Gubbi											
A	0-14	48.49	8.15	43.36	-	sc	1.66	18.09	6.70	11.39	53.96
Bt1	14-44	40.55	11.46	47.99	-	c	1.42	30.48	16.48	14.00	
Bt2	44-75	39.75	10.65	49.60	20	gc	1.60	27.13	12.57	14.56	
Bt3	75-104	43.67	10.00	46.33	40	vgc	1.70	34.41	18.16	16.25	
Bt4C	104-145	44.80	15.14	40.06	50	vgc	1.68	34.54	15.52	19.02	
Bt5C	145+										
P4 - Huliyurdurga, Kunigal											
Ap	0-12	34.08	12.57	53.35	-	c	1.39	34.48	18.70	15.78	77.55
A2	12-29	42.40	13.43	44.17	-	c	1.42	33.77	19.49	14.28	
Bw	29-63	40.12	11.55	48.33	-	c	1.40	34.13	18.24	15.89	
BC1	63-87	84.22	6.13	9.65	-	ls	1.43	34.44	18.78	15.66	
BC2	87-106	88.79	7.05	4.16	-	S	1.49	37.41	14.11	23.30	
	106+	Water saturation									

variation in clay and organic carbon content contributes difference in SMC.

Chemical Characteristics

The pH of the soil ranged from 5.71 to 8.94. The leaching of bases along with percolating water is primarily responsible for higher pH in sub-surface horizons. The electrical conductivity (EC) of soil varied from 0.034 to 0.252 dS m^{-1} (Table 5) indicating that the soils are non-saline, which might be due to granitic parent material with low soluble salts. The organic carbon (OC) content varied from 0.09 to 0.89 per cent and categorized as low to high. The surface horizon had higher organic carbon than sub-surface horizon and decreased with depth because of more biomass addition to surface (leaf litter, organic manure, crop residue etc.) (Vasundhara *et al*., 2020). The exchangeable bases ranged from 1.00 to 11.10 cmol (p+) kg^{-1} of soil. The wide range of cation exchange capacity of soil is related to the amount and

TABLE 5

Chemical characteristics of selected pedons of Tumkur district, Karnataka

Horizon	Depth (cm)	pH	EC (dS m^{-1})	OC (%)	Exchangeable bases cmol (p+) kg^{-1}	CEC	Base saturation (%)	CEC/ clay	ESP (%)
P1 - Kurubarahalli, Koratagere									
Ap	0-9	5.71	0.043	0.42	5.52	7.60	72.63	0.31	1.97
Bt1	9-28	6.04	0.041	0.23	7.25	9.40	77.13	0.27	1.49
Bt2C	28-55	6.84	0.050	0.16	11.10	13.50	82.22	0.36	0.81
Cr	55-60+	6.54	0.040	0.09	1.84	1.90	96.84	0.37	5.26
P2 - Chinnenahalli, Sira									
Ap	0-22	8.30	0.091	0.66	3.30	4.30	76.79	0.18	5.25
Bt1	22-36	8.45	0.091	0.24	5.91	6.20	95.25	0.17	4.68
Bt2	36-63	8.66	0.076	0.42	6.30	7.40	85.17	0.18	4.86
BC	63-105	8.66	0.061	0.15	5.43	5.50	98.73	0.15	4.89
CB	105-124	8.93	0.058	0.12	3.63	3.80	95.40	0.16	8.79
CrB	124-154+	8.94	0.060	0.12	2.27	2.60	87.34	0.14	12.02
P3 - Hosahalli forest, Gubbi									
A	0-14	5.96	0.047	0.89	4.97	5.20	95.58	0.12	4.42
Bt1	14-44	5.83	0.034	0.83	6.97	7.60	91.71	0.16	6.45
Bt2	44-75	7.27	0.036	0.45	8.44	9.60	87.95	0.19	4.58
Bt3	75-104	7.62	0.045	0.15	5.62	6.80	82.65	0.15	2.35
Bt4C	104-145	8.49	0.101	0.18	3.85	4.20	91.67	0.10	6.19
Bt5C	145+								
P4 - Huliyurdurga, Kunigal									
Ap	0-12	8.03	0.252	0.64	8.00	36.40	80.41	0.68	4.04
A2	12-29	8.34	0.167	0.39	8.50	32.40	92.32	0.73	4.32
Bw	29-63	8.45	0.180	0.41	5.75	36.50	95.67	0.76	4.33
BC1	63-87	8.33	0.163	0.27	1.50	6.20	91.50	0.64	9.35
BC2	87-106	8.43	0.133	0.25	1.00	2.80	87.50	0.67	7.50
	106+	Water saturation							

type of clay, and organic content of soils (Sekhar *et al*., 2017) and varied from 1.90 to 36.50 cmol (p+) kg^{-1} of soil. The base saturation ranged from 72.63 to 98.73 per cent and increased with depth due to leaching of bases along with percolating water. The CEC: Clay ratio ranged from sub active to super active range (0.10 to 0.76) which reflects the presence of kaolinite, mixed and smectitic mineralogy. The exchangeable sodium percentage depend mainly on parent material composition, vegetation and management, topography etc. and it varied from 0.81 to 12.02 per cent.

Soil Classification

Based on morphological, chemical, physical and climatic characteristics of the soils from the study area four pedons were classified up to the family level according to the criteria given by the Soil Survey Staff (2014).

The pedon 1 (Kurubarahalli, Koratagere) is having mineral soil that do not have a diagnostic horizon other than an ochric epipedon or anthropic horizon can be keyed out as Entisols. This pedon have less than 35 per cent (by vol.) rock fragments and a texture of loamy fine sand or coarser in all layers within particle size control section and can be classified under *Psamments* sub order and due to the presence of ustic soil moisture regime having where soil moisture control section is dry for some or all part for 90 or more cumulative days. It is moist, however, in some part either for >180 cumulative days or for 90 or more consecutive days, this pedon classified under *Ustipsamment* great group. The pedon1 fall under sub-group of *Lithic Ustipsamment* due to presence of lithic content within 50 cm of the mineral soil surface.

Pedon 2 is having clay illuviated argillic or kandic sub-surface horizons and do not have oxic, plaggen and spodic epipedon or sub-surface horizons above the clay translocated horizon, furthermore the argillic horizons have the base saturation by sum of cations of more than 35 per cent and clay illuviation is clearly identified by the existence of clay cutans with 7.5 cm or more thickened horizon and also more than one-tenth of the thickness of all the overlying horizons as thick as the sum. This is Ustalfs having kandic horizon and hence can be classified as *Kanhaplustalfs*. The sub-surface horizons in the upper 100 cm of the kandic horizons or throughout the entire kandic horizons if less than 100 cm thick, more than 50 per cent colour that have hue of 2.5 YR or redder, value, moist of 3 or less and dry value no more than one unit higher than moist value are classified under *Rhodic Kanhaplustalfs*.

The pedon 3 (Hosahalli forest, Gubbi) is having kandic sub-surface horizons with of low CEC clay ratio (<0.16) and low ECEC by clay ratio (<0.12) and clear indication of clay translocation. So, at great group level this pedons are classified as *Kandiustalfs*. Within that kandic horizon upper 75 cm or throughout the

TABLE 6

Soil classification of selected pedons of Tumkur district, Karnataka

Location	Order	Sub-order	Great group	Sub-group	Family
P1 - Kurubarahalli, Koratagere	Alfisols	Ustalfs	Rhodustalfs	TypicRhodustalfs	Fine, mixed, semi-active, TypicRhodustalfs
P2 - Chinnenahalli, Sira	Alfisols	Ustalfs	Kanhaplustalfs	RhodicKanhaplustalfs	Clayey Skeletal, mixed, sub -active, RhodicKanhaplustalfs
P3 - Hosahalli forest, Gubbi	Alfisols	Ustalfs	Kandiustalfs	RhodicKandiustalfs	Fine, Kaolinitic, sub-active, isohyperthermic Rhodic Kandiustalfs
P4 - Huliyurdurga, Kunigal	Inceptisols	Ustepts	Haplustepts	FluventicHaplustepts	Clayey over sandy, mixed, super-active, iso-hyperthermic Fluventic Haplustepts

TABLE 7

Soil organic carbon stocks of selected pedons of Tumkur district, Karnataka

Location	Soil organic carbon stocks (kg m^{-3})						SOC class/ land quality class
	0-30 cm	0-50 cm	30-100cm	0-100 cm	0-150 cm	Total	
P1 - Kurubarahalli, Koratagere	1.23	1.74	0.70	1.93	1.93	1.93	Very low
P2 - Chinnenahalli, Sira	2.37	3.48	2.80	5.16	6.12	6.20	Medium
P3 - Hosahalli forest, Gubbi	3.96	6.04	4.52	9.13	9.82	9.82	Moderate
P4 - Huliyurdurga, Kunigal	2.07	3.21	3.31	5.38	5.60	5.60	Low

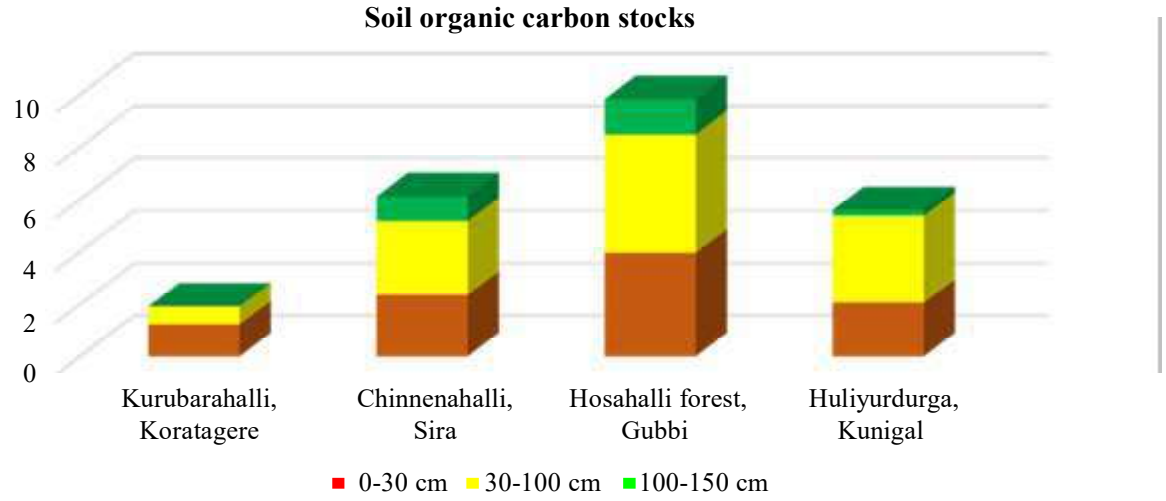

Fig. 2 : Soil organic carbon stocks depth wise of selected pedons

entire kandic horizon (if <75 cm thick) or more than 50 per cent of the colours that are having hue of 2.5YR or redder, value of moist soil of 3 or less and dry value no more than one unit higher than the moist value. Hence, sub group level this pedons are classified as *Rhodic Kandiustalfs*.

The pedon 4 (Hanapanahalli, Tiptur) is coming under Inceptisols as subsurface is having cambic horizon or an altered B horizon with higher chromas of colour and/or texture. At sub-order level, these pedons are coming under moisture regime Ustic, hence these pedons were classified as Ustepts. At great group level classified as *Haplustepts*. This having slope less than 25 per cent and an irregular decrease in organic carbon content between depth of 25 cm and either a depth of 125 cm below the soil surface or a densic, lithic or paralithic content, whichever is shallower and can be classified under *Fluventic Haplustepts*.

Soil Organic Carbon Stocks

Soil organic carbon stocks were very low to moderate in range with very low organic carbon stocks in Kurubarahalli of Koratagere (1.93 kg m^{-3}), low in Huliyurdurga of Kunigal (5.60 kg m^{-3}), medium in Chinnenahalli of Sira (6.20 kg m^{-3}) and moderate in Hosahalli forest of Gubbi (9.82 kg m^{-3}). The soil organic carbon stocks depend mainly on soil organic carbon content, depth of the pedon, gravel content and bulk density. Along with these crop cover and management, topographic condition, climate etc., influences the soil organic carbon stocks. In sub-surface presence of organic carbon content might be due to leaching of soluble organic compounds from

surface soil and their retention as clay-organic complex in finer texture sub-surface (Balesdent *et al*., 1988).

Soils of Tumkur are moderately deep to very deep, dark reddish brown to very dark grayish brown colour, moderately acidic to strongly alkaline with sandy to clayey texture. The climatic data analysis showed the need of life saving irrigation to meet the potential evapotranspiration demand. The CEC: clay ratio indicate the sub-active to super active indicating kaolinitic to the smectitic type of clay minerology. The major soil order observed are Alfisols and Inceptisols. The main constraints were depth, slope, excessive drainage low water holding capacity and water saturation in low land.

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