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Available sulphur status of Soils under different land use systems in Nandurbar district

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Abstract

The present study was conducted with the objective of characterizing, classifying, and assessing soil fertility under four major land-use categories: Agriculture, Horticulture, Forest, and Pasture lands of Nandurbar district. Two representative sites were selected under each system. Soils were examined for morphological characteristics following standard soil survey procedures, and depth-wise samples (20 cm intervals) were collected up to bedrock. Soils from agriculture, horticulture, and forest lands were identified as Vertisols and classified as Typic Haplusterts, whereas soils under pasture land belonged to Inceptisols and were classified as Vertic Haplustepts. Available sulphur across land use systems ranged from 10.71 to 20.68 mg kg⁻¹, indicating medium to high sulphur availability. Agriculture soils showed values from 12.13 to 20.36 mg kg⁻¹, horticulture soils 11.5 to 20.18 mg kg⁻¹, forest soils 11.66 to 20.68 mg kg⁻¹, and pasture soils 11.05 to 18.95 mg kg⁻¹. The lowest sulphur content (10.71 mg kg⁻¹) appeared at 60–80 cm in agriculture land, while the highest (20.68 mg kg⁻¹) occurred at 0–20 cm depth in forest soils. All systems showed a decline in sulphur content with increasing depth.

Keywords: Land-use systems, soil characterization, soil classification, vertisols, inceptisols, typic haplusterts

Introduction

Soil is one of the most critical natural resources supporting agricultural production systems, and it fundamentally determines the suitability, productivity, and long-term sustainability of land use. The physical and chemical attributes of soil influence crop performance, cropping patterns, and overall agricultural resilience. Hence, systematic understanding of soil resources is indispensable for formulating effective agricultural development strategies. Over the past few decades, the need for appropriate soil and water management has intensified, as maintaining soil health has become essential for achieving sustained high productivity, ensuring food security, and preserving environmental quality (Kasetiya *et al.*, 2022; Tripathi *et al.*, 2006) [5, 10]. India, the seventh-largest nation in terms of geographical area, encompasses 328.8 million hectares, of which approximately 158 million hectares are arable. However, rapid population growth and competing land uses have contributed to a significant decline in per-capita arable land—from 0.34 ha in 1961 to 0.14 ha in 2010—projected to further reduce to 0.09 ha by 2050 (Kasetiya *et al.*, 2022) [5]. Urban expansion, industrial development, infrastructure growth, soil erosion, and secondary salinization continue to threaten the country's cultivable land base (Lal, 2013) [8]. Despite these challenges, scientific land management interventions and improved agronomic practices offer opportunities to restore degraded soils and enhance their productivity potential.

In this context, obtaining precise scientific information on soil characteristics, limitations, potentials, and management requirements is vital for rational and sustainable land resource utilization. Soil characterization, classification, and mapping provide a scientific foundation for developing site-specific management strategies, optimizing land use, and addressing issues of soil degradation (Kumar *et al.*, 2013; Kasetiya *et al.*, 2022) [7, 5]. As the global demand for food continues to rise, understanding soil fertility and physico-chemical properties becomes even more crucial for sustaining agricultural production systems.

Nutrient depletion remains one of the major constraints to soil productivity in many agricultural

regions. The International Food Policy Research Institute (IFPRI, 2010) ^[4] identifies continuous cropping without nutrient replenishment, removal of crop residues, insufficient fertilizer use, and imbalanced nutrient application as key drivers of soil nutrient loss. These factors compromise soil fertility and threaten long-term agricultural sustainability (Wakene, 2001; Mohammed *et al.*, 2005; Kasetiya *et al.*, 2022) ^[1, 5]. Therefore, scientific assessment of soil properties not only aids in evaluating current fertility status but also serves as a foundation for developing sustainable, eco-friendly, and productivity-enhancing land-use models.

Nandurbar district is located in the northwestern part of Maharashtra and comprises six administrative talukas: Shahada, Nandurbar, Navapur, Taloda, Akkalkuwa, and Dhadgaon. Agriculture forms the backbone of the district, with major crops such as cotton, sugarcane, groundnut, sorghum, pigeon pea, chilli, papaya, banana, and various cucurbits commonly cultivated across the region (Kasetiya *et al.*, 2022) ^[5].

The district exhibits considerable variation in soil types. Approximately 40% of the area is covered by light soils, 35% by medium soils, and the remaining 25% by deep black soils. Light soils predominantly occur in the western parts of Akrani and Navapur, as well as in the southern region of Nandurbar taluka. Medium-textured soils are mainly distributed across the eastern portions of Nandurbar, Navapur, and Shahada talukas. In contrast, deep, fertile black soils are characteristic of Akkalkuwa, Taloda, Shahada, and several areas within Nandurbar itself (KVK Nandurbar, Soil & Agro Information), Kasetiya *et al.*, (2022) ^[5].

A number of soil properties—such as pH, electrical conductivity (EC), organic carbon content, cation exchange capacity (CEC), and soil texture—play a pivotal role in determining the availability of macro-, secondary-, and micronutrients. Understanding these properties is essential for assessing nutrient dynamics and planning effective soil fertility management strategies. Comprehensive information on nutrient status and its relationship with key soil characteristics can greatly contribute to developing appropriate nutrient management approaches for sustainable crop production.

Recognizing the agricultural significance of these diverse soil groups, the present investigation has been undertaken. This study aims to analyze the major soil orders, evaluate their characteristics, and generate scientifically grounded recommendations for improving soil health and land-use planning across the district.

Materials and Methods

Collection and processing of soil samples

Depth-wise soil samples were collected at 20 cm intervals up to bedrock from each of the four land-use systems. Two locations per system were selected, making a total of eight sampling sites. GPS was used to record the exact coordinates of sampling points.

The collected samples were air-dried, ground using a wooden pestle, and sieved through a 2 mm mesh. These processed samples were stored in labeled containers for laboratory analysis.

Determination of Available Sulphur

Available sulphur was estimated using the 0.15% $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ extraction method proposed by Chesnin and Yien (1951) ^[3]. The extracted sulphur was then quantified using turbidimetric techniques.

Results and Discussion

Available Sulphur

Sulphur is recognized as the fourth most essential nutrient in Indian agriculture, following nitrogen, phosphorus, and zinc. It plays a central role in the formation of proteins, oils, vitamins, and various flavour-enhancing compounds within plants. Because of its involvement in these biochemical processes, sulphur directly contributes to the nutritional and commercial quality of agricultural produce. When soils are deficient in sulphur, they are unable to supply crops with the quantity needed for optimal growth, ultimately resulting in sulphur-deficient plants and reduced yields.

In the present study, the available sulphur content across different land-use systems in Nandurbar district ranged from 10.71 to 20.68 mg kg^{-1} , placing these soils in the medium to high sulphur availability category (Table 1). Under agricultural land use, available sulphur levels varied between 10.71 and 20.36 mg kg^{-1} . In horticultural soils, the range was 11.50 to 20.18 mg kg^{-1} , while forest soils exhibited slightly higher values, spanning 11.66 to 20.68 mg kg^{-1} . Pasture lands recorded available sulphur levels between 11.05 and 18.95 mg kg^{-1} .

These variations highlight how land use influences sulphur dynamics in soil, and they underscore the need for land-use-specific nutrient management strategies to maintain crop productivity and soil health.

Table 1: Available sulphur status of soil under land use systems

Land use system	Depth (cm)	Available S (mg kg^{-1})
Agriculture 1	0-20	19.77
	20-40	20.30
	40-60	14.19
	60-80	10.71
	80-100	12.13
Agriculture 2	0-20	20.36
	20-40	19.51
	40-60	17.56
	60-80	16.88
	80-100	13.83
Horticulture1	0-20	19.04
	20-40	16.59
	40-60	15.40
	60-80	16.17
	80-100	12.36
Horticulture 2	0-20	20.18
	20-40	18.55
	40-60	18.27
	60-80	17.95
	80-100	11.5
Forest 1	0-20	20.58
	20-40	19.79
	40-60	17.33
	60-80	16.41
	80-100	14.13
Forest 2	0-20	20.68
	20-40	17.63
	40-60	15.36
	60-80	12.19
	80-100	11.66
Pasture 1	0-20	17.41
	20-40	18.51
	40-60	17.03
	60-80	15.22
Pasture 2	0-20	18.95
	20-40	16.98
	40-60	13.67
	60-80	11.05

The minimum available sulphur content (10.71 mg kg^{-1}) was recorded in the 60–80 cm soil layer under agricultural land use, whereas the maximum value (20.68 mg kg^{-1}) occurred in the 0–20 cm layer of forest soils. Across all land-use categories, sulphur availability consistently declined with increasing soil depth.

The higher concentration of sulphur in surface horizons can be attributed to the greater accumulation of organic matter in the upper layers compared to the sub-surface. Since organic matter is a major source of sulphur through mineralization, this pattern is expected. The observed positive association between available sulphur and organic carbon further reinforces this explanation. Similar depth-wise trends in sulphur distribution were reported by Basavaraju *et al.* (2005) ^[1], Kulhanek *et al.* (2016) ^[6], Kasetiya *et al.* (2022) ^[5], and Bier & Singh (2018) ^[2].

Conclusion

The assessment of soils under agriculture, horticulture, forest, and pasture land use systems in Nandurbar district revealed that the available sulphur content falls within the medium to high range in all land categories. This variation is due to change in organic matter levels, practices of land use, and depth of soil.

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