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Morpho-physical Properties of Soils of Kanamadi South Sub-watershed of Karnataka

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Authors' contributions

This work was carried out in collaboration between both authors. Author ADS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author PLP managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out to determine the morpho-physical status of soils of Kanamadi South sub- watershed in Karnataka state of India. A detailed soil survey of Kanamadi South sub watershed was carried out using IRS P6 LISS-IV image and a total of ten pedon location which were well distributed in Kanamadi South sub-watershed was selected. The soils were shallow to deep. Colour of pedons varied from 10 YR 2/1 (black) to 10 YR 4/3 (brown). Soil texture varied from clay to clay loam, having loose to moderately subangular to angular blocky in structure with few fine roots distributed in surface horizons. Generally, the clay content increased with depth. Consistency of soil pedons ranged 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 maximum water holding capacity of soil horizons ranged from 59.65 to 79.15 per cent and generally increased down the depth. The bulk density of pedons varied from 1.17 to 1.37 Mg m^{-3}. In general, bulk density varied with depth with lowest bulk density at surface and highest recorded in sub surface depths. The field capacity varied from 28.21% to 41.32 %.The morphological and physical properties study in area helps for resource inventorization for successful watershed planning for soil and water conservation to enhance the potential of fertility of soils and major fertility enhancement to increase the soil productivity.

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1. INTRODUCTION

Soil is one of the most important natural resources on which the sustenance of life depends. From the dawn of agriculture, cultivators recognized good soils being attracted to the fertile soils of river valleys. Most great civilizations have depended on good soils. Continuous replenishment of fertility by natural flooding made possible the stable, organized communities to shift from nomadic to modern society.

With the general acceptance of watershed as the principal unit of planning, many developmental activities based on suitable utilization of locally available natural resources, have been taken hence the watershed requires the detailed characterization and Inventorization of natural resources [1,2,3]. Soil resource mapping by using geo-spatial techniques, identification of constraints/ potentials, delineation of erosion-prone areas is pre-requisite for suggesting conservation measures [4] and several studies reported potential use of remote sensing for characterization and management of land resources at watershed level [5].

Kanamadi South sub-watershed is located in Tikota hobli of Vijayapura taluk of Vijayapura district in Karnataka was selected as study area. This area is well known for pomegranate and grapes production. The sub-watershed with a total area of 4170.17 ha lies between 75º21’ and 75º26’30" East longitudes and 16º51’ and 16º55’30" North latitudes.

This study creates a database on soil and land resources and such information will be vital for any land use planning in the area. Proper understanding of soils in terms of their distribution on a landscape and knowledge of their nature and properties are essential for judicious, beneficial, and optimal use on a sustainable basis. Such basic information about soils in the study area will be made available through this research.

2. MATERIALS AND METHODS

Kanamadi South sub-watershed (Vijayapura taluk, Vijayapura district of Karnataka state, India) is located in between 16^0 51' – 16^0 55' 30" North latitudes and 75^0 21' -75^0 26' 30" East longitudes, covering an area of about 4170.17 ha, bounded by Kanamadi village on the North, Bijjaragi village on the East, Honawada village on the South and Belagavi district on the West. The area receives an annual average rainfall of 711 mm distributed over May to October months. The highest elevation of this area is 854 m above mean sea level. The relief is very gently to strongly sloping. The general slope is more towards southwest direction. The drainage pattern is parallel. The soils are shallow to deep black clay in major areas. The summer is hot and humid and the winter is mild and dry. The mean annual precipitation is 400-800 mm.

2.1 Soil Survey

A detailed soil survey of Kanamadi South sub-watershed was carried out using IRS P6 LISS-IV image and Vijayapura district toposheet. The image and scanned toposheet were geocoded and subset were created in ArcGIS 10.2 on a 1: 12,500 scale. The area was then intensively traversed and 10 pedon locations were fixed on soil heterogeneity. At each pedon location, a fresh profile was opened and detailed morphological studies as described by USDA soil survey manual [6] and horizon-wise samples were collected and analyzed for physico-chemical parameters.

2.2 Morphological Properties of Pedons

Soil colour of the pedons was measured under dry and moist condition using Munsell colour chart. Other morphological characteristics studied were horizon boundaries, depth of solum, depth of each horizon, texture, structure, consistency in dry and wet conditions, size and quantity of lime nodules, weight of course fragments, pore size, presence and abundance of roots, presence and prominence of slickensides, depth, size and nature of cracks, *etc.* The morphological properties were described as per Soil Survey Staff [7]. The horizons were identified and designed according to revised keys to Soil Taxonomy [7].

2.3 Soil Sampling and Preparation for Analysis

Horizon wise soil samples were collected in polythene bags from all the pedons and taken to the laboratory for analysis. The large lumps were broken and spread on the sheet of brown paper and then air-dried in shade. The air-dried samples were ground with wooden pestle and mortar and passed through 2 mm sieve to separate the coarse fragments (>2 mm). The fine earth particles were stored in suitable sample bottles and labeled for easy identification. The coarse fragments were washed, dried, weighed and expressed as per cent of whole soil sample.

2.4 Methods of Soil Analysis

2.4.1 Particle size analysis

Particle size distribution of soil samples was determined by International pipette method as described by Piper [8] using sodium hydroxide as dispersing agent. From the dispersed suspension an aliquot of clay + silt and clay were pipetted out from specified depth at specific time intervals depending on the suspension temperature. The total sand obtained by repeated decantation of silt and clay was passed through 0.05 mm sieve. The fraction that was finer than 0.05 mm was added to silt determined initially by pipetting to have particle size classes as per USDA systems.

2.4.2 Bulk density (Mg m^{-3})

Bulk density was determined using clod coating method by dipping air dried, pre- weighed paraffin wax coated clod into a beaker of measured quantity of water and the volume displacement was determined as prescribed by Black [9].

2.4.3 Maximum water holding capacity (%)

Maximum water holding capacity of the soils was determined by Keen Raczkowaski brass box method as described by Coutts [10] and Piper [8].

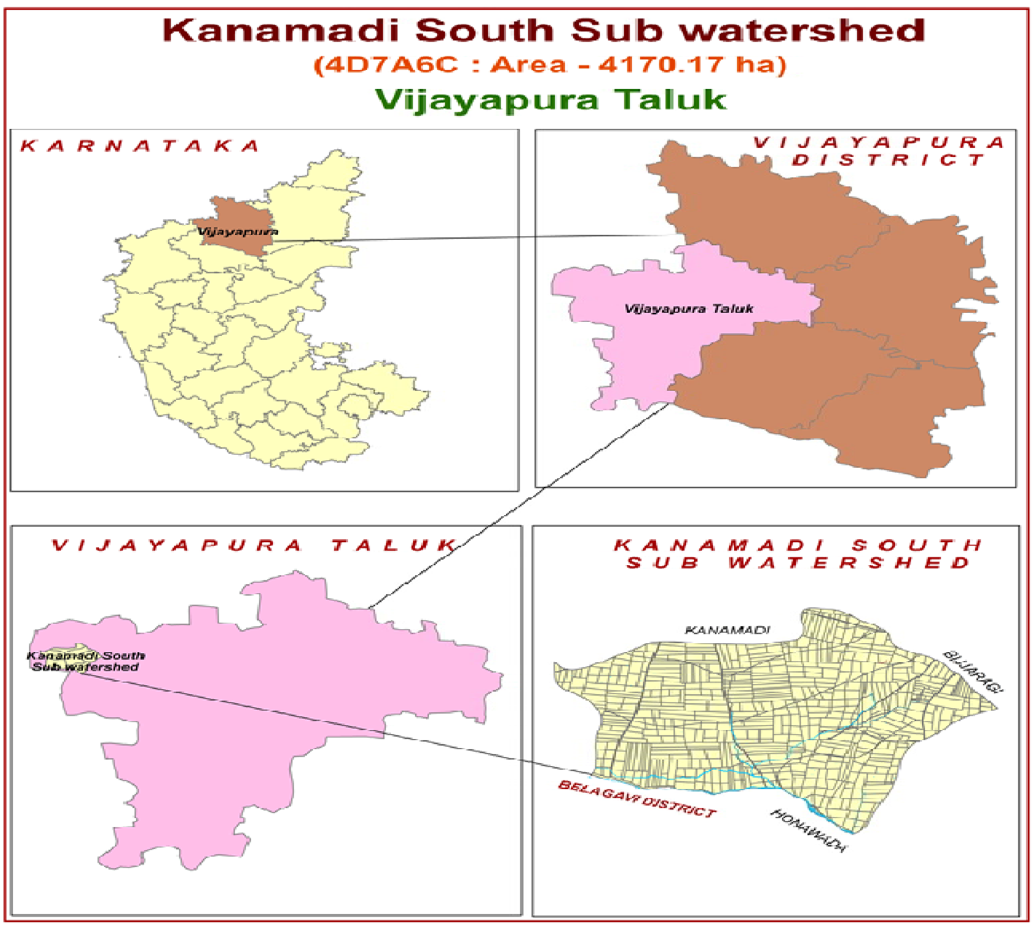

Fig. 1. Location of the study area

2.4.4 Field capacity

The field capacity of the soils was determined as described by Hendrickson and Viehmeyer [11] and Piper [8].

3. RESULTS AND DISCUSSION

3.1 Morphological Features of Pedons

The selected ten pedons were examined for morphological features consisting of black soils, which were distributed in undulating midland physiographical units. Landscape slope was with gradient B, gently undulating (1-3 % slope) and slope length of 50-150m and exhibit slight to moderate erosion having moderate well drainage condition.

Pedon 2 was shallow (25 - 50 cm); pedon 5 was moderately deep (50 - 100 cm) and deep soil depth was (>100 cm) observed in remaining soil pedons. The depths of pedons were because of manifestation of topography and slope gradient. The variation of depth in relation to physiography, is mainly because of non-availability of adequate amount of moisture for prolonged period in upland soils associated with removal of finer particles and their deposition at lower pediplain. The results obtained in the present study are in agreement with the findings of Ram and Seshagiri [12].

Colour of pedons varied from 10 YR 2/1 (black) to 10 YR 4/3 (brown) in soil pedons. Soil texture varied was and having subangular to angular blocky in structure with few fine roots distributed in surface horizons. The dark matrix colour of surface horizon was due to presence of high organic matter content [13,14]. Whereas, the sub-surface horizons had comparatively brighter colour throughout the profile, which might be due to low organic matter content and higher iron oxide. Similar observation was made by Madhanmohan [15] and Pulakeshi et al. [16].

Consistence of soil pedon ranged 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. In general, free $CaCO_3$ content was increasing from surface to lower depths of the pedons. (Table 1). This physical behavior of soils was not only due to the textural make up but also due to type of clay minerals present in these soils [17, 18].

These 10 pedons belonging to different series were examined systematically for morphological features in the field and horizon wise samples were collected. The detailed description and morphological features of ten soil pedons are presented in Table 1.

3.2 Physical Properties of Pedons

3.2.1 Distribution of soil separates in pedons

The distribution of different soil separates is presented in Table 2. The coarse fragment (gravel) varied from 15.65 (profile 8) to 1.54 percent (profile 1). In 3 pedons (pedon 1, 3 and 7,) coarse fragment content showed irregular trend with depth, but in all other pedons content of coarse fragments followed an increasing trend with depth and ranged from non- gravely to gravely nature. The higher coarser fraction was mainly attributed to the silicaceous and basaltic parent material [19]. Similar results were reported by Vinay et al. [20].

The coarse sand content varied from 6.5 to 20.6 %. The coarse sand was found highest in profile 10 (20.6 %) and lowest in profile 4 (6.5 %). The coarse sand was found to be increased in 2 pedons (profile 2 and 5), whereas all other profile depicted an irregular trend.

The fine sand content of pedons ranged from 12.2 to 30.7 per cent. The higher fine sand content was observed in pedon 10 (30.7 per cent) and the least in the pedon 8 (12.2 per cent). The fine sand content followed an irregular distribution with depth in all pedons except in pedons 2 and 5 where it decreased with depth.

Total sand content varied from 18.8 to 51 percent with pedon 8 (18.8 %) and pedon 10 (51 %) recorded highest and lowest total sand content respectively. One pedon (pedon 2) showed decrease in total sand content with depth whereas, all other pedons showed irregular trend in total sand distribution. In almost all the pedons, surface horizons exhibited higher sand content than the sub surface horizons. This might be due to the removal of finer fractions from the upper layers by clay eluviations and surface runoff. Results are in accordance with Dasog and Patil [18] and Pulakeshi et al. [16].

Silt content varied from 8.1 to 38.3 percent. The highest silt content was noticed in pedon 4 (38.3%), and lowest was noticed in pedon 3 (8.5%).

Table 1. Morphological features of the pedons

Horizon	Depth (cm)	Colour Dry	Colour Wet	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Boundary	Other salient features
Pedon 1 (midland)											
Ap	0-18	10YR 4/2	10 YR 3/2	c	2 m sbk	Sh	fr	ms mp	f f t	cs	Calcium carbonate granules was seen at 58-95,95-130 and 130-170 cm depth
Bw	18-58	10YR 4/2	10 YR 3/2	c	2 m sbk	Sh	fr	ms mp	f f t	cs	
Bwk1	58-95	10YR 4/2	10 YR 4/3	c	2 m sbk	Sh	fr	ms mp	f f t	cs	
Bwk2	95-130	10YR 4/2	10 YR 4/3	c	2 m sbk	Sh	fr	ms mp	f f t	cs	
Bwk3	130-170	10YR 4/2	10 YR 4/3	c	2 m sbk	Sh	fr	ms mp	f f t	cs	
Pedon 2 (midland)											
Ap	0 - 18	10 YR 4/3	10 YR 3/3	c	2 m sbk	Sh	fr	ms mp	f f t	cs	Few, fine concentrations were seen in two horizons
Bw	18-41	10 YR 4/3	10 YR 3/3	c	2 m sbk	sh	fr	ms mp	f f t	Cs	
Pedon 3 (midland)											
Ap	0-18	10 YR 4/2	10 YR 3/3	c	2 m sbk	sh	fr	Ms mp	f f t	cs	Distinct, faint stress features was observed at 50-88 cm depth.
Bw	18-50	10 YR 4/2	10 YR 3/2	c	2 m sbk	sh	fr	Ms mp	f f t	cs	
Bwk1	50-88	10 YR 4/2	10 YR 2/2	c	2 m sbk	sh	fr	Ms mp	f f t	cs	
Bck1	80-113	10 YR 4/2	10 YR 2/2	c	2 m sbk	sh	fr	Ms mp	f f t	cs	
Pedon 4 (midland)											
Ap	0-20	10YR 4/2	10 YR 3/2	c	2 m sbk	Sh	fr	ms	mp	cs	Slickensides and pressure faces were seen at depth 41-180 cm.
Bw	20-41	10YR 4/2	10 YR 3/2	c	2 m sbk	Sh	fr	ms	mp	cs	

Horizon	Depth (cm)	Colour		Texture	Structure	Consistence			Roots	Boundary	Other salient features
		Dry	Wet			Dry	Moist	Wet			
Bss1	41-80	10YR 4/2	10 YR 3/2	c	2 m abk	h	fi	vs	vp	cs	
Bss2	80-120	10YR 4/2	10 YR 3/2	c	2 m abk	h	fi	vs	vp	cs	
BssK1	120-150	10YR 4/2	10 YR 3/3	c	2 m abk	h	fi	vs	vp	cs	
BssK2	150-180	10YR 4/2	10 YR 3/3	c	2 m abk	h	fi	vs	vp	cs	
Pedon 5 (midland)											
Ap	0 - 20	10YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	cs	Few, fine concentrations were seen at 20-68 cm depth
Bw1	20 - 50	10YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	cs	
Bw2	50 - 68	10YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	cs	
Pedon 6 (midland)											
Ap	0-15	10 YR 3/1	10 YR 2/1	c	2 m sbk	sh	fr	ms	mp	cs	Predominating Slickensides and pressure faces were seen at depth 50-165 cm
Bw	15-50	10 YR 3/1	10 YR 2/1	c	2 m sbk	sh	fr	ms	mp	cs	
Bss1	50-90	10 YR 3/1	10 YR 2/1	c	2 m sbk	h	fi	vs	vp	cs	
Bss2	90-125	10 YR 3/1	10 YR 2/1	c	2 m sbk	h	fi	vs	vp	cs	
Bss3	125-165	10 YR 3/1	10 YR 2/1	c	2 m sbk	h	fi	vs	vp	cs	
Pedon 7 (midland)											
Ap	0-20	10 YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	cs	Slickensides and pressure faces were seen at depth 43-170 cm
Bw	20-43	10 YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	cs	
Bss1	43-80	10 YR 3/2	10 YR 2/1	c	3 m abk	h	fi	vs	vp	cs	

Horizon	Depth (cm)	Colour		Texture	Structure	Consistence			Roots	Boundary	Other salient features
		Dry	Wet			Dry	Moist	Wet			
Bss2	80-110	10 YR 3/2	10 YR 2/1	c	3 m abk	h	fi	vs	vp	cs	
Bss3	110-140	10 YR 3/2	10 YR 2/1	c	3 m abk	h	fi	vs	vp	cs	
Bss4	140-170	10 YR 3/2	10 YR 2/1	c	3 m abk	h	fi	vs	vp	cs	
Pedon 8 (midland)											
Ap	0-15	10 YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	cs	Slickensides and pressure faces were seen at depth 41-160 cm
Bw	15-41	10 YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	Cs	
Bss1	41-80	10 YR 3/2	10 YR 2/1	c	3 m abk	h	fi	vs	vp	Cs	
Bss2	80-120	10 YR 3/2	10 YR 2/1	c	2 m abk	h	fi	vs	vp	Cs	
Bss3	120-160	10 YR 3/2	10 YR 2/1	c	2 m abk	h	fi	vs	vp	Cs	
Pedon 9 (midland)											
Ap	0-15	10 YR 3/1	10 YR 2/1	c	2 m sbk	sh	fr	ms	mp	cs	Slickensides and pressure faces were seen at depth 55-93 cm
Bw	15-55	10 YR 3/1	10 YR 2/1	c	2 m sbk	sh	fr	ms	mp	Cs	Patchy, few Calcium carbonates coats were seen at depth 93-133 cm.
Bssk1	55-93	10 YR 3/1	10 YR 4/3	c	3 m abk	h	fi	vs	vp	Cs	
Bwk1	93-133	10 YR 3/1	10 YR 4/3	c	3 m abk	h	fi	vs	vp	Cs	
Bwk2	133-170	10 YR 3/1	10 YR 4/3	c	3 m abk	h	fi	vs	vp	Cs	
Pedon 10 (midland)											
Ap	0-12	10YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	cs	Patchy, few Calcium carbonates coats were seen at depth 75-170 cm
Bw	12-38	10YR 3/2	10 YR 2/2	c	2 m sbk	sh	fr	ms	mp	cs	

Horizon	Depth (cm)	Colour		Texture	Structure	Consistence			Roots	Boundary	Other salient features
		Dry	Wet			Dry	Moist	Wet			
Bwk1	38-75	10YR 3/2	10 YR 4/3	c	2 m sbk	sh	fr	ms	mp	cs	
Bwk2	75-110	10YR 3/2	10 YR 4/3	c	2 m sbk	sh	fr	ms	mp	cs	
Bwk3	110-130	10YR 3/2	10 YR 4/3	c	2 m sbk	sh	fr	ms	mp	cs	
Bwk4	130-170	10YR 3/2	10 YR 4/3	c	2 m sbk	sh	fr	ms	mp	cs	

Table 2. Distribution of soil seperates in pedons

Pedon No.	Horizon	Depth (cm)	Gravel (Coarse fragment)(%)	Coarse sand (%)	Fine sand (%)	Total sand (%)	Silt (%)	Clay (%)	Textural class
1	Ap	0-18	2.04	15.6	23.5	39.1	20.56	40.34	c
	Bw	18-58	1.54	12.9	24.6	37.5	17.3	45.2	c
	Bwk1	58-95	3.56	13.2	22.3	35.5	15.3	49.2	c
	Bwk2	95-130	1.85	13.8	21.6	35.4	17.3	47.3	c
	Bwk3	130-170	1.56	14.6	25.4	40	14.4	45.6	c
2	Ap	0 - 18	4.65	13.6	16.5	30.1	26.5	43.4	c
	Bw	18- 41	6.54	15.4	20.3	35.7	17.7	46.6	c
3	Ap	0-18	5.36	11.6	20.6	32.2	22.2	45.6	c
	Bw	18-50	4.75	10.5	24.5	35	17.5	47.5	c
	Bwk1	50-88	6.36	9.6	23.4	33	18.4	48.6	c
	Bck1	80-113	8.54	14.4	26.5	40.9	8.5	50.6	c
4	Ap	0-20	3.15	13.2	19.5	32.7	25.7	41.6	c
	Bw	20-41	5.31	6.5	15.6	22.1	38.3	39.6	cl
	Bss1	41-80	10.34	8.4	17.5	25.9	30.6	43.5	c
	Bss2	80-120	12.36	6.6	18.6	25.2	27.2	47.6	c
	BssK1	120-150	13.65	8.3	20.3	28.6	21.9	49.5	c
	BssK2	150-180	12.54	10.2	22.5	32.7	14.7	52.6	c
5	Ap	0 - 20	3.56	11.5	18.1	29.6	29.8	40.6	c
	Bw1	20 - 50	4.65	12.8	20.5	33.3	16.9	49.8	c
	Bw2	50 - 68	5.46	13.6	21.6	35.2	14.2	50.6	c

Pedon No.	Horizon	Depth (cm)	Gravel (Coarse fragment)(%)	Coarse sand (%)	Fine sand (%)	Total sand (%)	Silt (%)	Clay (%)	Textural class
6	Ap	0-15	9.05	9.2	24	33.2	26.5	40.3	c
	Bw	15-50	7.65	8.6	25.6	34.2	21.5	44.3	c
	Bss1	50-90	12.25	10.4	27.7	38.1	11.8	50.1	c
	Bss2	90-125	13.65	13.2	28.8	42	4.8	53.2	c
	Bss3	125-165	14.36	12.5	27.5	40	12.6	47.4	c
	Ap	0-20	9.05	12.5	29.4	41.9	14.7	43.4	c
	Bw	20-43	14.41	10.4	25.3	35.7	17.7	46.6	c
7	Bss1	43-80	15.63	13.2	26.6	39.8	10.8	49.4	c
	Bss2	80-110	13.25	12.5	25.4	37.9	9.8	52.3	c
	Bss3	110-140	12.76	10.6	22.3	32.9	19.7	47.4	c
	Bss4	140-170	10.54	13.7	21.5	35.2	14.6	50.2	c
	Ap	0-15	7.28	6.6	12.2	18.8	29.7	51.5	c
	Bw	15-41	4.25	7.5	15.5	23	28.5	48.5	c
8	Bss1	41-80	5.65	10.2	17.7	27.9	24.7	47.4	c
	Bss2	80-120	12.35	13.5	20.3	33.8	12.7	53.5	c
	Bss3	120-160	15.65	15.6	21.6	37.2	17.2	45.6	c
	Ap	0-15	8.36	10.4	15.5	25.9	24.9	49.2	c
	Bw	15-55	9.54	13.6	24.8	38.4	14.2	47.4	c
9	Bssk1	55-93	10.24	12.5	26.6	39.1	9.3	51.6	c
	Bwk1	93-133	11.15	10.8	27.7	38.5	8.1	53.4	c
	Bwk2	133-170	12.34	9.5	30.6	40.1	9.6	50.3	c
	Ap	0-12	7.28	12.6	24.3	36.9	21.5	41.6	c
	Bw	0-38	4.46	13.4	25.6	39	10.9	50.1	c
10	Bwk1	38-75	3.96	20.3	30.7	51	8.4	40.6	c
	Bwk2	75-110	6.54	16.4	26.4	42.8	12.9	44.3	c
	Bwk3	110-130	8.65	15.6	20.5	36.1	21	42.9	c
	Bwk4	130-170	10.54	13.7	18.6	32.3	22.1	45.6	c

Table 3. Physical properties of the pedons

Pedon No.	Horizon	Depth (cm)	Bulk density ($Mg\ m^{-3}$)	Field capacity (%)	Maximum water holding capacity (%)
1	Ap	0-18	1.22	31.5	59.65
	Bw	18-58	1.23	35.43	62.32
	Bwk1	58-95	1.28	34.53	63.35
	Bwk2	95-130	1.29	30.53	65.62
	Bwk3	130-170	1.32	35.14	66.15
2	Ap	0 - 18	1.33	33.14	68.15
	Bw	18- 41	1.35	35.23	69.32
3	Ap	0-18	1.21	35.23	68.54
	Bw	18-50	1.23	37.53	70.32
	Bwk1	50-88	1.25	33.1	71.35
	Bck1	80-113	1.30	32.05	72.25
4	Ap	0-20	1.32	39.15	73.18
	Bw	20-41	1.33	40.32	70.18
	Bss1	41-80	1.35	34.81	69.41
	Bss2	80-120	1.37	37.31	75.25
	BssK1	120-150	1.37	36.51	74.24
	BssK2	150-180	1.38	38.14	76.32
5	Ap	0 - 20	1.18	28.21	69.14
	Bw1	20 - 50	1.21	30.35	68.11
	Bw2	50 - 68	1.23	29.62	68.03
6	Ap	0-15	1.18	37.12	59.56
	Bw	15-50	1.22	37.63	60.34
	Bss1	50-90	1.25	38.72	62.15
	Bss2	90-125	1.27	40.14	64.32
	Bss3	125-165	1.30	39.32	65.65
	Ap	0-20	1.21	38.47	77.03
7	Bw	20-43	1.24	36.03	78.32
	Bss1	43-80	1.25	35.46	79.15
	Bss2	80-110	1.25	37.65	73.32
	Bss3	110-140	1.27	39.32	75.52
	Bss4	140-170	1.28	38.51	77.65

Pedon No.	Horizon	Depth (cm)	Bulk density (Mg m^{-3})	Field capacity (%)	Maximum water holding capacity (%)
8	Ap	0-15	1.22	33.21	77.03
	Bw	15-41	1.24	34.62	73.18
	Bss1	41-80	1.25	36.65	70.01
	Bss2	80-120	1.26	38.95	69.32
	Bss3	120-160	1.28	40.43	73.15
9	Ap	0-15	1.22	31.32	74.21
	Bw	15-55	1.22	33.42	69.14
	Bssk1	55-93	1.24	37.65	68.11
	Bwk1	93-133	1.25	40.15	70.04
	Bwk2	133-170	1.27	41.32	73.15
10	Ap	0-12	1.17	30.35	76.02
	Bw	12-38	1.19	31.62	72.25
	Bwk1	38-75	1.20	33.51	74.32
	Bwk2	75-110	1.21	34.52	75.15
	Bwk3	110-130	1.23	35.51	76.65
	Bwk4	130-170	1.25	36.62	77.35

The pedons exhibited irregular trend in silt content. The silt content followed irregular trend in depth in most of pedons and increased in depth in few pedons. This might be due to differential weathering of parent material.

Clay content varied from 39.6 to 53.5 percent with pedon 4 showing lowest clay content (39.6 %) and pedon 8 showed highest clay content (53.5 %). All the pedons showed irregular trend in clay content with depth and overall texture of all the pedons (9 pedons) was clayey with only 1 pedon (pedon 4) was clay loam in texture. In general the clay content increased with depth, higher clay content was seen in deeper layers. Increase in clay content with depth might be attributed to the illuviation process occurring during soil development. Similar results were reported by Pulakeshi et al. [16]

3.2.2 Bulk density

The bulk density of pedons varied from 1.17 to 1.37 Mg m^{-3}. In general bulk density varied with depth with lowest bulk density at surface and highest recorded in sub surface depths. The surface horizon recorded lowest bulk density of 1.17 Mg m^{-3} (pedon 10). The highest bulk density of 1.37 Mg m^{-3} was recorded in pedon 4. (Table 3). The increase in bulk density with depth was attributed to increased compaction due to load of overlying layers [21]. Similar observations were also reported by Tumbal and Patil [22] in Balapur micro-watershed in Koppal district.

3.2.3 Field capacity

The field capacity varied from 28.21% to 41.32 %. The highest field capacity was observed in pedon 9 (41.32%) and lowest was found in pedon 4 (1.37 %). The general trend of increase in field capacity with depth was seen with exception of pedon 7 where there was decrease in field capacity along the horizons. Remaining pedons recorded an irregular trend in percent field capacity (Table 3). The field capacity varied from 26.39 to 40.65 per cent. These differences were due to variation in clay and organic carbon content of the pedons and results are in line with Thangaswamy et al. [17] who reported variations in field capacity due to variation in physical properties in Sivagiri micro-watershed and Denis et al. [23] in Singanalli-Bogur micro watershed.

3.2.4 Maximum water holding capacity

The maximum water holding capacity of soil horizons ranged from 59.65 to 79.15 per cent. The highest was recorded in pedon 7 and the lowest in pedon 1 (Table 3). Irrespective of soil pedon, the surface depth (mostly Ap) recorded lower MWHC than the soil layer below that. The second horizon usually showed higher MWHC and further increased with depth. Variation in clay and organic carbon content of the soil pedons was reported to influencing factors [18]. Even the type of clay could have attributed for differential water holding capacity of soil pedons. The results are in accordance with findings of Gangopadhyay et al. [24].

4. CONCLUSIONS

The study area Kanamadi South sub-watershed lies in northern dry zone of Karnataka of India which has shallow to deep black clay soil. The soils were shallow to deep. Colour of pedons varied from black to brown . Soil texture varied from clay to clay loam, having loose to moderately subangular to angular blocky in structure with few fine roots distributed in surface horizons. Generally, the clay content increased with depth. The maximum water holding capacity of soil horizons generally increased down the depth of pedons. In general, bulk density varied with depth with lowest bulk density at surface and highest recorded in sub surface depths. The morphological and physical properties study in area helps for resource inventorization for successful watershed planning for soil and water conservation to enhance the potential of fertility of soils and major fertility enhancement to increase the soil productivity. Hence, the physical properties taken into consideration for planning watershed development planning.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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