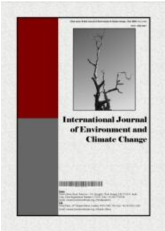

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Vertical Distribution of Physical and Chemical Properties of Soils of Ramapura-1 Microwatershed of Yadgir Taluk and District of Karnataka, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author RH approved the study and sanctioned the fund. Author MBMK designed the study, wrote the protocol and wrote the first draft of the manuscript. Author KVN corrected the manuscript and managed the analyses of the study. Author KVS prepared the maps in GIS environment. Author BAD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

By using digitized cadastral map and satellite imagery an investigation was carried out to study the vertical distribution of physical and chemical properties of soils of Ramapura-1 microwatershed of Yadgir taluk and district of Karnataka, India. The soil texture varied from loamy sand to sandy clay loam in surface and sandy clay loam to clay in subsurface. The per cent moisture distribution was varied from 3.89 to 54.94 per cent and it was increase with depth. The soils under the study were slightly acidic to alkaline (5.57 to 10.32) and non-saline in reaction. The organic carbon content was low to high (0.12 to 1.16 %) and decreased with depth. The per cent calcium carbonates in soils ranged from 0.60 to 8.19 per cent and uneven distribution in most of the soil series. The distribution of exchangeable bases in the order of Ca^{2+}>Na^{+}>Mg^{2+}>K^{+}. Most of the soil series were irregular in distribution of CEC (1.70 to 51.20 cmol (p^{+}) kg^{-1}) and CEC/clay ratio. The per cent base saturation was increase with depth in most of the series.

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Keywords: Distribution; microwatershed; depth; series; irregular.

1. INTRODUCTION

Soils are highly spatially variable due to the combined effects of physical, chemical and biological processes that operate with different intensities and at different scales. Managing soil variability is an integral aspect of precision farming. Uniform management of field often results in over application of inputs in areas with high nutrient levels and under application in areas with low nutrient levels [1]. Application of variable rates of inputs, needs partitioning of farm lands into land management unit that are homogeneous with respect to soil properties like texture, depth, fertility etc. Sustainable agricultural productivity aims to produce components that are directly consumed by human beings and contribute to the satisfaction of human needs by producing quantity and quality products with little damage to the environment, such as soils. Thus the overall productivity and sustainability of a given agricultural sector are functions of fertile soils and productive lands. However, soil fertility depletion is the fundamental biophysical cause for declining per capita food production [2]. The study and understanding of soil properties and their distribution over an area has proved to be useful for the development of soil management plan for efficient utilization of limited land resources. Moreover, it is very important for agrotechnology transfer [3]. The inherent ability of soils to supply nutrients for crop growth and maintenance of soil physical conditions to optimize crop yields is the most important component of soil that virtually determines the productivity of agricultural system. A thorough and proper understanding of morphological, physical and chemical characteristics of the soils gives greater insight of the dynamics of the soil. Different land use systems viz. Agriculture, horticulture, forestry, agrihorticulture, pastures and wasteland system lead to the change in physio-chemical properties and also change in nutrient content [4]. As the soil properties change among all above mentioned land use systems which in turn leads to change in type of vegetation and productivity among different land use systems, therefore it is not possible to develop a single short list of soil properties which is suitable for all purposes. Maintaining soils in a state of high productivity on sustainable basis is important for meeting basic needs of the people. Hence, the study was carried out with the objective of determining vertical distribution of physicochemical characteristics of soils of Ramapura-1 microwatershed of Yadgir Taluk and District of Karnataka, India.

2. MATERIALS AND METHODS

The soil survey was conducted in the Ramapura-1microwatershedof Yadgir Taluk and District of Karnataka (Fig. 1). The area lies between 16^0 33’ and 16^0 35’ North latitudes and 77^0 16’ and 77^0 18’ East longitudes covering an area of about 537 ha. Granite gneiss and alluvium is the major rock types in the watershed. The elevation ranges from 367 to 379 m above mean sea level (MSL). The climate is semiarid and categorized as drought- prone with an average annual rainfall of 866 mm and mean maximum temperature of 30^0C to 45°C. Length of growing period (LGP) ranges from 120 to 150 days. The detailed survey of the land resources occurring in the microwatershed was carried out by using digitized cadastral map and satellite imagery as base supplied by the KSRSAC. Apart from the cadastral map, remote sensing data products from Cartosat-1 and LISS-IV merged at the scale of 1:7920 were used in conjunction with the cadastral map to identify the rock types, the landscapes, landforms and other surface features. The cadastral map was overlaid on the satellite imagery that helps to identify the parcel boundaries and other permanent features. Apart from cadastral maps and images, toposheets of the area (1:50,000 scale) were used for initial traversing, identification of geology and landforms, drainage features, present land use and also for selection of transects in the microwatershed. While traversing, landforms and physiographic units identified were checked. Then, intensive traversing of each physiographic unit like hills, ridges, uplands and valleys was carried out. Based on the variability observed on the surface, transects were selected across the slope covering all the landform units in the microwatershed [5]. Apart from the transect study, profiles were also studied at random, almost like in a grid pattern, outside the transect areas. Based on the soil-site characteristics, eleven soil series (soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management) were identified using the method employed by Reddy (2006)[6]. The eleven identified soil series such as Jinkera**(**JNK), Badiyala**(**BDL), Halagera**(**HLG), Ramapura (RMP), Yalleri

(YLR),Rachanalli(RHN), Gondedagi (GDG),Anur (ANR),Sowrashtrahalli (SWR), Hegganakera (HGN) andMylapura (MYP). Horizon wise soil samples were collected, processed and analysed for physical and chemical properties by following the procedure outlined by Sarma et al. [7].

3. RESULTS AND DISCUSSION

3.1 Physical Properties

The distribution of particle size (Table 1) in surface to subsurface soil showed that, the sand content varied from 16.08 to 93.37 per cent and it was higher at surface horizons as compared to subsurface horizon, which might be due to granitic type of parent material from which the soils were derived and intermittent erosion and or clay translocation [8]. Sand distribution was irregular in most of the series. Silt content was varied from 2.90 to 25.22 per cent, the distribution was irregular in most of the series, which might be due to variation in weathering of parent material or in-situ formation [9]. The clay content varied from 2.31 to 64.59 per cent, the distribution was increase with depth in most of the series due to vertical migration/translocation of clay from surface to lower horizons [10 and 11] and variability of weathering in different horizons and irregular with depth in Jinkera**(**JNK), Badiyala**(**BDL) and Halagera**(**HLG) series. Texture of the soil was loamy sand to sandy clay loam and clay in surface soil and sandy clay loam to clay in subsurface horizon, the results were in conformity with the findings of Chandrakala et al. [12]. The per cent moisture was varied from 3.89 to 54.94 per cent and it was increase with depth due to increase clay content [13].

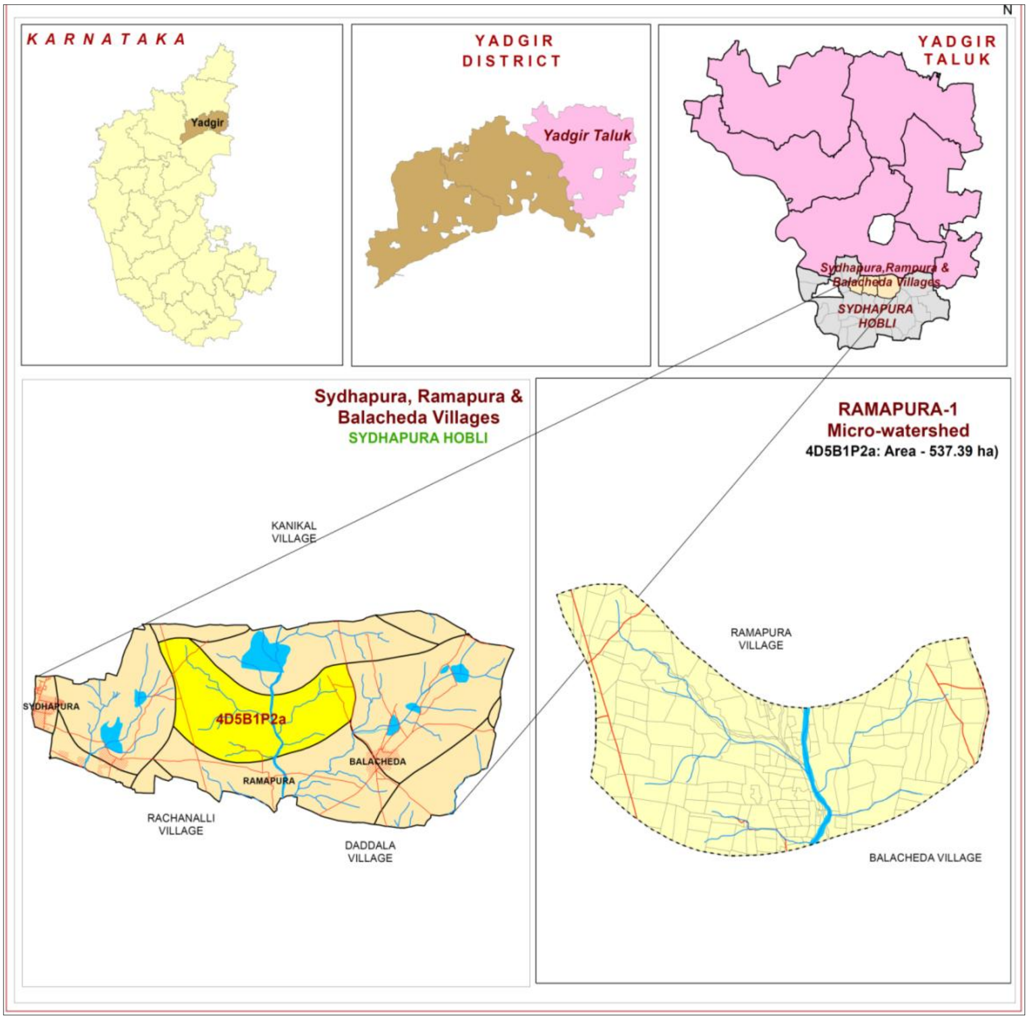

Fig.1. Location map of Ramapura-1 Microwatershed

Table 1. Physical properties of Ramapura-1 microwatershed

Depth (cm)	Horizon	Sand (2.0-0.05mm)	Silt (0.05-0.002mm)	Clay (<0.002mm)	Texture Class	% Moisture
Jinkera(JNK)						
0-15	Ap	66.84	13.62	19.54	sl	14.42
15-38	Bw1	59.08	12.11	28.81	scl	18.21
38-50	Bw2	68.21	11.68	20.11	scl	14.54
Badiyala(BDL)						
0-12	Ap	87.13	7.04	5.83	ls	6.27
12-28	Bw1	64.63	13.30	22.07	scl	16.34
28-52	BC	73.11	12.02	14.87	sl	12.94
Halagera(HLG)						
0-8	Ap	81.02	8.42	10.56	ls	9.10
8-22	Bw1	61.00	11.50	27.50	scl	16.91
22-53	Bw2	61.41	13.80	24.79	scl	17.08
Ramapura (RMP)						
0-7	Ap	93.37	4.32	2.31	s	3.89
7-28	A2	83.08	7.65	9.26	ls	6.25
28-70	Bt1	61.88	6.38	31.74	scl	15.95
Yalleri (YLR)						
0-5	Ap	81.69	5.44	12.87	sl	8.60
5-34	Bt1	38.78	6.73	54.49	c	25.33
34-75	Bt2	40.35	2.90	56.75	c	24.49
Rachanalli (RHN)						
0-8	Ap	77.72	14.09	8.19	sl	10.76
8-43	Bw1	76.00	10.38	13.62	sl	21.48
43-87	Bw2	52.64	19.95	27.41	scl	40.80
Gondedagi (GDG)						
0-17	Ap	84.15	7.67	8.18	ls	5.83
17-55	Bt1	62.36	11.26	26.38	scl	14.94
55-115	Bt2	57.78	13.38	28.84	scl	17.93
Anur (ANR)						
0-18	Ap	64.60	13.44	21.96	scl	16.59
18-49	Bw1	56.66	12.19	31.15	scl	33.38
49-95	Bw2	39.94	17.81	42.25	c	44.68
95-123	Bw3	30.65	17.58	51.77	c	54.94
Sowrashtrahalli (SWR)						
0-9	Ap	32.07	21.06	46.87	c	33.69
9-34	BA	32.29	20.37	47.35	c	37.43
34-67	Bss1	30.11	23.13	46.76	c	38.02
67-124	Bss2	19.93	23.40	56.66	c	42.55
Hegganakera (HGN)						
0-8	Ap	20.20	25.22	54.58	c	42.47
8-24	BA	21.18	21.70	57.12	c	41.88
24-50	Bss1	18.76	21.67	59.57	c	40.46
50-86	Bss2	16.74	22.24	61.02	c	42.18
86-146	Bss3	18.64	20.20	61.16	c	40.03
146-170	Bss4	16.08	19.33	64.59	c	40.28
Mylapura (MYP)						
0-18	Ap	54.46	22.28	23.26	scl	25.10
18-48	Bw1	52.88	21.23	25.89	scl	25.77
48-80	Bw2	47.20	24.81	27.99	scl	35.44
80-120	Bw3	46.88	22.15	30.97	scl	31.08
120-148	Bw4	40.97	20.70	38.33	cl	36.39
148-180	Bw5	41.71	18.93	39.36	cl	39.85

** Ap- Disturbance of surface layer by mechanical means. A2- Surface horizon below Ap horizon. Bw- Formed below surface horizon with development of colour/structure, Bw1-Bw2-Bw3-Bw4-Bw5: vertical subdivision of Bw. Bc- Dominated by properties of B horizon with limited properties of parent material. Bt- B horizon with accumulation of silicate clay, Bt1-Bt2: vertical subdivision of Bt. BA-Transition horizon dominated B horizon with some influence of A horizon. Bss- B horizon with presence of slickensides, Bss1-Bss2-Bss3-Bss4: vertical subdivision of Bss.*

3.2 Chemical Properties

The chemical properties of soils are presented in Table 2. The pH of the soils was slightly acidic to alkaline in reaction (5.57 to 10.32). This wide variation of pH in soils was attributed to the nature of the parent material, leaching, presence of calcium carbonate and exchangeable sodium. Increasing trend of pH with depth in most of the series due to the presence of exchangeable bases brought by runoff water in surface horizons and also prevalence of higher temperature during most part of the year resulting accumulation of soluble salts in surface to subsurface [14]. Soil series such as Jinkera**(**JNK), Anur (ANR), Hegganakera (HGN) and Mylapura (MYP) shows irregular in pH distribution Thangasamy et al. [15] reported that the variation in soil pH is associated with parent material, rainfall and topography. Identified soil series were nonsaline 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 [16]. Majority of the series were uneven in distribution of EC. Organic carbon content of the soils was low to high and varied from 0.12 to 1.16 per cent. In surface soils, the distribution of organic carbon was high in Badiyala**(**BDL), Sowrashtrahalli (SWR), Hegganakera (HGN) and Mylapura (MYP) series due to low removal or depletion of organic carbon from the surface and continuously under cropping and seasonal addition of plant biomass will enhance high organic carbon in surface soil. Decrease OC with depth in most of the soil series due to degradation of organic matter occurring at a faster rate coupled with low vegetative cover [17]. The $CaCO_3$ is the dispersed precipitate of calcium carbonate in the solum. The per cent calcium carbonate in soil ranged from 0.60 to 8.19 %. Most of the soil series were irregular in distribution of $CaCO_3$ and increased with depth in Badiyala**(**BDL) and Halagera**(**HLG) series. Accumulation of $CaCO_3$ due to a negative precipitation-evapotranspiration (P−ET) balance and some geological properties (parent material). The presence of calcium carbonate nodules is common due to seasonal climates yielding mean annual precipitation (MAP) between 760 mm and 1000 mm. Sawhney et al. [18] also reported the higher amount of calcium carbonate in the soils developed due to finer texture of soils that slow down the infiltration rate of water and/ or accretion of carbonates due to lateral subsurface water flow. In general, the results indicated that geomorphic position affects soil properties.

The exchangeable bases exhibited regular and irregular trends because of topographic position. Among exchangeable cations, calcium was dominant [0.70 to 16.43 cmol (p^+) kg^{-1}] in all the identified series followed by sodium [0.01 to 12.03 cmol (p^+) kg^{-1}], magnesium [0.18 to 4.72 cmol (p^+) kg^{-1}] and potassium [0.06 to 1.10 cmol (p^+) kg^{-1}]. Exchangeable calcium had positive correlation with clay and pH, the distribution was increase with depth in Ramapura (RMP), Rachanalli (RHN) and Gondedagi (GDG) series due to presence of base rich materials. Majority of the soil series were irregular in distribution of exchangeable Na and high distribution was noticed in Rachanalli (RHN), Anur (ANR), Hegganakera (HGN) and Mylapura (MYP) series due to high pH and presence of soil minerals producing sodium carbonate and sodium bicarbonate upon weathering. The distribution of exchangeable magnesium was present in low amount than calcium because of its higher mobility. The exchangaeable potassium distribution was low amounts in soil might be due to preferential losses of monovalent cations over divalent cations in leaching under high rainfall condition [19]. Cation exchange capacity (CEC) showed variation in all the soils and ranged from 1.70 to 51.20 cmol (p^+) kg^{-1}. The CEC values largely influenced by the high clay content in black soils are attributed to their smectite clay mineralogy [20]. Most of the soil series were irregular in distribution of CEC and increased with depth in Ramapura (RMP), Rachanalli (RHN), Gondedagi (GDG), Anur (ANR) and Sowrashtrahalli (SWR) series which may be related to the higher clay content down the profile. Similar results were obtained by Sharma and Anil Kumar [21].

The CEC/clay ratios were found to vary from 0.35 to 1.10 in identified soil series, their distribution was uneven in Badiyala**(**BDL), Ramapura (RMP), Sowrashtrahalli (SWR), Hegganakera (HGN) and Mylapura (MYP) series and decrease with depth in Halagera**(**HLG), Yalleri (YLR), Rachanalli (RHN), Gondedagi (GDG) and Anur (ANR) series. Since CEC was the charge behaviour of soils, where clay was the fundamental block contributing towards cation exchange, the high CEC of the black soils was attributed to the high clay content and smectitic clay mineralogy [20]. Base saturation ranges from 56 to 100 per cent which was found to increase trend with depth. This may be attributed

Table 2. Chemical properties of Ramapura-1 microwatershed

Depth (cm)	Horizon	pH	E.C. dS m^{-1}	O.C%	$CaCO_3$ %	Exchangeable bases				CEC	CEC/Clay	Base saturation %
						Ca	Mg	K	Na			
						[Cmol (p^+) kg^{-1}]						
Jinkera(JNK)												
0-15	Ap	8.42	0.14	0.70	0.65	-	-	0.15	0.03	14.50	0.74	100
15-38	Bw1	8.38	0.22	0.31	2.21	-	-	0.09	0.23	21.70	0.75	100
38-50	Bw2	8.40	0.19	0.25	1.17	-	-	0.07	0.19	15.90	0.79	100
Badiyala(BDL)												
0-12	Ap	6.20	0.07	1.00	-	2.80	0.98	0.14	0.01	4.20	0.72	93
12-28	Bw1	9.04	0.25	0.80	3.20	-	-	0.16	0.69	16.90	0.77	100
28-52	BC	9.41	0.36	1.10	3.60	-	-	0.16	1.39	11.10	0.75	100
Halagera(HLG)												
0-8	Ap	8.49	0.18	0.30	2.99	-	-	0.24	0.06	8.80	0.83	100
8-22	Bw1	8.57	0.11	0.45	4.03	-	-	0.11	0.02	19.50	0.71	100
22-53	Bw2	8.70	0.11	0.27	7.67	-	-	0.11	0.05	15.50	0.63	100
Ramapura (RMP)												
0-7	Ap	5.97	0.04	0.34	-	0.70	0.18	0.06	0.01	1.70	0.74	56
7-28	A2	6.06	0.03	0.26	-	1.83	0.53	0.07	0.05	3.30	0.36	75
28-70	Bt1	6.65	0.20	0.26	-	7.05	3.19	0.15	0.95	13.00	0.41	87
Yalleri (YLR)												
0-5	Ap	6.91	0.06	0.70	-	5.29	1.37	0.28	0.03	6.90	0.54	100
5-34	Bt1	7.05	0.05	0.62	-	16.43	3.89	0.26	0.09	21.60	0.40	96
34-75	Bt2	7.25	0.06	0.59	-	15.22	3.46	0.25	0.14	19.90	0.35	96
Rachanalli (RHN)												
0-8	Ap	8.16	0.22	0.38	1.20	5.43	2.49	0.16	0.79	8.99	1.10	99
8-43	Bw1	9.63	0.26	0.19	0.60	6.25	4.72	0.09	4.31	14.66	1.08	105
43-87	Bw2	10.09	1.01	0.15	5.76	-	-	0.21	11.77	24.08	0.88	100
Gondedagi (GDG)												
0-17	Ap	5.57	0.25	0.60	-	3.45	0.92	0.14	0.01	5.83	0.71	78
17-55	Bt1	6.20	0.04	0.57	-	9.79	1.58	0.07	0.05	14.96	0.57	77
55-115	Bt2	8.32	0.14	0.45	6.24	-	-	0.08	0.05	15.84	0.55	100
Anur (ANR)												
0-18	Ap	10.17	0.36	0.48	6.11	-	-	0.25	3.52	19.90	0.91	100
18-49	Bw1	10.32	1.38	0.30	6.76	-	-	0.21	12.03	24.60	0.79	100

Depth (cm)	Horizon	pH	E.C. dS m^{-1}	O.C%	$CaCO_3$ %	Exchangeable bases				CEC	CEC/Clay	Base saturation %
						Ca	Mg	K	Na			
						[Cmol (p^+) kg^{-1}]						
49-95	Bw2	10.08	2.55	0.17	6.11	-	-	0.33	11.49	32.60	0.77	100
95-123	Bw3	9.92	2.56	0.12	7.93	-	-	0.51	6.03	36.00	0.70	100
Sowrashtrahalli (SWR)												
0-9	Ap	8.44	0.18	0.77	7.47	-	-	0.79	0.21	47.70	1.02	100
9-34	BA	8.57	0.14	0.81	6.86	-	-	0.51	0.23	47.80	1.01	100
34-67	Bss1	8.73	0.12	0.81	6.48	-	-	0.28	0.44	50.60	1.08	100
67-124	Bss2	8.71	0.16	0.77	7.56	-	-	0.42	0.91	51.20	0.90	100
Hegganakera (HGN)												
0-8	Ap	8.77	1.33	1.16	8.19	-	-	1.10	5.21	36.23	0.66	100
8-24	BA	8.93	1.11	0.64	5.46	-	-	0.87	4.23	35.50	0.62	100
24-50	Bss1	8.85	0.98	0.32	3.38	-	-	0.71	3.78	36.69	0.62	100
50-86	Bss2	8.54	0.56	0.24	3.38	-	-	0.58	3.07	39.16	0.64	100
86-146	Bss3	8.45	0.52	0.24	3.38	-	-	0.62	2.82	38.52	0.63	100
146-170	Bss4	8.64	0.51	0.20	4.29	-	-	0.60	2.99	36.87	0.57	100
Mylapura (MYP)												
0-18	Ap	9.32	0.41	0.93	7.15	-	-	0.45	2.27	17.39	0.75	100
18-48	Bw1	10.01	0.55	0.60	7.41	-	-	0.64	4.33	17.11	0.66	100
48-80	Bw2	9.98	2.32	0.24	4.81	-	-	0.62	8.93	19.95	0.71	100
80-120	Bw3	9.79	3.55	0.16	3.90	-	-	0.81	4.04	21.59	0.70	100
120-148	Bw4	9.43	3.92	0.32	3.38	-	-	0.53	5.15	26.17	0.68	100
148-180	Bw5	9.22	3.46	0.36	3.77	-	-	0.51	7.37	28.55	0.73	100

** Ap- Disturbance of surface layer by mechanical means.*
A2- Surface horizon below Ap horizon.
Bw- Formed below surface horizon with development of colour/structure,
Bw1-Bw2-Bw3-Bw4-Bw5: vertical subdivision of Bw.
Bc- Dominated by properties of B horizon with limited properties of parent material.
Bt-B horizon with accumulation of silicate clay,
Bt1-Bt2: vertical subdivision of Bt.
BA- Transition horizon dominated B horizon with some influence of A horizon.
Bss- B horizon with presence of slickensides,
Bss1-Bss2-Bss3-Bss4: vertical subdivision of Bss.

to the removal of bases by water. The influence of exchangeable Ca^{2+} and Mg^{2+} contributed for higher base saturation in these soils. Same results were also reported by Srinivasan et al. [22] and Meena et al. [23].

4. CONCLUSION

It can be concluded that, the sand and silt distribution was irregular in most of series. Clay content was increase with depth in most of the soil series. Texture of the soil was loamy sand to sandy clay loam in surface and sandy clay loam to clay in subsurface. Per cent moisture was increase with depth. The pH of the soils was slightly acidic to alkaline in reaction. OC was low to high and their distribution was decrease with depth in most of the soil series. Per cent $CaCO_3$ was high with uneven distribution in most of the soil series. The distribution of exchangeable bases in the order of $Ca^{2+}>Na^{+}>Mg^{2+}>K^{+}$. Most of the soil series were irregular in distribution of CEC and CEC/clay ratio. The per cent base saturation was increase trend with depth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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