



Soil Characteristics Across Various Landform Sequences in Bilaspur, Chhattisgarh, 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.

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ABSTRACT

The present study explores about soil Morphology and its Variations across Landform Sequences in Bilaspur, Chhattisgarh, India. To maintain soil productivity and prevent land degradation, scientifically managing soil resources is crucial, requiring precise and comprehensive land resource information. *Vertisols* make up the majority of the soils, according to the investigation. On hills, hill slopes and pediments, soils are moderately shallow due to severe erosion, with yellow-red hues (7.5 YR 5/3) indicating excessively-drained to somewhat excessive, sandy clay loam to gravelly clay textures. In the upper undulating, lower plain and alluvial plains, soils are moderately deep to very deep and influenced by sediment deposition with textures ranging from clay loam and clay and greyer hues (10YR 4/2) indicating waterlogging. Soil structure varies from medium, weak sub-angular blocky on hills to stronger blocky structures in lower, altered areas. Diagnostic horizons include a thick Ap horizon up to 25 cm in the pediment, a Bt horizon up to 24 cm in upper undulating and a well-developed Bw horizon in alluvial plains, reflecting stages of pedogenesis. Overall, the study highlights the complex interactions between topography, hydrology and soil properties across the Bilaspur region.

Keywords: Landform sequence; hydrology; agro-ecological environments; soil mapping.

1. INTRODUCTION

Soil is a vital natural resource, meeting the rising demands for food, fiber, fodder and fuel. With limited potential to expand cultivated areas, maintaining soil health is crucial. The growing human and animal populations have intensified the demand for food, but soil productivity is limited by its inherent characteristics, agro-ecological settings and management practices. Thus, efficient land evaluation is essential for sustainable agriculture (Chandrakar et al., 2025). In order to supply the growing demands for food, fiber, fodder, and fuel, soil is an essential natural resource. Keeping the soil healthy is essential because there is little chance of increasing the farmed area. The need for food has increased due to the expanding human and animal populations, yet soil productivity is constrained by its natural properties, agroecological environments, and management techniques. Therefore, sustainable agriculture depends on effective land evaluation. For sustainable soil management under such conditions, it is crucial to have information about soil physicochemical and biological properties for different land uses. Land use influences both the biological and physicochemical properties of a soil. For example, land use governs the addition of soil organic matter (SOM), the composition of carbon (C) compound being added to soil, the development of soil by the action of the plant roots, the variations in soil physicochemical properties, and nutrient availability. Land use not only influences the soil surface but also its sub-surface characteristics, leading to variations in physical and chemical conditions, nutrient availability, soil moisture dynamics, and microbial

population across different depths (Hota et al., 2022; Reza et al., 2022).

According to FAO (1976), land evaluation assesses land performance for specific uses, involving the analysis of landforms, soils, vegetation, climate and other factors. Soil-site suitability studies help identify crops best suited for specific soil units, maximizing productivity and sustainability. Sustainable land use depends on soil resilience, balancing degradation and restoration processes. Environmental factors like water, temperature, sunlight and nutrient availability directly impact crop growth, influencing plant suitability to different habitats. Given threats like land degradation and urban expansion, detailed soil-site information is necessary for effective planning and resource management. Agricultural land availability has steadily decreased, highlighting the urgent need to manage finite land and water resources wisely. Vertisols are common in tropical and subtropical areas since such areas experience extreme dryness and extreme wetness. Vertisols are useful in agriculture and are considered fertile enhancing high produces offering cultivation of two crop varieties in rotation within one agricultural season. Overcultivation with minimal use of management practices are accountable for vertisols fertility depletion and decline in their quality posing a threat to semi-arid and arid crop farming (Nyaombo, 2024).

Chhattisgarh, with its diverse landforms, soil types and social dynamics, is divided into three agro-climatic zones: Chhattisgarh Plains, Bastar Plateau and Northern Hills. While 45.8% of the state is forested, 54% is agricultural land, with

32% of it under double cropping (cropping intensity 138%). Resource-poor farmers in Bilaspur district face severe challenges due to degrading natural resources. The area, marked by lateritic acidic soils and undulating terrain is prone to soil erosion. Despite ample water resources, high rainfall leads to rapid runoff because of uneven topography. Most tribal farmers are economically disadvantaged, farming small, fragmented plots with limited knowledge of modern agricultural practices. Rice is the main crop grown across all landforms, but irrigation is available on only 20% of the cultivated land, resulting in widespread mono-cropping of "rice-fallow" (Ayam et al., 2020).

To maintain soil productivity and prevent land degradation, scientifically managing soil resources is crucial, requiring precise and

comprehensive land resource information. Recently, more focus has been placed on soil characterization, accurate soil mapping and developing scientific criteria for land evaluation and multi-purpose land use. Detailed knowledge of soil resources, including their spatial distribution and limitations, is essential for agricultural land use planning. With this in mind, a landform sequence study was conducted to characterize soils at the watershed scale for sustainable agriculture in Chhattisgarh.

2. MATERIALS AND METHODS

2.1 Study Area

The study area, the Chhoti Narmada Nadi Watershed falls within the Kota and Takhatpur block in Bilaspur District of Chhattisgarh state, is

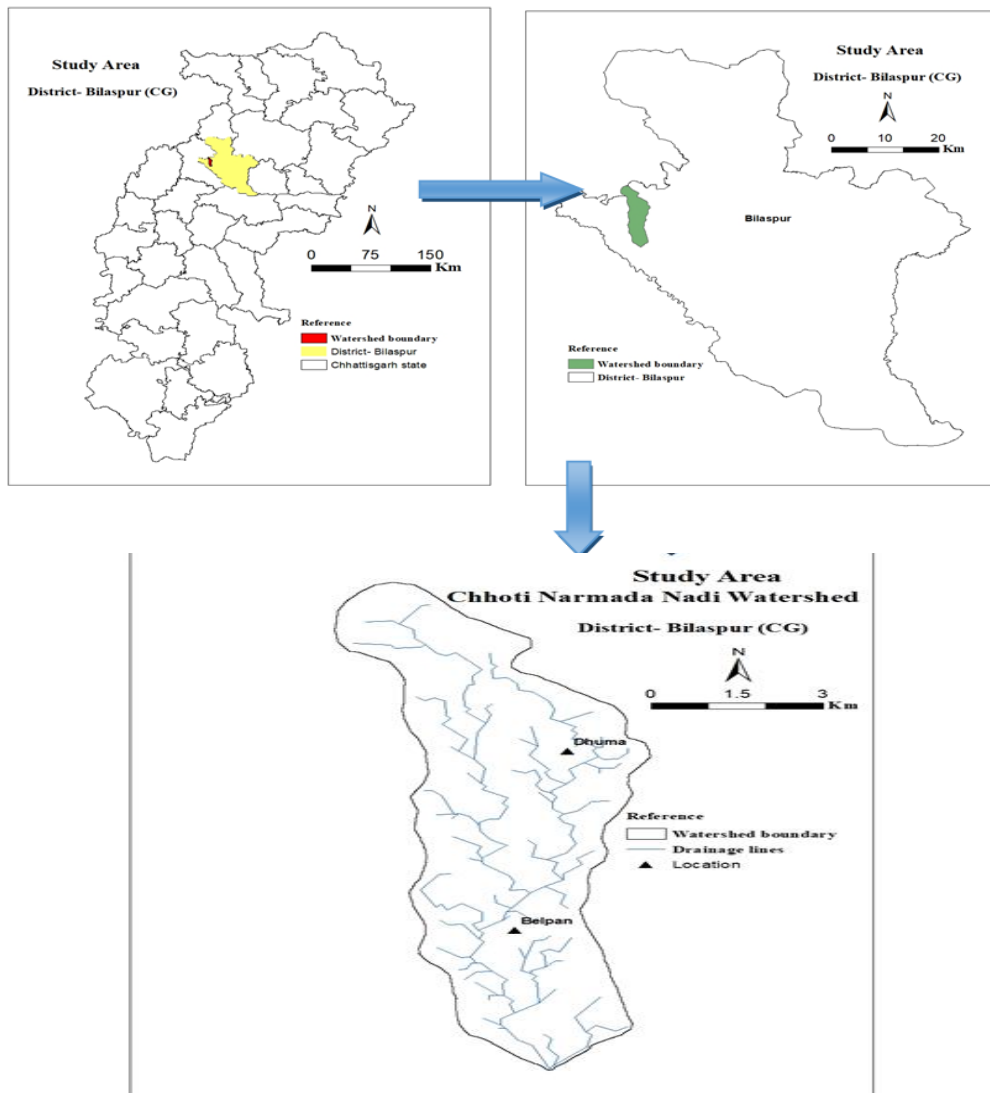


Fig. 1. Location of the study area

situated geographically between 22° 10' 35.73" to 22° 16' 73.21" N latitude and 81° 51' 59.83" to 81° 53' 11.71" E longitude. The altitude ranges from 204 to 536 meters above mean sea level (MSL), covering a total geographical area of approximately 4336.3 hectares. (Fig. 1) which falls under moderate steep slope to very gently sloping, sub-tropical, semi-arid, continental and monsoon transitional ESR with sandy clay loam and clayey soil. (Fig. 1).

2.2 Soil Survey and Soil Site Characterization

Understanding soil variability within the study area, 12 representative soil profiles were carefully examined. Each profile, measuring 1.5 meters in length, 1.0 meter in width and up to 1.5 meters deep (or until reaching the murum layer), was analyzed for various morphological properties, following the USDA Soil Survey Manual (Soil Survey Staff, 1998). Special attention was given to cracking depth, width and the extent of slickensides, which were thoroughly documented. Site and soil characteristics such as slope, stoniness, erosion, color, texture and structure were recorded using standardized formats. Soils were classified according to the Keys to Soil Taxonomy (Soil Survey Staff, 2003).

2.3 Morphological Characterization of Soil Profiles

The soil profiles were examined in the field for morphological characteristics following the IARI Manual (1971) and USDA Soil Survey Manual (Soil Survey Staff, 1998). Key features of each horizon, such as depth, color, texture, gravel volume, structure, consistence, calcareousness, roots and pores were recorded. Additionally, the content of coarse fragments in the soil, expressed as a percentage by volume was also noted.

3. RESULTS AND DISCUSSION

3.1 Morphological Characteristics of Soils

3.1.1 The soil depths

The data provided in Table 1, it is evident that the soil depth varies significantly across different landforms. The soils on the hill, hill slopes and pediment are generally moderately shallow, reflecting the impact of severe erosion due to elevated areas with moderately steep slopes. As

one moves down the slope, soils transition to moderate deep depth in the upper undulating. In the lower plain and alluvial plain, the soils are very deep, indicating a more stable accumulation of materials and less erosion compared to the hill and hill slope areas. In the lower plain and alluvial plain very deep soils were observed influenced by the deposition of sediments from upstream.

3.1.2 Soil colour

The soils across different landforms showed a distinct color pattern influenced by topography and drainage. On the hills, yellow-red hues (7.5 YR 5/3) indicated well-drained conditions. As the landscape transitioned to pediment, upper undulating and alluvial plain, the colors became less red greyer hues (10YR 4/2) and reflected mixed drainage, indicating poorer drainage and reductive environments. In alluvial plain, greyer hues (10YR 4/2, 10YR 3/2) dominated due to waterlogged conditions. This color gradient reflects the relationship between topography, drainage and soil processes.

3.1.3 Soil texture

The data in Table 1 shows a clear pattern in soil texture across different landforms. On the hills & hill slope, the soil is mostly sandy clay loam, indicating coarse textures. As the landscape descends, textures shift to finer materials like loam, sandy loam and clay on pediment and upper undulating. In the lower plain and alluvial plain, textures become finer, clay loam to clay. This progression reflects the typical soil-landform relationship, where coarser soils occur on higher slopes and finer soils in lower, flatter areas.

3.1.4 Coarse fragments

Fine iron-manganese concretions were observed in the soils of the hill & hill slope and pediment landforms, suggesting relatively less influence of hydrological processes in these areas. As we move to the upper undulating and lower plain, the presence of fine-common to fine-medium concretions becomes more prevalent, indicating increased soil moisture or seasonal waterlogging. In the alluvial plain, fine to common concretions were noted, with a range of fine to medium in quantity, reflecting a more consistent presence of water and possibly longer periods of saturation. These observations point to a higher degree of water interaction and

Table 1. Ranged morphological characteristics of soils at various landform units

Landform	Horizon	Thickness (cm)	Matrix colour	Texture	Structure	Coarse frag. %	Consistence	Nodules conture	Roots
							(D-M-W)	(S,Q)	(S,Q)
Hill & Hill slope	A	28	7.5 YR 5/3	scl-loam	m1 sbb	fg-30%	h-vs-vp	f-m	f-m
	Bw1	22	7.5 YR 5/4	scl-loam	m1 sbk	fg-15%	sh-vs-vp	f-f	f-m
	Bc	25	7.5 YR 4/4	scl-loam	m1 sbk	fg-15%	sh-vs-vp	f-f	vf-f
Pediment	AP	24-25 (24.50)	5 YR 5/3	Loam	m1 sbk	60%	L-s-p	f-m	vf-m
	Bw1	23-26 (24.50)	5 YR 5/4	c-loam	m1 sg	80%	sh-s-p	f-c	f-f
	CR	24-24 (24)	2.5 YR 5/6	c	sg	95%	sg	v-c	f-f
Upper Undulating	AP	26 - 28 (27)	5 YR 4/3	s-clay	m1 sbk	fg 30%,	h-vs-vp	c-m	f-m
	Bw1	25 -26 (25.67)	7.5 YR 4/2	c	m1 sbk	30%	h-vs-vp	c-m	f-m
	Bt1	20-26 (23.33)	10 YR 4/3	c	m1 sbk	30%	sh-vs-vp	f-m	f-f
	Bt2	20-22 (21)	10 YR 4/3	c	m1 sbk	30%,	sh-vs-vp	f-m	f-f
	CR	52-55 (53)	5 YR 4/4	c	m1 sg	30%	sh-vs-vp	c-c	—
Lower plain	AP	22-28 (25.25)	10 YR 3/1	s-clay	m3-sab	fg-40%,	vh-vs-vp	c-m	c-m
	Bw1	23-32 (27.25)	10 YR 3/1	c	m2 sbk	40%	vh-vs-vp	f-m	c-m
	Bss1	24-24 (24)	10 YR 3/1	c	m2 sbk	40%	h-vs-vp	f-m	f-m
	Bss2	18-26 (22)	10 YR 2/1	c	m1 sbk	40%	sh-vs-vp	f-m	f-m
	Bc	46-60 (51.50)	10 YR 2/1	c	m1 sbk	40%	sh-vs-vp	f-f	f-f
Alluvial plain	AP	24	10 YR 4/2	c-loam	m2 sbk	f-f 15%	vh-vf-vp	vf-f	f-m
	Bw1	28	10 YR 4/1	c	m2 sbk	f-f 15%	vh-vf-vp	vf-f	f-m
	Bw2	24	10 YR 3/2	c	m2 sbk	f-f 15%	sh-vs-vp	vf-f	f-f
	Bw3	20	10 YR 4/2	c	m1 sbk	f-f	sh-vs-vp	vf-f	f-f
	Bc	54	10 YR 4/3	c	m1 sbk	f-f	sh-vs-vp	vf-f	f-f

alternating reduced and oxidative conditions conducive to the formation of iron-manganese concretions. These findings are consistent with the results reported by Wadodkar and Ravisankar (2011), highlighting the influence of soil moisture and environmental conditions on concretion formation.

3.1.5 Soil structure

The data shows a consistent medium, weak sub-angular blocky structure (m1sbk) in soils across the hills & hill slopes and pediment, indicating stable soil formation. In the pediment, this structure persists, but in the lower plain, a shift to medium, moderate sub-angular blocky (m2sbk) and angular blocky structures (abk) is noted, reflecting increased soil alteration. The alluvial plain maintains a weak sub-angular blocky structure. Overall, topography and hydrology influence soil structure, with stronger blocky structures forming in lower, altered areas.

3.1.6 Diagnostic horizon

The diagnostic horizons across various landforms exhibit notable variations. The anthropic horizon (Ap) ranges from 24 to 27 cm in thickness, with the thickest layers found in the alluvial plain (28 cm) and the thinnest in the hills & hill slope (22 cm). This horizon reflects historical human activity and soil modification. The argillic horizon (Bt) varies substantially, from 23.33 to 25.67 cm in the upper undulating with increased thickness in the lower lower plain and alluvial plain regions, indicating significant clay illuviation. The Cambic horizon (Bw) displays varying thickness, absent in the upper undulating and pediment but well-developed in the lower plain and alluvial plain, with layers ranging from 20 to 27.25 cm. This progression from Bw to Bt horizons highlights the stages of soil development and pedogenesis across different topographies.

4. CONCLUSION

The soil characteristics across various landforms reveal distinct patterns influenced by topography, hydrology and soil-forming processes. Soil depth varies from very shallow on hills and slopes to very deep in alluvial plains, reflecting the impact of erosion and sediment deposition. Soil color transitions from yellow-redder hues on hills indicating good drainage, to yellows and greys in lower plain and alluvial plains, reflecting poorer drainage and waterlogging. Texture patterns

show coarser soils on higher elevations, such as sandy clay loam on hills, shifting to finer textures like clay loam and clay in lower areas. Soil structure remains predominantly medium, weak sub-angular blocky across higher elevations but becomes more pronounced with stronger blocky structures in lower, more altered areas. Diagnostic horizons, including Ap, Bt and Bw vary significantly in thickness, with Ap horizons generally thicker in lower, less eroded areas and Bt horizons thicker in regions with clay illuviation. Overall, these patterns underscore the complex interplay between soil formation processes and landscape features.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Ayam, G. P., Reddy, G., Kumar, N., Singh, S. K., Sahu, K. K., Shrivastava, G. K., Saxena, R. R. and Deshmukh, B. L. 2020. Characterization of soils of Jagdalpur in a topo-sequence. *Int. J. Chem. Stud*, 8(1), pp.1001-1007.
- Chandrakar, K., Ayam, GP., LK Shrivastava, Jitendra Kumar and Dev Narayan. Morphological characterization of soils of Mahasamund in a topo-sequence. *International Journal of Research in Agronomy* 2025; 8(1): 77-80
- FAO, 1976.A framework on Land Evaluation, *FAO Soil Bull. No. 32*, FAO, Rome,; p.64.
- Hota, S., Mishra, V., Mourya, K. K., Giri, K., Kumar, D., Jha, P. K., ... & Ray, S. K. (2022). Land use, landform, and soil management as determinants of soil physicochemical properties and microbial abundance of Lower Brahmaputra Valley, India. *Sustainability*, 14(4), 2241.
- IARI (Indian Agricultural Research Institute) Manual, 1971. *Soil Survey Manual: AISLUS Organization*, IARI Publ., New Delhi; p.121.
- Nyaombo, J. J. (2024). *Vertisols Pedological Characterization: Soil Morphology*,

- Properties, Classification and Fertility Levels. Asian Journal of Soil Science and Plant Nutrition, 10(3), 208–221. <https://doi.org/10.9734/ajsspn/2024/v10i3332>
- Reza, S. K., Ray, P., Alam, N. M., Mukhopadhyay, S., Singh, S. K., & Ray, S. K. (2022). Soil properties-landform relationship in Purvanchal range of Tripura, Northeastern India: An implication of pedogenesis. Journal of the Geological Society of India, 98(3), 402-410.
- Soil Survey Staff. Key to Soil Taxonomy, Ninth Edition. United States Department of Agriculture, Washington, D.C., USA, 2003.
- Soil Survey Staff. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. USDA Handbook 436, US Government Printing Office, Washington, D.C., 1998.
- Wadodkar, Milind R. and Ravisankar, T. 2011. Mapping of Lateritic Soils of Midlands in Kerala Using Resourcesat-1 LISS-III and SRTM DEM Data. J Indian Soc Remote Sens, 39(4): 537–546.

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