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RESEARCH PAPER

Effect of land use systems on soil morphological features and physical properties of Bada micro watershed (4D4F2j05) in Northern Transition Zone of Karnataka

B. HARSHITH SURYA[1*], B. R. JAGADEESH[1], V. B. KULIGOD[1], M. P. POTDAR[2] AND H. M. SANTHOSHA[3]

[1]Department of Soil Science and Agricultural Chemistry, [2]Department of Agronomy,
[3]Division of Horticulture, College of Agriculture, Dharwad
University of Agricultural Sciences, Dharwad - 580 005, India
*E-mail: harshithsuryabhimala@gmail.com

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Abstract: A study was conducted to assess the impact of diverse land uses (Forest, barren land, agriculture and horticulture) in Bada micro watershed for morphological features and physical properties of soil. Across land uses, the darker soil colors were observed in forest land use. The surface soil horizons and moist soil recorded darker hue. The characteristic crumby type of soil structure is identified in forest pedons. The greater amount of root distribution in forest land use reflected the presence of perennial trees in forest land, whereas annual crops and shrubs were characteristic of other land use systems. There was no significant difference in soil texture observed among the different land use systems. The ideal and lowest bulk density was found in forest (1.27 Mg m^{-3}) among the land use systems. The highest porosity and maximum water holding capacity (MWHC) were observed in forest land, followed by agriculture, horticulture and barren land use systems.

Key words: Bada micro watershed, Land use system, Morphological features

Introduction

Soil represents one of the most intricate and dynamic natural resources essential for sustaining terrestrial life on earth, serving as the fundamental basis for agricultural production. It functions as a reservoir of nutrients, providing all the vital elements necessary to support plant growth. However, global arable land is increasingly threatened by continuous degradation driven by rapid urbanization, accelerated desertification and excessive exploitation due to human activities. Soil demonstrates considerable variability in its morphology, chemical composition and fertility, factors that collectively determine its response to various land use systems and crop management strategies. Inadequate soil management practices in cultivated areas have resulted in elevated rates of soil erosion, reduced crop yields and productivity and a decline in overall soil quality (Pimentel and Burgess, 2013). These challenges underscore the necessity for a thorough understanding of soil properties to optimize its sustainable utilization.

A land use system can be defined as a mode of utilizing a specific part of land, which significantly impacts soil properties. It encompasses the intended function of the land, the quality of its management and the surrounding social and environmental factors. These systems are inherently dynamic and their sustainability is contingent upon balancing human needs with the land's inherent capacity. Land use systems critically influence nutrient availability and cycling and they may also affect secondary succession and biomass production (Lu *et al*., 2002). Assessing the effects of various land use systems on soil properties is essential for identifying optimal management practices for particular environmental contexts. The successful application of these practices necessitates attention to the spatial scale at which land use decisions occur, especially at finer scales.

Material and methods

A survey was carried out in Bada micro watershed (4D4F2j05), Shiggaon taluk of Haveri district under Northern Transition Zone of Karnataka (Zone 8). The study area located at 14°55'30"to 14°58'0" North latitudes and 75°11'45" to 75°14'0" East longitudes, covering an area of about 592.62 ha (Fig 1). A total of eight profile pits were excavated down to the parent material, corresponding to the different land use systems. Two profile pits from each land use system (Forest, barren land, agriculture and horticulture) underwent morphological examination for matrix color, soil structure and root distribution in accordance with the procedures specified in the Keys to Soil Taxonomy by the USDA Soil Survey Staff (Anon., 2022). Soil samples collected horizon wise along with clods were placed in polythene bags and transported to the laboratory for subsequent processing and analysis. Soil samples collected from various land use systems were subjected to laboratory analysis to determine physical properties, adhering to the established standard protocols as outlined by Piper (2019). The particle size analysis was carried out using the international pipette method, bulk density (BD) was determined using clod coating method, porosity was calculated using the formula porosity (%) = [1 – (Bulk Density / Particle Density)] × 100 and maximum water holding capacity (MWHC) of the soils was determined using the Keen's Raczkowaski brass box method.

Results and discussion

Morphological features:

Soil color exhibited variation across the pedons, ranging from 5 YR 3/3 (dark reddish brown) to 10 YR 5/4 (yellowish brown) (Table 1). The darker soil colors were typically observed in moist conditions due to increased light absorption (Sirisathitkul and Sirisathitkul, 2025). Among different land use systems, forest soils consistently displayed darker color. The pronounced dark matrix color observed in the surface horizons and forest soils is attributable to higher organic matter concentrations, as reported by Tripathi *et al.* (2006) and Mini *et al.* (2007). Conversely, subsurface horizons exhibited relatively lighter colors throughout the soil profile, which can be explained by diminished organic matter content. This pattern corroborates with the findings of Madhanmohan (2008) and Pulakeshi *et al.* (2014).

The soil structure of pedons demonstrated variability across different land use systems. The surface horizons consistently exhibited a weak, medium sized subangular blocky structure regardless of land use type, except forest land use which was characterized by a weak, fine crumby structure (Table 1). In contrast, the subsurface horizons showed a moderate, medium subangular blocky structure across all land uses, except forest land use which displayed a weak to moderate, fine crumby structure. The presence of a subangular blocky structure has been linked to higher clay content (Kadao *et al.*, 2003; Leelavathi *et al.*, 2009). Conversely, the crumby structure observed in forest pedons is likely attributable to enhanced soil aggregation resulting from increased organic matter content (Sheikh *et al.*, 2009).

The distribution of roots across various land use systems demonstrated a consistent pattern relative to soil depth (Table 1). Specifically, the root distribution within the soils reflected the presence of perennial trees in forest land, while annual crops

Table 1. Morphological features of soil pedons across different land use systems

Land use	Horizon	Depth (cm)	Matrix colour		Structure			Root
			Dry	Moist	G	S	T	distribution
Forest (Pedon - 1)	A	0-5	7.5YR 5/4	7.5YR 3/4	1	f	cr	cmt
	Bw$_1$	5-25	5YR 5/3	5YR 4/3	2	f	cr	mft
	Bw$_2$	25-45	5YR 5/4	5YR 4/4	2	f	cr	mfp
	Bw$_3$	45-70	5YR 5/4	5YR 4/4	2	f	cr	mfp
	Bw$_4$	70-90	5YR 5/3	5YR 4/3	1	f	cr	-
Forest (Pedon - 2)	A	0-6	7.5YR 5/4	7.5YR 4/4	1	f	cr	cmt
	Bw$_1$	6-30	5YR 4/3	5YR 3/3	1	f	cr	mft
	Bw$_2$	30-50	5YR 4/3	5YR 3/3	1	f	cr	mfp
	Bw$_3$	50-80	5YR 4/3	5YR 3/3	1	f	cr	mfp
	Bw$_4$	80-115	5YR 5/3	5YR 4/3	1	f	cr	-
Barren (Pedon - 1)	A	0-12	10YR 4/4	10YR 3/3	1	m	sbk	mmt
	Bw$_1$	12-30	10YR 4/3	10YR 3/3	2	m	sbk	fft
	Bw$_2$	30-74	10YR 4/4	10YR 3/4	2	m	sbk	-
	BC	74-90	10YR 4/6	10YR 3/6	1	m	sbk	-
Barren (Pedon - 2)	A	0-10	10YR 5/4	10YR 4/4	1	m	sbk	mmt
	Bw$_1$	10-25	10YR 4/3	10YR 3/3	2	m	sbk	fft
	Bw$_2$	25-45	7.5YR 4/3	7.5YR 3/3	1	m	sbk	-
	Bw$_3$	45-60	7.5YR 4/3	7.5YR 3/3	1	m	sbk	-
	Bw$_4$	60-80	7.5YR 4/3	7.5YR 3/3	1	m	sbk	-
Agriculture (Pedon - 1)	Ap	0-15	10YR 4/4	10YR 3/2	1	m	sbk	mmt
	Bw$_1$	15-35	7.5YR 4/2	7.5YR 3/2	2	m	sbk	cft
	Bw$_2$	35-60	7.5YR 4/2	7.5YR 3/2	2	m	sbk	-
	Bw$_3$	60-100	5YR 4/3	5YR 3/3	1	m	sbk	-
	Bw$_4$	100-160	5YR 4/3	5YR 3/3	1	m	sbk	-
Agriculture (Pedon - 2)	Ap	0-15	10YR 4/3	10YR 3/3	1	m	sbk	mmt
	Bw$_1$	15-35	10YR 4/2	10YR 3/2	2	m	sbk	fft
	Bw$_2$	35-68	10YR 4/3	10YR 3/3	2	m	sbk	-
	BC	68-110	10YR 4/4	10YR 3/4	1	m	sbk	-
Horticulture (Pedon - 1)	Ap	0-10	10YR 4/4	10YR 3/3	1	m	sbk	mft
	Bw	10-45	10YR 4/3	10YR 3/3	2	m	sbk	fft
	BC	45-90	10YR 4/2	10YR 3/2	1	m	sbk	-
Horticulture (Pedon - 2)	Ap	0-19	7.5YR 4/4	7.5YR 3/4	1	m	sbk	cmt
	Bw	19-45	5YR 4/3	5YR 3/3	2	m	sbk	fft
	BC$_1$	45-71	5YR 4/3	5YR 3/3	1	m	sbk	-
	BC$_2$	71-120	5YR 4/4	5YR 3/4	1	m	sbk	-

G-Grade (1-weak, 2-moderate), S-Size (f-fine, m-medium),T-Type (cr-crumby, sbk-subangular blocky); Roots: Quantity (f-few, c-common, m-many), Size (vf-very fine, f-fine, m-medium, c-coarse, vc-very coarse), Location (p-between peds, c-in cracks, t-throughout).

Table 2. Physical properties of soil pedons across different land use systems

Serial No.	Horizon	Depth (cm)	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Textural class	Bulk density (Mg m^{3})	Porosity (%)	MWHC (%)
					Forest					
Pedon-1	A	0-5	9.5	28.8	18.8	42.9	Clay	1.17	59.67	55.17
	Bw$_1$	5-25	9.4	28.3	18.0	44.3	Clay	1.20	59.34	54.89
	Bw$_2$	25-45	9.3	28.1	17.2	45.4	Clay	1.25	57.95	53.70
	Bw$_3$	45-70	9.1	27.5	16.6	46.8	Clay	1.29	56.94	52.92
	Bw$_4$	70-90	8.7	26.3	17.0	48.0	Clay	1.34	55.13	51.27
		W	9.1	27.6	17.3	46.0	-	1.27	57.45	53.29
Pedon-2	A	0-6	10.1	30.0	18.2	41.7	Clay	1.20	59.02	54.72
	Bw$_1$	6-30	9.8	29.4	17.6	43.2	Clay	1.24	57.76	53.56
	Bw$_2$	30-50	9.6	28.9	16.9	44.6	Clay	1.27	57.06	52.96
	Bw$_3$	50-80	9.3	28.2	16.3	46.2	Clay	1.30	55.97	52.03
	Bw$_4$	80-115	9.1	27.6	16.0	47.3	Clay	1.34	54.70	50.92
		W	9.4	28.5	16.7	45.4	-	1.29	56.31	52.31
					Barren					
Pedon-1	A	0-12	11.0	22.1	21.3	45.6	Clay	1.34	42.06	39.64
	Bw$_1$	12-30	10.7	21.5	21.0	46.8	Clay	1.37	41.10	38.84
	Bw$_2$	30-74	13.2	26.5	18.8	41.5	Clay	1.41	39.55	37.61
	BC	74-90	12.8	25.6	18.3	43.3	Clay	1.43	38.51	36.73
		W	12.3	24.8	19.5	43.4	-	1.40	40.01	37.97
Pedon-2	A	0-10	13.6	27.4	20.7	38.3	Clay loam	1.36	41.35	39.01
	Bw$_1$	10-25	13.4	27.0	20.0	39.6	Clay loam	1.38	40.85	38.67
	Bw$_2$	25-45	12.8	25.6	19.2	42.4	Clay	1.41	40.26	38.16
	Bw$_3$	45-60	13.0	26.2	18.8	42.0	Clay	1.43	39.85	37.83
	Bw$_4$	60-80	13.8	27.6	17.9	40.7	Clay	1.46	38.66	36.80
		W	13.3	26.7	19.1	40.9	-	1.41	40.03	37.96
					Agriculture					
Pedon-1	Ap	0-15	8.8	22.3	19.0	49.9	Clay	1.29	49.69	46.47
	Bw$_1$	15-35	11.0	27.5	12.7	48.8	Clay	1.32	48.66	45.68
	Bw$_2$	35-60	10.8	27.3	14.6	47.3	Clay	1.34	48.21	45.31
	Bw$_3$	60-100	9.4	23.6	21.3	45.7	Clay	1.36	47.38	44.72
	Bw$_4$	100-160	9.9	24.9	25.9	39.3	Clay loam	1.39	46.53	43.95
		W	10.0	25.0	20.7	44.3	-	1.36	47.57	44.81
Pedon-2	Ap	0-15	9.4	23.5	21.5	45.6	Clay	1.31	48.93	45.87
	Bw$_1$	15-35	9.6	23.4	19.1	47.9	Clay	1.34	47.90	45.08
	Bw$_2$	35-68	10.6	26.6	19.3	43.5	Clay	1.37	47.50	44.76
	BC	68-110	11.7	29.5	15.9	42.9	Clay	1.40	46.28	43.78
		W	10.7	26.7	18.3	44.4	-	1.37	47.30	44.60
					Horticulture					
Pedon-1	Ap	0-10	10.7	23.5	20.9	44.9	Clay	1.26	52.89	49.19
	Bw	10-45	11.6	25.5	19.6	43.3	Clay	1.28	52.21	48.59
	BC	45-90	12.1	26.8	18.3	42.8	Clay	1.31	51.06	47.60
		W	11.8	25.9	19.1	43.2	-	1.29	51.71	48.16
Pedon-2	Ap	0-19	12.1	26.7	22.2	39.0	Clay loam	1.28	51.72	48.18
	Bw	19-45	12.2	25.7	20.8	41.3	Clay	1.31	50.98	47.60
	BC$_1$	45-71	11.8	26.0	19.7	42.5	Clay	1.35	50.15	46.85
	BC$_2$	71-120	12.9	28.6	17.6	40.9	Clay	1.38	49.02	45.88
		W	12.4	27.1	19.5	41.0	-	1.34	50.12	46.83

W- Weighted average

and shrubs were characteristic of other land use systems. These observations align with the findings documented by Sashikala *et al.* (2019) and Nalge *et al.* (2020).

Physical properties

The soil texture observed across various land use systems varied from clay to clay loam (Table 2). There was no significant difference in soil texture observed among the different land use systems, which is attributable to the fact that soil texture is an inherent characteristic primarily determined by the weathering of the parent material. These results are consistent with the findings reported by Sharma *et al.* (2022), Dhaliwal *et al.* (2023) and Pandey *et al.* (2023).

The elevated bulk density observed in agriculture (1.41 Mg m^{-3}) and horticulture (1.39 Mg m^{-3}) land use may be attributed to the impact of trampling and intensive cultivation (Table 2). These results align with the findings of Yihenew and Getachew (2013). Conversely, the lowest bulk density among all land use types was found in forest (1.27 Mg m^{-3}), likely due to higher organic matter content that enhances soil aggregation and reduced soil disturbance (Gorems and Goshal, 2020). The elevated bulk density in barren land (1.34 Mg m^{-3}) was ascribed to the absence of organic matter and sparse vegetation cover (Rakshita *et al*., 2025).

The highest soil porosity was observed under forest (57.45%) land use systems, followed sequentially by horticulture (51.71%), agriculture (47.57%) and barren land (40.03%) (Table 2). This trend can be attributed to the elevated levels of soil organic matter present in forest areas, which mitigates soil compaction, facilitates the formation of soil aggregates and consequently enhances air and water permeability by increasing porosity. Comparable results have been reported in previous studies conducted by Chaudhari *et al*. (2013), Tanveera *et al*. (2016) and Singh *et al*. (2024).

The highest MWHC was observed in forest land (53.29%), followed by horticulture (48.16%), agriculture (44.81%) and barren land (37.97%) (Table 2). This pattern can be attributed to the elevated organic matter content and the increased proportion of clay particles, both of which contribute to enhanced water retention. These results corroborate the findings of Harsha *et al.* (2021), Reddy *et al*. (2021) and Karthik and Jain (2022).

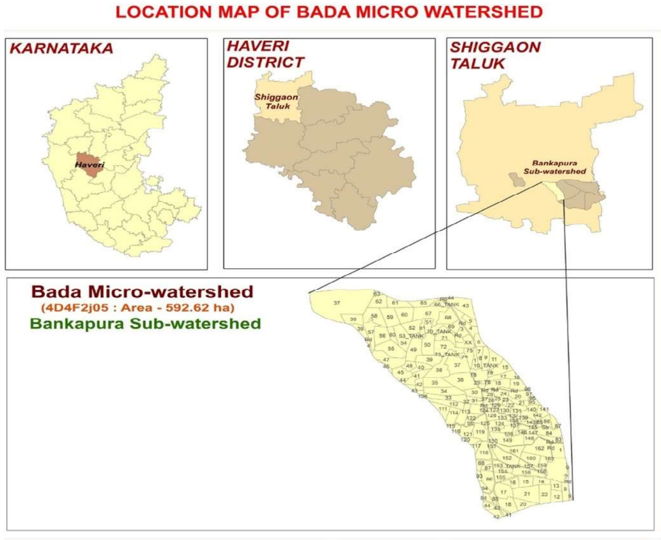

Fig 1. Location map of the Bada micro watershed

Conclusion

The research highlights that forest soils exhibited enhanced morphological and physical characteristics compared to other land use systems, with organic matter as a key factor. As, organic matter improves soil structure, aeration, nutrient cycling and also serves as a foundation for long term soil quality and environmental sustainability.

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