International Journal of Plant & Soil Science

Volume 36, Issue 7, Page 1080-1091, 2024; Article no.IJPSS.119455
ISSN: 2320-7035

Morphological and Physico-chemical Properties of Soils of Amtur-3 Micro-Watershed on Schistose Landscape in Bailhongal *taluk* of Belagavi District, Karnataka, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i74822

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/119455

Original Research Article

Received: 03/05/2024
Accepted: 06/07/2024
Published: 09/07/2024

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***Cite as:** Fathima, Firdosh, M. Hebbara, M. V. Manjunatha, V. B. Kuligod, and S. Rajkumara. 2024. "Morphological and Physico-Chemical Properties of Soils of Amtur-3 Micro-Watershed on Schistose Landscape in Bailhongal Taluk of Belagavi District, Karnataka, India". International Journal of Plant & Soil Science 36 (7):1080-91. https://doi.org/10.9734/ijpss/2024/v36i74822.*

ABSTRACT

Aims: To assess the morphological and physico-chemical properties of two soil series *viz*., KKT (Kabulayathkatti *tanda*) and SDH (Singadahalli) of Amtur-3 micro-watershed developed on schistose landscape in northern transition zone of Karnataka.

Place and Duration of Study: The study was carried out in the Amtur-3 micro-watershed (4D5B8t04) located in Bailhongal *taluk* of Belagavi district, Karnataka during 2022-2024.

Methodology: Horizon-wise soil samples were collected from the two representative pedons *viz*., KKT (Kabulayathkatti *tanda*) and SDH (Singadahalli) soil series, were identified, characterized and classified up to family level according to revisions in Soil Taxonomy using morphological, physical and chemical properties.

Results: The soils of these two series were sandy clay loam to clay in texture, neutral in soil reaction and had low salt content. Calcium and magnesium were the dominant cations followed by sodium and potassium. Both the soil series belonged to the order *Inceptisol*.

Keywords: Inceptisol; pedon; physico-chemical properties; schistose landscape.

1. INTRODUCTION

Characterizing soil resources through land inventory offers valuable insights into the potential and constraints of soil productivity, laying the groundwork for effective soil resource management. A deep understanding of soil types and their properties, derived from comprehensive soil surveys and classifications is crucial for devising alternative land use strategies. Belagavi district in Northern Karnataka, encompassing three distinct Agro-climatic zones (Agro-climatic zone – 3, 8 & 9), features a diverse landscape with varying topography, landforms and geological formations. As a result, the district exhibits a range of soil types, each with unique physical, chemical and morphological attributes that vary spatially and with depth. This study aims to deliver a precise and scientific inventory of schist-derived soils, detailing their types, characteristics and distribution across Bailhongal *taluk* in Belagavi district, Karnataka. Such detailed understanding will enable informed predictions regarding their potentiality and further their suitability for sustained crop production.

2. MATERIALS AND METHODS

2.1 Study Area and Site Characteristics

Amtur-3 micro-watershed of Bailahongal *taluk*, Belagavi district is located between 15°47’0” – 15°49’0” North latitudes and 74°49’30” – 74°51’0” East longitudes. Amtur-3 micro-watershed comes under Agro-climatic Zone 8: Northern Transition Zone of Karnataka. Most of the zone is at an elevation of 450-900 m MSL. The average annual rainfall of the zone ranges from 620 to 1025 mm [1]. The soils are shallow to medium black clay and red sandy loam in equal proportions. The main cropping season is *kharif*. Maize, rice, jowar, pulses, groundnut, cotton, wheat, sugarcane and some vegetable crops like chilli, potato, peas and onion are the major crops grown in the area.

2.2 Geology of Study Area

The Archaen schist; an extension of the Dharwar schist belt is observed in Amtur-3 micro-watershed of Bailhongal *taluk*.

2.3 Soil Sampling and Laboratory Analysis

Soil survey was carried out in the study area using high-resolution 8-band multispectral commercial satellite imagery (WorldView 2 - 50cm SR) and cadastral map of village. After intensive traversing, two representative soil series were identified and studied in detail. Horizon-wise soil samples were collected from these pedons representing KKT (Kabulayathkatti *tanda*) and SDH (Singadahalli) soil series and characterized for morphological characters *viz*; colour, structure, texture, consistency, roots and boundary and physical properties *viz*; per cent distribution of soil primary particles (sand, silt and clay), bulk density, particle density, water holding capacity and porosity. Soil chemical properties *viz*; pH (1:2.5), EC (1:2.5, dS m^{-1}), OC (g kg^{-1}), $CaCO_3$ (%), exchangeable cations (K, Na, Ca & Mg; cmol (p+) kg^{-1}), CEC [cmol (p+) kg^{-1}], per cent base saturation (PBS) and exchangeable sodium percentage (ESP) were analyzed using standard analytical procedures. The soils were classified at family level according to revisions in soil taxonomy [2].

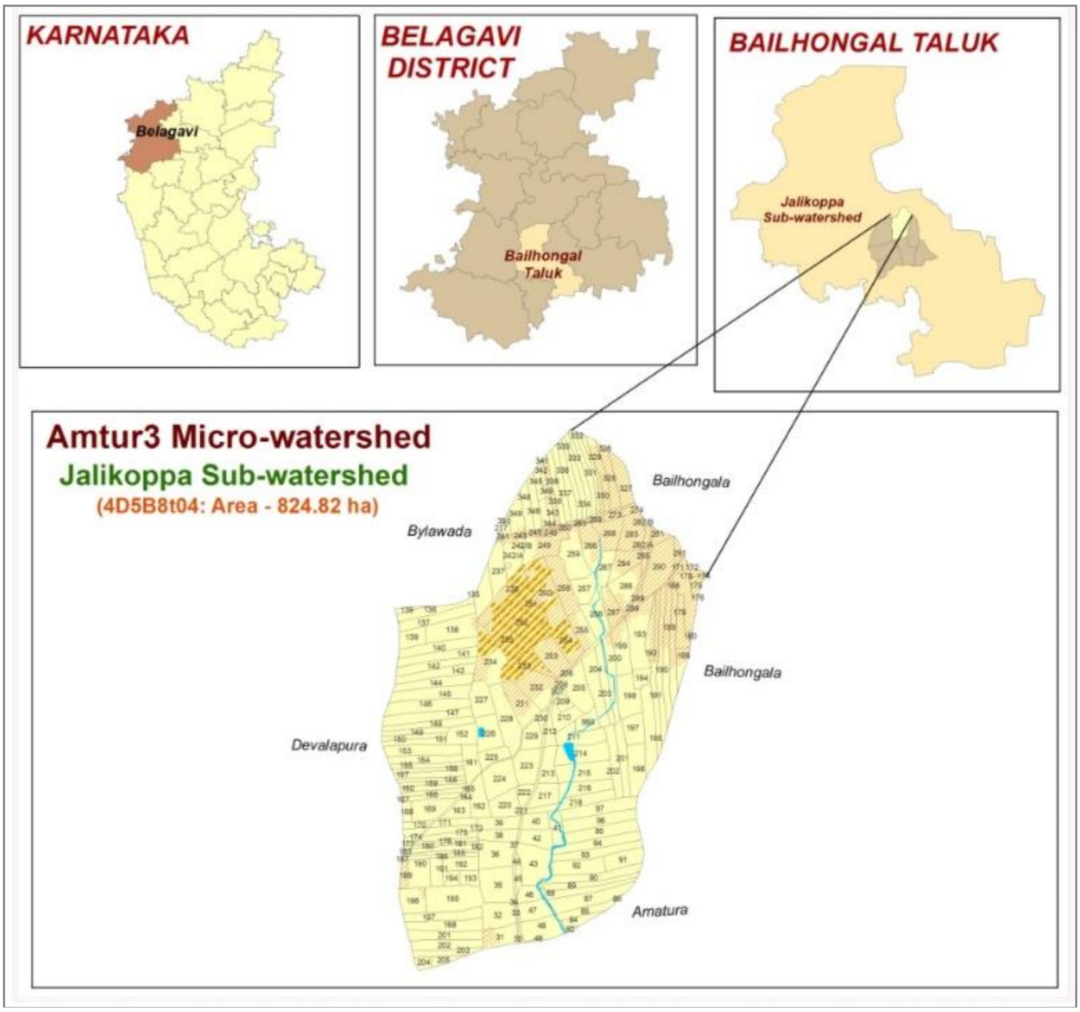

Fig. 1. Location map of Amtur-3 micro-watershed

3. RESULTS AND DISCUSSION

The morphological features of the schist-derived upland pedons (KKT and SDH) are summarized in Table 1. The KKT series was moderately deep (68+ cm) while, SDH series was deep (104+ cm) exhibiting four and five distinct horizons, respectively. The horizon sequence in KKT series is Ap - Bw - Bc- Cr and SDH series followed the sequence of Ap - Bw1 - Bc - Cb - Cr. The soil colour ranged from dark brown (7.5YR3/3) to dark yellowish brown (10YR3/4) in the dry matrix and brown (10YR4/3) to dark brown (7.5YR3/3) in the moist matrix. Notably, the colour variation with depth is minimal, suggesting uniform properties across the profile, probably due to uniform distribution of mineral matter and organic matter in the profile. Similar finding was documented by Nagendra and Patil [3] in the Shirol West-1 micro-watershed of Karnataka. The rich organic matter in surface horizons might have contributed to darker hues, while deeper layers showed lighter yellowish-brown colour. This can be attributed to decrease in soil organic carbon with depth. The SDH series maintained a consistent 10YR hue possible due to clay-humus complexes and lime in smectite-dominated soils [4] The presence of hydrated iron and manganese oxides, especially under humid conditions can also influence the 10YR soil hues [5].

The parent material for both soil series is schist, a mineral-rich metamorphic rock containing mica, quartz and feldspar. The darker hue of upper horizon is obviously due to higher organic carbon content and deposition of finer particles. As these finer weathered materials migrate deeper through processes like leaching and eluviation, colour lightens, reflecting the schist's predominant quartzitic composition. Schist's layered structure, with varying layer orientations and compositions affected the soil's colour and drainage. Thus, the larger colour variations in schist-derived soils reflected the parent material's heterogeneity, different stages of weathering and pedogenic processes across soil horizons. Similar influence of schist parent material and other soil forming factors on variation in soil colour was observed by Pulakeshi et al. [4], Nasre et al. [6] and Sashikala et al. [7].

The soils in the study area exhibited sub-angular blocky structure in the surface horizons of both soil series (Table 1). The sub-angular blocky structure prevalent in the surface horizons of pedons reflects the mode of particle arrangement and aggregation influenced by the characteristics of the schist parent material, offering valuable information for distinguishing between different soil horizons [4]. The structure in both pedons transitioned from predominantly weak in the surface horizon to strong medium sub-angular blocky in the subsurface horizons. This variation can be attributed to the high clay content present in the subsurface layers, which affected particle aggregation and structure formation. The heterogeneity in soil structure between surface and subsurface layers, attributed to the finer materials transported from higher topographic positions and the accelerated weathering processes [8].

The variation in dry and moist consistencies between the two-upland schist-derived soil series could be due to differences in their soil texture and clay content (Table 1). In KKT series, with sandy clay loam texture, the soil exhibited a slightly hard to friable consistency when dry and a medium sticky to medium plastic consistency when moist. The moderate clay content in this pedon contributed to its cohesive properties, but the sandy component allowed for better aeration and drainage. In contrast, SDH series with clay loam to clay texture displayed a very hard dry consistency and a firmer moist consistency. The higher clay content in this pedon contributed to higher moisture retention, resulting in increased stickiness and plasticity when wet. These differences in soil texture and clay content between these two-soil series influenced their respective consistencies. These results aligned with observations made by Sarkar et al. [9] in similar schist-derived soils.

The differences in soil texture between KKT and SDH could be attributed to variations in the degree of weathering processes they underwent. The KKT series predominantly exhibited a sandy clay loam texture throughout its profile (Table 1). The coarser texture of this pedon was likely due to a lower degree of weathering of the schist parent material, resulting in the retention of larger soil particles such as sand and silt. On the other hand, pedon-2 (SDH) displayed a clay loam to clay texture, indicating a higher proportion of finer particles like clay resulting from more extensive weathering of the schist parent material. The gradual and smooth boundaries observed in both pedons suggested consistent soil-forming processes influenced by the uniformity of the schist parent material. Thus, the differences in texture between the two series reflected varying degrees of schist weathering and subsequent particle size distribution in the soils. The physical and chemical characteristics of the parent material conjoint with other soil forming factors influence the breakdown and weathering processes that ultimately determine the texture of the resulting soil as noted by Pulakeshi et al. [4] in chlorite schist derived soils which exhibited clay, silt loam and silt clay loam textures in Mantagani village, Karnataka.

Roots were found in varying densities in both pedons, with many fine roots in surface soil to fewer in the subsurface layers (Table 1). However, neither pedon exhibited prominent slickensides or pressure faces. This suggested that while minor soil displacement might have occurred due to geological processes like tectonic activity or erosion, there was no substantial soil movement induced by pressure. The stable soil structure and absence of distinct slickensides pointed to a relatively undisturbed soil profile. This stability was likely attributed to the cohesive nature of clay particles and the resilience of the underlying parent material, which had resisted significant alteration from external forces.

Both the soil series exhibited an ochric epipedon, characterized by its pale color and low organic matter content, indicated a younger age of these soils or limited soil-forming processes at the surface, resulting in an undifferentiated upper layer (Table 1). On the other hand, the cambic endopedon observed in both pedons pointed to a transitional zone within the soil profile where soil-forming processes were more active in the overlying horizons and less active in the underlying material. This horizon often exhibited subtle changes in colour or structure, reflecting weak evidence of alteration by soil-forming processes.

Physical characteristics of KKT and SDH series are presented in Table 2. A perusal of the data on particle size distribution in soils according to the USDA textural triangle revealed that the soil of KKT series was sandy clay loam and SDH was clay loam to clay in texture. The KKT pedon exhibited mean highest sand content (46.93%), with a higher content recorded in Bw horizon (48.89%), followed by clay fractions (29.42%), exhibiting a depth-wise increasing trend. In contrast, SDH pedon showed mean highest clay fractions (38.88%). The higher clay content recorded in Bc horizon (45.68%), with a depth-wise increasing trend, followed by sand fractions exhibiting decreasing trend with depth. Both pedons showed irregular distribution of silt content with depth.

The mean highest sand content was observed in KKT upland soil pedon, which could be attributed to the slow weathering rates of resistant minerals in the schist parent material. These minerals, often associated with the coarser sand fraction, were released at a slower pace compared to finer particles during weathering. Upland soils generally showed higher sand content than lowland soils, regardless of the parent rock, due to their sloping locations which made them more prone to erosion. The finer soil fractions eroded from uplands tend to accumulate in midland and lowland areas, leaving behind the less erodible coarse sand fractions. This process likely resulted in the elevated sand content observed throughout the KKT pedon. Similar observations were made by Sanjay and Kuligod [10] in the schist-derived upland Kabalaykatti (KLK) series and by Reddy et al. [11] in the basaltic terrain of Central India, reinforcing the idea that erosion and mineral resistance significantly influence sand distribution in upland soils.

The sharp increase in clay content with depth in SDH pedon suggested active leaching processes. In upland environments, especially with well-drained soils like those developed from schist, water movement through the soil profile can selectively transport and remove finer particles. This process is facilitated by the permeable nature of the soil and the absence of stagnant water, which accelerates the removal of clay particles from the upland to lowland areas/horizons, resulting in the enrichment of clay with depth. Sanjay and Kuligod [10] similarly observed elevated clay content in subsurface horizons due to illuviation during soil development. Additionally, the irregular distribution of silt content in both pedons may result from pedological processes such as sedimentation and redeposition. Erosion and sedimentation dynamics, particularly in steep upland areas, caused the redistribution of soil particles, leading to variable silt concentrations across the soil profile. This pattern aligns with findings by Sharma et al. [12] and Sanjay and Kuligod [10], highlighting the significant role of terrain and water movement in shaping soil texture and composition.

The mean water holding capacity of the pedons ranged from 30.36 (KKT) to 42.87 per cent (SDH) (Table 2). The variations in values were due to variations in soil depth, amount of clay and silt content and organic carbon status. The highest water holding capacity was observed in pedon-2 (SDH) compared to pedon-1 (KKT) due to the presence of higher amount of clay and deeper soil depth. This observation aligned with the studies of Singh et al. [13] who found the influence of texture on soil moisture constant and they noted that soil moisture constant increased with increase in the clay and silt content. Maximum water holding capacity of pedons in the surface layer ranged from 26.91 to 30.81 per cent and in lower horizons varied between 28.96 to 50.81 per cent. Maximum water holding capacity increased from surface to the lower horizons and followed the trend of clay variation in pedons [3]. These results were in line with those of Thangasamy et al. [14] in soils of Sivagiri village in Chittoor district of Andhra Pradesh.

Bulk density varied from 1.29 to 1.39 Mg m^{-3} in KKT Pedon, whereas in SDH pedon, it varied from 1.30 to 1.37 Mg m^{-3} (Table 2), suggesting that soils of study area possessed enough pore spaces, organic matter and soil solids for sustained crop production. Notably, bulk density tends to increase with depth, as observed in both pedons, a trend attributed to the illuviation of colloidal particles, clogging of pores in sub-soil layers and reduction of organic carbon with depth. This pattern was consistent with findings from Wakwoya et al. [15] and Dhruw et al. [16], who reported bulk density increasing from 1.39 to 1.81 Mg m^{-3} due to overburden pressure. Similarly, Patil et al. [17] noted a rise in bulk density from 1.12 to 1.54 Mg m^{-3} with depth, linked to dispersed clays and lower organic carbon. Additionally, soils in the Shikohpur watershed of Gurgaon district, Haryana, showed higher bulk densities due to their coarse texture, calcium carbonate presence and low organic carbon [18]. These observations highlight the

Table 1. Morphological properties of Kabulayathkatti *tanda* (KKT) and Singadahalli (SDH) soil series of Amtur-3 micro-watershed

Soil series	Horizon	Depth (cm)	Colour		Texture	Structure	Consistency			Roots	Boundary	Other features
			Dry	Moist			Dry	Moist	Wet			
KKT	Ap	0-10	7.5YR3/3 (Dark Brown)	7.5YR3/4 (Dark Brown)	scl	1msbk	sh	fr	msmp	mf t	gs	ochric
	Bw	10-28	7.5YR3/4 (Dark Brown)	7.5YR3/4 (Dark Brown))	scl	2msbk	sh	fr	msmp	cf t	gs	
	BC	28-68	7.5YR4/4 (Brown)	7.5YR3/3 (Dark Brown)	scl	1msbk	-	fr	msmp	-	gs	cambic
	Cr	68+	-	-	-	-	-	-	-	-	-	
SDH	Ap	0-27	10YR4/2 (Dark Grayish Brown)	10YR3/2 (Brown)	l	1msbk	h	fr	vsvp	mf t	gs	ochric
	Bw1	27-50	10YR3/3 (Dark Brown)	10YR4/2 (Dark Grayish Brown)	cl	2msbk	vh	fi	vsvp	fvf t	gs	
	BC	50-69	10YR3/4 (Dark Yellowish Brown)	10YR4/3 (Brown)	c	2msbk	-	fr	msmp	-	gs	cambic
	CB	69-104	-	-	c	2msbk	-	fr	sssp	-	gs	
	Cr	104+	-	-	-	-	-	-	-	-	-	

Table 2. Physical properties of Kabulayathkatti *tanda* (KKT) and Singadahalli (SDH) soil series of Amtur-3 micro-watershed

Horizon	Depth(cm)	Sand	Silt	Clay	BD	PD	MWHC	Pore space
		% of fine earth			(Mg m^{-3})		(%)	
				Kabulayathkatti *tanda* (KKT)				
AP	0-10	45.80	27.00	28.22	1.29	2.56	30.81	49.61
Bw	10-28	48.89	22.89	27.22	1.38	2.75	28.96	49.82
BC	28-68	47.95	21.92	32.12	1.39	2.78	29.42	50.00
Cr	68+	45.08	22.80	30.12	1.39	2.75	32.23	49.45
Mean		**46.93**	**23.65**	**29.42**	**1.36**	**2.71**	**30.36**	**49.72**
SD		**1.79**	**2.27**	**2.16**	**0.05**	**0.10**	**1.48**	**0.24**
CV		**3.81**	**9.61**	**7.36**	**3.56**	**3.73**	**4.87**	**0.48**
				Singadahalli (SDH)				
AP	0-27	44.89	31.88	23.23	1.30	2.60	26.91	50.00
Bw1	27-50	40.76	20.96	38.28	1.34	2.67	39.47	49.81
BC	50-69	32.78	21.54	45.68	1.36	2.71	50.81	49.82
CB	69-104	24.87	31.56	43.57	1.37	2.70	48.91	49.26
Cr	104+	30.67	25.68	43.65	1.35	2.68	48.23	49.63
Mean		**34.79**	**26.32**	**38.88**	**1.34**	**2.67**	**42.87**	**49.70**
SD		**8.02**	**5.25**	**9.17**	**0.03**	**0.04**	**9.93**	**0.28**
CV		**23.04**	**19.95**	**23.58**	**2.01**	**1.62**	**23.17**	**0.57**

Table 3. Chemical properties of Kabulayathkatti *tanda* (KKT) and Singadahalli (SDH) soil series of Amtur-3 micro-watershed

Horizon	Depth (cm)	pH (1:2.5)	EC (1:2.5) (dS m^{-1})	OC (g kg^{-1})	$CaCO_3$ (%)	Exchangeable cations					CEC [cmol (p+) kg^{-1}]	BSP	ESP
						Ca	Mg	Na	K	Total Ex. Bases			
						[cmol (p+) kg^{-1}]						(%)	
Kabulayathkatti *tanda* (KKT)													
Ap	0-10	6.44	0.23	6.20	2.00	11.00	5.00	0.03	0.06	16.09	18.12	88.80	0.17
Bw	10-28	6.40	0.32	2.76	2.50	11.30	6.10	0.10	0.03	17.53	19.23	91.16	0.52
BC	28-68	6.70	0.32	1.90	11.25	12.20	5.80	0.16	0.09	18.25	20.32	89.81	0.79
Cr	68+	-	-	-	-	-	-	-	-	-	-	-	-
Mean		**6.51**	**0.29**	**5.65**	**5.25**	**11.50**	**5.63**	**0.10**	**0.06**	**17.29**	**19.22**	**89.92**	**0.49**
SD		**0.16**	**0.05**	**2.60**	**5.20**	**0.62**	**0.57**	**0.07**	**0.03**	**1.10**	**1.10**	**1.19**	**0.31**
CV		**2.50**	**17.92**	**46.00**	**99.09**	**5.43**	**10.09**	**67.31**	**50.00**	**6.36**	**5.72**	**1.32**	**63.53**
Singadahalli (SDH)													
Ap	0-27	6.45	0.19	4.90	9.25	14.90	6.50	0.03	0.10	21.53	26.89	80.07	0.11
Bw1	27-50	7.10	0.21	3.50	6.25	17.40	8.50	0.08	0.02	26.00	29.78	87.31	0.27
BC	50-69	7.53	0.25	2.13	11.25	14.50	7.70	0.17	0.06	22.43	25.67	87.38	0.66
CB	69-104	7.51	0.23	1.80	5.00	16.60	7.10	0.10	0.04	23.84	27.54	86.56	0.36
Cr	104+	-	-	-	-	-	-	-	-	-	-	-	-
Mean		**7.15**	**0.22**	**3.41**	**7.94**	**15.85**	**7.45**	**0.10**	**0.06**	**23.45**	**27.47**	**85.33**	**0.35**
SD		**0.51**	**0.03**	**0.45**	**2.84**	**1.38**	**0.85**	**0.06**	**0.03**	**1.95**	**1.72**	**3.53**	**0.23**
CV		**7.07**	**11.74**	**13.15**	**35.76**	**8.69**	**11.47**	**61.08**	**62.10**	**8.31**	**6.28**	**4.13**	**65.95**

Table 4. Classification of soils (Keys to Soil Taxonomy, 2012 by Soil Survey Staff)

Pedon	Order	Suborder	Great group	Subgroup	Family
KKT	*Inceptisol*	*ustepts*	*Haplustepts*	*TypicHaplustepts*	*Fine loamy Mixed Superactive Iso-hyperthermic Typic Haplustepts*
SDH	*Inceptisol*	*ustepts*	*Haplustepts*	*VerticHaplustepts*	*Fine, smectitic, iso-hyperthermic, Vertic Haplustepts*

complexity of soil density dynamics and their implications for agricultural practices. Furthermore, particle density remained relatively stable, followed the increasing trend with depth. Porosity in both pedons was relatively consistent throughout the profile, ranged from 49.26 to 50.00 per cent. Brady and Weil [19] revealed that, the ideal values of total pore space, which are acceptable for production of crops, were approximately 50 per cent. Hence, both pedons in the study area were in closely acceptable range of total porosity values for crops production.

Results of analysis showed that mean of soil reaction in study area ranged from 6.51 to 7.15, indicating soils are neutral in reaction (Table 3). The highest value of pH was observed in the of Bc horizon of SDH series, while lowest pH was found in the Bw horizon of KKT series. The estimated values of pH in both schist-derived upland pedons suggested a balanced soil environment, conducive to various plant growth and microbial growth.

The relatively higher pH values in the SDH pedon is because of its calcareous nature (Table 3). Calcareous soils typically contain calcium carbonate ($CaCO_3$), which can buffer against changes in soil pH, keeping it elevated. On the other hand, the other pedon (KKT) displayed lower pH values compared to the former. The schist-derived parent material in KKT pedon might weather differently, releasing fewer bases and leading to slightly acidic to neutral soil environment. This variation in weathering rates and mineral composition could influence the soil's chemical properties, resulting in distinct pH levels between the two pedons. Sitanggang et al. [18] documented increase in soil reaction down the slope and attributed it to leaching of bases from higher topography and getting deposited at lower elevations. These processes collectively contributed to the observed pH trends in the soil profiles. Similar results were reported by Thangasamy et al. [14].

Electrical conductivity was relatively higher in KKT pedon compared to SDH pedon, indicating that the soils of SDH series are less leached compared to KKT series (Table 3). The mean values of EC in both the pedons (0.22 to 0.29 dS m^{-1}) were found to be < 1 dS m^{-1}, indicating that soils are safe for all types of crop production. The non-saline nature of both the pedons might be due to proper management or inherent properties of soil and leaching of salts to lower horizons [15]. In the soils studied, the electrical conductivity generally increased with depths. The upper solum was relatively low in salts than in the lower solum. This might be due to leaching of salts from the soil surface to lower depths due to irrigation and their accumulation in lower depths. Even at the time when irrigation was introduced, the distribution of salts showed a concentration of salts in the lower solum in Malaprabha project area of Karnataka.

The per cent mean values of free calcium carbonate in pedons ranged from 5.25 to 7.94 per cent, suggesting that soils were calcareous (Table 3). The calcium carbonate content increased with depth due to the accumulation of calcium released from calcium rich parent material and also precipitation of calcium and magnesium as carbonates and bicarbonates in the solum through calcification. Ravikumar et al. [20] observed that free calcium carbonate levels were in safe zone in 48A distributary of Malaprabha right bank command of Karnataka. The free calcium carbonates in black and red soils ranged from 10.7 to 19.9 and 5.2 to 7.9 per cent, respectively [4].

Organic carbon content in KKT and SDH series (SDH) ranged from 1.90 to 6.20 and 1.80 to 4.90 g kg^{-1}, respectively, which in general accumulated in surface layers (Table 3). The lower contents of organic carbon apparently resulted because of high temperature which might have induced its rapid oxidation. These observations were in line with the findings reported by Basavaraju et al. [21] for soils of Chandragiri Mandal of Chittoor district of Andhra Pradesh. The organic carbon content of surface soil was higher than the subsurface soils, due to high amount of litter and the crop residues at the surface and followed the decreasing trend with depth. It reflects the rapid rate of organic matter mineralization in these soils. Similar findings were reported by Shadaksharappa et al. [22] for Malaprabha command area soils.

The dominant cations on the clay complex were calcium followed by magnesium, sodium and potassium. The mean values of exchangeable calcium (11.50 to 15.85 cmol (p^+) kg^{-1}) and magnesium (5.80 to 7.45 cmol (p^+) kg^{-1}) dominated over the exchangeable sodium and potassium (Table 3). The exchangeable calcium and magnesium were found higher in lower horizons compared to surface soil. The content of exchangeable sodium in SDH and KKT (0.03 – 0.17cmol (p^+) kg^{-1}, respectively) varied with soil depth. The soils under investigation contained exchangeable potassium in quantities ≤ 1 cmol (p^+) kg^{-1} and the values exhibited an irregular distribution with depth, varied from 0.30 – 0.10 cmol (p^+) kg^{-1}.

The exchangeable bases in both soil series were in the order: Ca^{+2}> Mg^{+2}> Na^+> K^+ on the exchangeable complex, indicating that soils are mild weathered and less leached. Due to higher mobility of magnesium than calcium, magnesium was found in lesser amount than calcium ions. Lesser value of exchangeable monovalents (Na^+, K^+) compared to divalents (Ca^{+2}, Mg^{+2}) was due to easy leaching of monovalents and preferential adsorption of divalent as reported by Ravikumar et al. [20] in 48A distributary of Malaprabha right bank Command of Karnataka.

The cation exchange capacity found higher in lower horizons and followed the trend of clay (Table 3). This is due to accumulation of clay in lower depths and may be due to presence of smectitic group of clay minerals [23]. Similar findings have been reported by Shadaksharappa et al. [22] in Malaprabha Command soils.

The mean values of base saturation and exchangeable sodium percentage (ESP) ranged from 85.33 to 89.92 and 0.35 to 0.49 per cent, respectively. Base saturation values were higher in deeper horizons compared to the surface horizon, showing an increasing trend with depth, correlating with soil reaction. Increased base saturation with depth is attributed to the downward movement of bases from the upper to lower horizons, as reported by Meenakshi et al. [24] in soils of the Pannur North-3 micro-watershed. The mean values of ESP in pedons ranged from 0.35 to 0.49 per cent (Table 3). ESP values also indicated higher concentrations in deeper horizons, suggesting the onset of sodiumization processes in lower horizons.

The soils of Amtur-3 micro-watershed area were classified up to the family level (Table 4) based on the soil characteristics of pedons and the climate of the study area, following the Soil Taxonomy revision by Soil Survey Staff [2]. The Kabulayathkatti *tanda* and Singadahalli soil series, originating from weathered schist, fall under the *Inceptisol* order because of their youthful age and undeveloped horizons. These soils show signs of ongoing weathering due to their young schist parent material, exhibiting the absence of defined horizons and exhibiting typical *Inceptisol* characteristics.

The Kabulayathkatti *tanda* soil series, derived from weathered schist, showed a fine loamy texture characterized by a mixture of sand, silt and clay particles, predominantly fine in nature due to schist weathering. Classified as Mixed, the soil comprises a diverse blend of mineral components and organic matter across its profile. Its super-active nature results from rapid mineral weathering of schist, ensuring high nutrient availability and efficient nutrient cycling. The *Isohyperthermic* temperature regime indicated stable temperatures year-round, likely influenced by the region's climate. Lastly, being classified as *Typic Haplustepts*, it indicates that soils have a subsurface horizon with a high base saturation and significant accumulation of clay. These soils are typically found in semi-arid to sub-humid regions with minimal diagnostic horizons and they are used for agricultural purposes due to their fertility.

The Singadahalli series soil was classified as Fine in texture, characterized by its small particle size, which influences water retention and nutrient availability due to the weathering of schist parent material. This soil is smectitic, containing clay minerals like smectite with high cation exchange capacity and swelling properties, which result from the weathering of schist. The temperature regime is described as *iso-hyperthermic*, indicating consistent temperatures throughout the year, likely due to the stable climate. Additionally, the soil was classified as *Vertic Haplustepts*, reflecting its significant volume changes from the expansion and contraction of smectitic clays in response to wetting and drying cycles, with high organic matter content at the surface and exhibiting minimal diagnostic horizons below. These soils are often found in regions with distinct wet and dry seasons and can pose challenges for agriculture and constructions due to their tendency to crack and swell.

4. CONCLUSION

Overall, the schist-derived upland pedons (KKT and SDH) of Amtur-3 micro-watershed exhibited distinct morphological and physical characteristics. The parent material, schist, influenced the soil's colour, texture and structure. Soils studied were sandy clay loam (KKT) and clay loam to clay (SDH) in texture with depth-wise increased trend in clay content. Water holding capacity was optimal for crop production, influenced by soil depth, clay and silt content. The pH was neutral and EC (<1 dS m^{-1})

increased with depth. Organic carbon decreased and calcium carbonate content increased with depth. Calcium and magnesium were the dominant exchangeable cations followed by sodium and potassium. Base saturation and exchangeable sodium percentage (ESP) values increased with depth. According to revisions in Soil Taxonomy, soils of Amtur-3 micro-watershed belonged to the order *Inceptisol*.

ACKNOWLEDGEMENT

The manuscript is part of the REWARD project funded by Government of Karnataka. The authors duly acknowledge the technical support from the staff of REWARD project, UAS Dharwad.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/119455