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Land resources inventory of Hittnalli micro-watershed of Vijayapura district of Karnataka

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Abstract
The present study was undertaken to characterize soils in Hittnalli micro-watershed located in the northern dry zone of Karnataka. The study revealed that the pedons were classified as midland and low land categories. Soils were deep to very deep. They showed brown to very dark gray colour in dry condition, very dark grayish brown to dark grayish brown colour when wet at surface layers while in sub-surface layers colour varied from brown to black both in dry and wet conditions. The soils were clay in texture with moderate medium sub-angular blocky to strong medium angular blocky structure in surface and in sub-surface sub-angular to angular blocky. The pedons expressed slightly hard to hard consistency when dry, firm when moist and moderately to very sticky and moderately to very plastic when wet with moderate calcareousness in surface layers to highly calcareous at sub-surface layers. All the pedons exhibited a clear smooth and gradual smooth boundary, strong to violent effervescence with dilute HCl. In pedons clay dominated over sand and silt, the clay content increases with depth, bulk density in surface layers lower than the sub-surface layers, water holding capacity of sub-surface layers was higher than the surface layer. Soil pH was moderately to strongly alkaline nature with non saline, organic carbon decreased with depth. Free lime content follow an irregular trend with the depth. The dominant cation in the soil was Ca followed by Mg >Na >K with high CEC, it increased with depth followed the trend of clay. Base saturation was high with irregular trend with depth, a lower ESP (< 15%) indicated the non sodic nature. The available potassium showed decrease trend with depth.

Keywords: Hittnalli, micro-watershed, soil resource inventory, soil charectarization

1. Introduction
Soil is a sole of infinite living organisms, the sustainable management of these soil resources is essential for maintenance of environmental balance but today the indiscriminate use of soil resources coupled with lack of management has, led to degradation of soil resources. The natural resources are the national treasures the proper planning of these are prerequisite for the best possible utilization. Recently the concept of watershed based holistic development has emerged as one of the potential approaches in rain fed areas, which can lead to higher productivity and sustainability in agricultural production. The sustainable development of a region need not only require protection and reclamation of natural resources particularly soil and land, but also need a scientific basis for the management in harmony with environment. For the sustainable use of the natural resources, a detailed study of land resources giving its potential and constraints to use becomes a pre-requisite for planning. Land use according to its capability is essential for conserving natural resources for sustainable agriculture.

Knowledge of soil and land resources with respect to their spatial distribution, characteristics, potentials, limitations and their suitability for alternate land uses helps in formulating strategies to obtain higher productivity on sustained basis in order to meet the food requirement of growing population. Soil resource inventory through characterization of resources provides an insight into the potentials and limitations of soil productivity and a framework for the management of soil resources which is needed to realize the concept of watershed development approach successfully. Land use and management practices have considerable influence on available status of nutrients.

The systematic inventory of natural resources like soil, water, land use, forest, *etc.* at a faster rate through scientific methods by using modern tools like remote sensing (RS) geographic information system (GIS) and global position system (GPS) it helps in providing adequate information in terms of land form slope land use and soil characteristics *viz.*, texture, depth, structure, stoniness, drainage, acidity, salinity *etc*. Thus the advent of these has revolutionized in mapping of spatial and non-spatial natural resource information which helps in evolving a variable decision support for achieving sustainable development of agriculture with an objective to characterize soil in respect to physical and chemical properties and soil classification, the suitability of various crops were computed with GIS to determine the effect

of soil properties on various crops. Considering the above points the present investigation detailed soil survey was under taken to characterize the land resources inventory of Hittnalli micro-watershed of Vijayapura district of Karnataka using RS and GPS.

Materials and Methods

Study Area: The Hittnalli micro-watershed is located in Vijayapura taluk of Vijayapura district which comes under Northern Dry Zone (Zone 3) of Karnataka. The soils of this micro-watershed belong to order *Vertisol.* The study area receives an average rainfall of about 765.5 mm. Water is the major constraint in this area due to low rainfall, the major crops of this area are red gram, sorghum and chickpea. The selected Hittnalli micro-watershed is located 10 km away from Vijayapura, district which locate 15º 48' 9.014" N to 15º 49' 26.003" N latitude, 75º 35' 23.398" E to 75º 36' 28.813" E longitude and mean elevation ranged from 441.5 to 541.5 m above MSL. The location of micro-watershed is shown in Fig. 1 and 2. The Hittnalli micro-watershed has nearly level to gentle sloping topography *i.e.* nearly flat terrain. Soils are slight to moderately erodible under the influence of intensive rainfall and small branched type of drainage system was observed in the flat terrain. The basalt is the major parent rock which develops deep black soils. The 2:1 types of clay minerals were observed in this area and soil belongs to *Vertisol* order. The micro-watershed comes under tropical type of climate. The mean annual maximum and minium temperature are 33.5^{0}C, and 19.2^{0}C respectively. The mean annual temperature is 26.38^{0}C during the year 2017. Study area receives 765.5 mm of mean annual rainfall, mean annual morning relative humidity was 79 per cent, mean annual evening relative humidity was 43.3 per cent with annual wind speed of 8.0 KMPH. (www.Agromet.Vijayapura) [17].

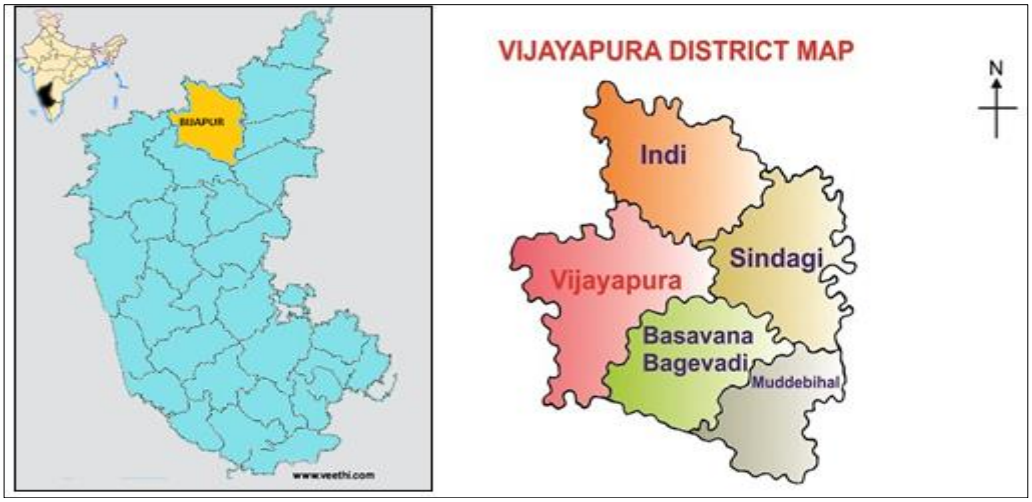

Fig 1: Vijayapura district map

Fig 2: Codastral map of Hittnalli village

Soil survey and characterization

Detailed soil survey was carried-out at cadastral level using satellite image of Hittnalli micro-watershed. Four pedons were selected based on heterogeneity and landform in the micro-watershed for the investigation, at each identified location soil profile was excavated by orienting in such a manner that sunlight falls on the wall of the profile and detailed morphological description was carried out in a field as described by Soil Survey Staff (Anon., 2014) [2]. Soil colour of the pedons was measured both under dry and moist condition using Munsell colour chart. Other morphological characteristics studied with depth of solum, depth of each horizon, texture, structure, consistency at dry, moist and wet conditions, coarse fragments, slickenside, quantity of conca and conir, *etc.* In profiles, horizon-wise soil samples were collected based on morphological characteristics of profiles. The details of the pedons are given in Table.1.

Table 1: Soil profile site surface characterization of Hittnalli micro-watershed

Attributes		Pedon Number			
		Pedon-1	**Pedon-2**	**Pedon-3**	**Pedon-4**
Location	Lat. (^{0}N)	16º 43’ 52.4”	16º 44’ 07.0’’	16º 43’ 21.7’’	16º 42’ 50.2’’
	Long.(^{0}E)	75º 45’ 41.3’’	75º 45’ 10.5’’	75º 45’ 22.9’’	75º 45’ 23.6’’
Altitude (m)		480.0	487.0	483.0	474.0
Landform		Mid land	Low land	Mid land	Mid land
Flooding		No	No	No	No
Topography		Nearly level	Nearly level	Nearly level	Nearly level
Slope	Gradient (%)	1-3	1-3	1-3	1-3
	Length (m)	50-150	50-150	150-300	150-300
Erosion		Moderate	Moderate	Moderate	Moderate
Drainage		Moderate well	Moderate well	Moderate well	Somewhat poor
Runoff		Moderate	Moderate	Moderate	Moderate
Rock outcrops		No	No	No	No
Surface fragments diameter (cm)		< 2	< 2	< 2	< 2
Gravels coverage (%)		< 15	< 15	15-35	< 15
Stones & boulders (%)		0.01-0.1	0.01-0.1	0.1-3	0.01-0.1
Parent materials		Basalt	Basalt	Basalt	Basalt
Natural vegetation		Neem, Acasia	Neem, Acasia, Banni	Neem, Acasia, coconut,banni	Neem, Acasia
Land use		Redrgam	Wheat	Redrgam	Redrgam
Ground water depth (m)		> 50	> 50	> 50	> 50

Laboratory analysis of soils

Soil samples are air dried and passed through 2 mm sieve and analyzed for soil physical properties (Soil texture, Soil structure, Soil colour, Soil consistency, Bulk density (Black 1965) [5], MWHC (Piper, 2002) [14] and particle-size distribution following International Pipette method (Piper 2002) [14], physcio-chemical properties like pH and electrical conductivity (EC) in 1:2.5 soil:water suspension (Jackson 1973) [8] and chemical properties organic carbon was estimated by Walkley and Black method (Piper, 2002) [14], Free $CaCo_3$ in acid neutralization method (Piper 2002) [14], Exc. Ca and Mg in EDTA titration method (Black, 1965) [5], available potassium (1:5), Exc. Na and K in flame photometric method (Jackson 1973) [8] and cation exchange capacity (CEC) and exchangeable cations were determined as described by Jackson (1973) [8].

Results and Discussion

Morphological characteristics

Land Forms: The pedons P-1, P-3 and P-4 were classified as midland while pedon P-2 was classified under low land categories. Terrain is a surface physiographic condition which includes geology, slope, topography, erosion, drainage, runoff, surface gravels, rock outcrops and land use land and cover. Surface soils were gently sloped, erosion is moderate, non-gravelly to slightly gravelly, nearly level plain topography, moderately well drained, no rock outcrops. The similar results were observed by Meenkshibai *et al.* (2018) [10] for Pannur micro-watershed of Manvi taluk of Raichur district.

Soil Depth: Soils were deep to very deep, Pedon P-3 was 138 cm in depth (deep) and pedons P-1, P-2 and P-4 were more than 180 cm depth (very deep). The watershed area was covered by *Vertisols* and the parent material was not observed even upto 180 cm depth, therefore, soils were categorized into deep to very deep. Area of the micro-watershed was categorized under low to medium lands. This may be the reason for deep to very deep depth of soils. The variations in horizon wise depths were due to movement of water and pedogenic process. Low rainfall in the region lead to lesser percolation through the profile hence, minimal differentiation was observed. The similar observations were made by Anjali and Hebbara (2017) [1] in Kavalur sub-watershed of Koppal.

Soil Colour: The pedons showed brown to very dark gray colour in dry condition, very dark grayish brown to dark grayish brown colour when wet at surface layers while in sub-surface layers colour varied from brown to black when dry and wet conditions. The homogeneous type of colour was existed due to plain terrain and parent material as a whole, there was not much clear variation in soil colour but there existed small variation at sub-surface layers. The dark colour might be attributed to the presence of iron sulphide and manganese oxide in combination with the organic complex. Patil and Dasog (1999) [13].

Texture: Clay texture was observed in all the pedons in both surface and sub-surface, most of the layers showed more than 50 per cent clay and most of them are swelling and shrinking type. These findings were in conformity with the observations of Dasog and Patil (2011) [6].

Structure: Soil structures of all the pedons were found to be identical with minor variations. The structure of pedons varied from moderate medium sub-angular blocky to strong

medium angular blocky in surface. Sub-angular to angular blocky structure in the sub-soil horizons was due to slickensides formation in these soils.

Soil Consistency: The pedons expressed slightly hard to hard consistency when dry, firm when moist and moderately to very sticky and moderately to very plastic when wet. The strong aggregated stability was due to high clay, presence of free lime, moisture and organic matter resulted in hard consistency in black soils. Moderately sticky and moderately plastic when wet were due to coarse fragments.

Calcareousness: The soils are moderate in calcareousness in surface layers to highly calcareous at sub-surface layers.

Boundary: All the pedons exhibited a clear smooth and gradual smooth boundary.

Effervescence: All the pedons exhibited a strong to violent effervescence with dilute HCl.

Surface crack features: Wide and deep cracks were observed since the soils come under order *Vertisol*.

Table 2: Morphological features of the pedons of Hittnalli micro-watershed

Pedon No.	Horizons	Depth (cm)	Boundary	Colour		Texture	Structure	Consistencen5			Effer test with HCl
				Dry	Moist		(Gr-Sz-Ty)	Dry	Moist	Wet	
P-1	Ap	0-20	Cs	10YR 4/2	10YR3/2	c	2 m sbk	sh	fi	ms & mp	2
	Bss	20-58	Cs	10YR 3/2	10YR3/2	c	3 m abk	h	fi	vs & vp	2
	Bss2	58-95	Cs	10YR 3/3	10YR 3/2	c	3 m abk	h	fi	vs & vp	3
	Bssk1	95-125	Cw	10YR 3/3	10YR 3/3	c	3 m abk	h	fi	vs & vp	3
	Bssk2	125-173	Cs	10YR 4/3	10YR 4/3	c	3 m abk	h	fi	vs & vp	3
	Bck1	173-180+	Cs	10YR 3/3	10YR 3/3	c	2 m sbk	h	fi	ms & mp	3
P-2	Ap	0-20	Cs	10YR 4/3	10YR 4/2	c	2 m sbk	sh	fi	vs & vp	3
	Bw1	20-50	Gs	10YR 3/3	10YR 3/2	c	2 m sbk	sh	fi	vs & vp	3
	Bck1	50-91	Gs	10YR 4/2	10YR 4/2	c	2 m sbk	sh	fi	vs & vp	3
	Bck2	91-145	Gs	10YR 4/3	10YR 4/3	c	2 m sbk	sh	fi	vs & vp	3
	Bck3	145-180+	Gs	10YR 3/3	10YR 3/3	c	2 m sbk	sh	fi	vs & vp	3
P-3	Ap	0-12	Gs	10YR 3/2	10YR 3/2	c	2 m sbk	sh	fi	ms & mp	2
	Bw1	12-34	Cs	10YR 3/2	10YR 3/2	c	2 m sbk	sh	fi	ms & mp	3
	Bck1	34-80	Cs	10YR 4/2	10YR 4/2	c	2 m sbk	sh	fi	ms & mp	3
	Bc1	80-138+	Cs	10YR 4/3	10YR 4/3	c	2 m sbk	sh	fi	ms & mp	3
P-4	Ap	0-30	Gs	10YR 3/3	10YR 3/2	c	2 m sbk	sh	fi	vs & vp	2
	Bss1	30-61	Gs	10YR 3/1	10YR 2/2	c	3 m sbk	h	fi	vs & vp	2
	Bss2	61-113	Gs	10YR 2/1	10YR 2/1	c	3 m sbk	h	fi	vs & vp	2
	Bss3	113-165	Gs	10YR 2/1	10YR 2/1	c	3 m sbk	h	fi	vs & vp	2
	Bss4	165-180+	Gs	10YR 2/2	10YR 2/2	c	3 m sbk	h	fi	vs & vp	2

Note: cs- clearsmooth, cw- clear wavy, gs- gradual wavy, c- clay sh – slighly hard, m – medium, sbk – subangular blocky, abk-angular bloky, sh- slightlyhard, h–hard, fi– firm, ms– moderately sticky, mp– moderately plastic, vs– very sticky, vp– very plastic, 2- strong, 3- violent.

Physical properties of pedons

Particle size distribution

The sand, silt and clay content of pedons ranged from 17.21 to 29.34, 16.48 to 27.58 and 47.29 to 61.52 per cent respectively. The terrain being plain in entire micro-watershed area, clay dominated over sand and silt in the profiles. The increased in clay content with depth was observed in the study area could be due to several processes like illuviation of the finer fraction to the lower depth and vertical migration of clay and translocation of clay from the surface to lower horizons (Dasog and Patil 2011) [6]. Sand content was low compared to silt in all the pedons. High clay and silt content in some of the pedons of study area may be due to their formation on the transported parent material. Silt and sand content of pedons exhibited an irregular and decreasing trend with depth respectively; this was due to variation in weathering of parent material. These results were in agreement with the findings of Ashok Kumar and Jagadeesh (2010) [3] in sugarcane growing soils of Ahmadnagar.

Bulk density: The bulk density in surface layers (Ap) ranged from 1.22 to 1.32 Mg m^{-3}. In sub-surface layers it varied from 1.26 to 1.51 Mg m^{-3}. The upper surface horizon bulk density was low due higher organic matter content and also looseness of soil by tillage whereas in sub-surface layers registered higher bulk densities due to decreased organic matter content and also due to compactness of soil.

Maximum water holding capacity (MWHC): Maximum water holding capacity (MWHC) of pedons ranged from 50.31 to 68.40 per cent in surface layers whereas in sub-surface layers of pedons it ranged from 48.60 to 72.60 per cent. The water holding capacity of sub-surface layers was higher than the surface layer due to the high clay content in sub-surface compared to surface layers. These variations in MWHC due to clay and organic carbon content.

Chemical properties of pedons

Soil reaction: Soil pH of pedons ranged from 8.23 to 8.72 and was moderately to strongly alkaline nature. The existence of alkaline reaction in soil was due to high CEC, accumulation of bases in the solum and high lime content due to semi-arid climate (Satyanarayana and Biswas, 1970) [16]. The lower pH value in surface layers was mainly due to removal of bases by runoff water, the increased pH with depth due to increased bases with depth. This increase in soil reaction down the slope could be due to leaching of bases from higher topography and getting deposited at lower elevations.

Electrical conductivity: The electrical conductivity ranged from 0.18 to 0.67 dS m^{-1}. The soils were categorized into non saline due to very low concentration of total soluble salts. The soluble salt content increased with depth and upper layer of soils contained relatively low soluble salt content than the lower layer. This might be due to leaching of salts from the

soil surface to lower depth due to rainfall or irrigation and their accumulation in lower depth (Goroji, 1994) [7].

Organic carbon content: The organic carbon in the surface layer ranged from 4.6 to 6.3 g kg^{-1}. The soil organic carbon content of surface soil was greater than sub-surface layer and it decreased with depth. This was due 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) [4] in soils of Chandragiri Mandal of Chittor district of Andhra Pradesh.

Free lime content: Free lime content ranged from 9.74 to 25.13 per cent. Free lime content follow an irregular trend with the depth. In surface layers of soil calcareous gravels were observed, the pedons were high in free lime content, the sub-surface free lime was more than surface layer. The free lime is accumulated as precipitated $CaCO_3$ in the solum. This generally happened due to precipitation and evapo-transpiration balance (P-ET balance) being in favour of evaporation and some geological properties. Similar report has been made by Pulakeshi *et al.* (2014) [15] for the soils of Mantagani village of Haveri district of Karnataka.

Available potassium (K_2O): Available potassium in the surface layer ranged from 691.72 to 780.0 kg ha^{-1} whereas in sub-surface layer ranged from 374.76 to 666.85 kg ha^{-1} and available potassium content of pedons ranged from 374.76 to 780.0 kg ha^{-1}. The highest available potassium was observed in surface layers and showed decrease trend with depth. The higher available K content in surface layer of profile might due to more exposure of potassium bearing minerals to weathering condition, addition of potassium fertilizer, higher CEC and high organic carbon observed at surface layer. Similar results were reported by Nalima *et al.* (2017) [12].

Table 3: Physical and chemical properties of pedons of Hittnalli micro-watershed

Pedon No.	Horizons	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	BD (Mg m^{-3})	MWHC (%)	pH (1:2.5)	EC (dS m^{-1}) (1:2.5)	OC (g kg^{-1})	Free $CaCO_3$ (%)	Available K_2O kg ha^{-1}
P-1	Ap	0-20	29.34	16.48	54.18	1.22	59.00	8.46	0.20	6.1	11.41	753.57
	Bss1	20-58	26.69	17.04	56.27	1.26	61.60	8.57	0.22	3.8	14.16	666.85
	Bss2	58-95	21.37	19.30	59.33	1.27	63.41	8.63	0.32	3.4	15.37	620.09
	Bssk1	95-125	20.51	19.42	60.07	1.33	64.50	8.67	0.52	1.7	19.74	475.04
	Bssk2	125-173	19.26	19.60	61.14	1.36	69.50	8.68	0.60	1.3	18.46	448.58
	Bck1	173-180+	17.21	21.27	61.52	1.42	69.76	8.94	0.67	0.7	16.34	423.15
Solum weighted average			22.40	18.85	58.75	1.31	64.63	8.66	0.42	2.8	15.91	564.55
P-2	Ap	0-20	24.54	1.32	55.83	1.32	68.40	8.52	0.30	4.6	15.62	780.00
	Bw1	20-50	22.39	1.36	56.67	1.36	69.56	8.56	0.32	3.1	16.76	659.72
	Bck1	50-91	21.08	1.40	57.00	1.40	70.44	8.84	0.36	2.6	25.13	610.19
	Bck2	91-145	20.26	1.42	58.83	1.42	70.81	8.88	0.43	1.3	23.67	553.85
	Bck3	145-180+	18.21	1.50	59.26	1.50	70.60	8.72	0.52	1.2	22.49	524.61
Solum weighted average			21.30	21.19	57.52	1.40	70.36	8.70	0.38	2.6	20.3	625.67
P-3	Ap	0-12	27.89	1.25	47.29	1.25	50.31	8.44	0.18	5.2	11.72	705.84
	Bw1	12-34	25.27	1.30	48.14	1.30	54.16	8.48	0.18	4.1	17.51	664.06
	Bck1	34-80	22.71	26.67	50.62	1.41	48.60	8.68	0.21	1.8	24.46	451.07
	Bc1	80-138+	19.56	27.58	52.86	1.56	50.60	8.75	0.28	1.1	20.23	492.53
Solum weighted average			24.11	26.92	48.98	1.38	50.92	8.59	0.21	3.1	18.48	578.38
P-4	Ap	0-30	23.84	23.67	50.49	1.29	63.50	8.23	0.22	6.3	14.84	691.72
	Bss1	30-61	22.26	23.68	54.06	1.32	65.05	8.28	0.29	2.8	11.51	608.72
	Bss2	61-113	19.57	24.45	55.98	1.42	68.35	8.34	0.31	1.9	9.74	533.26
	Bss3	113-165	17.94	24.86	57.20	1.48	71.02	8.38	0.36	0.8	15.43	436.00
	Bss4	165-180+	17.81	24.07	58.12	1.51	68.88	8.44	0.42	0.5	12.84	374.76
Solum weighted average			20.28	24.15	55.57	1.40	67.36	8.33	0.32	2.5	12.87	528.82

Exchangeable cations: The exchangeable calcium ranged from 34.6 to 40.8 cmol (p+) kg^{-1}, exchangeable magnesium from 8.8 to 12.7 cmol (p+) kg^{-1}, exchangeable potassium from 0.58 to 1.56 cmol (p+) kg^{-1} and exchangeable sodium from 1.12 to 4.29 cmol (p+) kg^{-1}. The sum of exchangeable cations ranged from 47.37 to 55.81 cmol (p+) kg^{-1}. The dominant cation in the soil was Ca followed by Mg >Na >K. This was due to Ca^{2+} shows the strongest relationship with clay compares to Mg^{2+}, K^{+} and Na^{+}. Magnesium was present in lower amount than Ca^{2+} because of its mobility. The dominance of Ca and Mg in the soil was due to soils derived from the basic cation rich minerals. Madhan Mohan (2008) [9] also concluded that black soils in Hangal taluk were dominated by Ca and Mg. The low value of exchangeable monovalents compared to divalent was due to leaching of monovalents than divalent.

Cation exchange capacity: The cation exchange capacity in pedons ranged from 52.10 to 60.40 cmol (p+) kg^{-1} and the solum weighted average ranged from 55.08 to 58.37 cmol (p+) kg^{-1}. The CEC of the soil was high due to the predominance of smectitc type of clay minerals, the CEC of soils increased with profile depths and followed the trend of clay content. This is due to accumulation of clay and presence of expanding type of clay minerals. The studies done by Madhan Mohan (2008)[9] also revealed similar results of uniform CEC among different pedons falling under plain topography.

Base saturation: The per cent base saturation ranged from 84.99 to 92.71 per cent in surface layers whereas in sub-surface layers it ranged from 85.79 to 94.68 per cent. The base saturation does not follow any specific trend throughout the profile depth. The black soils showed very high per cent base saturation due to presence of basic cations, CEC, restricted drainage. The similar results have been reported by Mohan *et al.* (2013) [11] in soils of Hanumanakoppa micro-watershed in Northern transitional zone of Karnataka.

Exchangeable sodium percentage (ESP): The exchangeable sodium percentage (ESP) ranged from 3.53 to 6.28 per cent in surface layers whereas in sub-surface layers ranged from 1.93 to 7.42 per cent. A lower ESP (< 15%) throughout the depth in soils clearly indicated that soils are non sodic in nature. Exchangeable sodium percentage values did not follow definite trend with the depth in all pedons. Similar findings were observed on soils derived from chlorite schist in North Karnataka by Pulakeshi *et al.* (2014) [15].

Table 4: Chemical properties of pedons of Hittnalli micro-watershed

Pedon Number	Horizons	Depth (cm)	Ca	Mg	K	Na	Sum of exchangeable cations	CEC	BS	ESP
			(cmol (p+)kg^{-1})						(%)	
P-1	Ap	0-20	34.6	11.8	1.56	2.56	50.52	53.44	94.54	4.79
	Bss1	20-58	36.2	10.3	1.38	1.86	49.74	54.80	90.77	3.39
	Bss2	58-95	35.7	12.7	1.33	2.91	52.64	56.50	93.17	5.15
	Bssk1	95-125	40.8	9.6	1.24	4.17	55.81	58.84	94.85	7.09
	Bssk2	125-173	38.6	10.5	1.16	3.51	53.77	59.10	90.98	5.94
	Bck1	173-180+	35.3	9.9	1.11	4.29	50.60	57.80	87.54	7.42
Solum weighted average			36.87	10.80	1.30	3.22	52.18	56.75	91.97	5.63
P-2	Ap	0-20	37.1	11.7	1.32	2.82	52.94	55.23	95.85	5.11
	Bw1	20-50	38.6	10.1	1.31	3.35	53.36	57.70	92.48	5.81
	Bck1	50-91	40.3	11.3	0.85	2.19	54.64	58.84	92.86	3.72
	Bck2	91-145	38.6	10.8	0.74	2.79	52.93	59.70	88.66	4.67
	Bck3	145-180+	39.7	9.4	0.66	3.13	52.89	60.40	87.57	5.18
Solum weighted average			38.86	10.66	0.98	2.86	53.35	58.37	91.48	4.90
P-3	Ap	0-12	35.4	9.1	1.12	3.27	48.89	52.10	93.84	6.28
	Bw1	12-34	37.6	10.2	0.96	1.22	49.98	54.92	91.01	2.22
	Bck1	34-80	37.9	8.8	0.65	1.75	49.10	55.14	89.05	3.17
	Bc1	80-138+	40.2	11.4	0.79	1.12	53.51	58.16	92.00	1.93
Solum weighted average			37.78	9.88	0.88	1.84	50.37	55.08	91.47	3.40
P-4	Ap	0-30	38.6	11.2	1.16	1.98	52.94	56.10	94.37	3.53
	Bss1	30-61	37.6	9.3	0.98	2.89	50.77	56.57	89.75	5.11
	Bss2	61-113	35.9	11.1	0.78	3.55	51.33	56.81	90.35	6.25
	Bss3	113-165	38.4	8.8	0.66	2.42	50.28	57.60	87.29	4.20
	Bss4	165-180+	34.9	10.3	0.58	1.59	47.37	52.40	90.40	3.03
Solum weighted average			37.08	10.14	0.83	2.49	50.54	55.90	90.43	4.42

Conclusion

The present study has given an insight view on potentials and limitations of the soils of the study area. This could help to improve the productivity and design a framework for managing the soils of watershed successfully. The results of Hittnalli micro-watershed shows that the soil properties and management practices have influenced the kind of soils in the study area. Soils were in low to mid land with deep to very deep, with clay in texture, structure moderate medium sub-angular blocky to strong medium angular blocky structure in surface and in sub surface sub-angular to angular blocky, slightly hard to hard consistency and moderately to very plastic with moderate calcareousness. In pedons clay dominated over sand and silt, and clay content increases with depth, bulk density in surface layers lower than the sub-surface layers, water holding capacity of sub-surface layers was higher than the surface layer. Soil pH was moderately to strongly alkaline nature with non saline, organic carbon decreased with depth. Free lime content follow an irregular trend with the depth. The dominant cation in the soil was Ca followed by Mg >Na >K with high CEC it increased with depths. Base saturation was high with irregular trend with depth, a lower ESP (< 15%) indicated the non sodic nature. The available potassium showed decrease trend with depth.

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