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Assessment of Soil Micronutrient Status and Nutrient Indexing of the PDKV-Adopted Muradpur Model Village in Buldhana District, Maharashtra, 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 investigation assessed the soil micronutrient status and nutrient index values (NIVs) of the PDKV-adopted Muradpur Model Village in Buldhana district, Maharashtra, India. The study area was divided into eight sampling blocks (A, B, C, D, E, F, G and H), and 84 geo-referenced surface soil samples were collected from a depth of 0–20 cm using a GPS-based sampling approach. The samples were analysed for soil

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pH, electrical conductivity (EC), organic carbon (OC), calcium carbonate ($CaCO_3$) and DTPA-extractable micronutrients (Zn, Fe, Cu and Mn) using standard analytical procedures. The soils were neutral to slightly alkaline and free from soluble-salt hazards. Soil organic carbon ranged from 2.00 to 7.10 g kg^{-1}, with a mean of 4.71 g kg^{-1}, indicating low to moderately high status. Calcium carbonate ranged from 1.79 to 6.93%, with a mean of 4.24%, indicating moderately calcareous soils. Available zinc ranged from 0.40 to 2.20 mg kg^{-1}, with a mean of 1.10 mg kg^{-1} and an NIV of 1.75. Available iron ranged from 3.18 to 11.34 mg kg^{-1}, with a mean of 7.07 mg kg^{-1} and an NIV of 1.54. Available copper ranged from 0.64 to 2.75 mg kg^{-1}, with a mean of 1.71 mg kg^{-1} and an NIV of 2.80. Available manganese ranged from 5.96 to 16.47 mg kg^{-1}, with a mean of 9.67 mg kg^{-1} and an NIV of 2.35. Zinc was identified as the most limiting micronutrient, whereas iron, copper and manganese were generally sufficient for crop production. The nutrient-index maps and geo-referenced database provide information for site-specific nutrient management, balanced fertiliser application and sustainable soil-fertility management.

Keywords: Micronutrients; DTPA-extractable nutrients; soil fertility; nutrient index value; GPS-based soil sampling.

1. Introduction

Soil fertility is one of the most important factors influencing crop growth, productivity and agricultural sustainability. Characterisation of soils and evaluation of their fertility status provide essential information for developing appropriate nutrient-management strategies and ensuring sustainable agricultural production. Soil-fertility assessment helps to identify nutrient deficiencies and guides balanced fertiliser application to achieve higher crop yields while maintaining long-term soil health.

The adoption of intensive agricultural practices following the introduction of high-yielding varieties (HYVs) during the Green Revolution in India led to a substantial increase in the use of chemical fertilisers, particularly NPK and micronutrient fertilisers. However, continuous cultivation, monocropping, intensive tillage, imbalanced fertiliser application, limited use of organic manures, inadequate recycling of crop residues, soil erosion and indiscriminate irrigation have accelerated nutrient depletion and soil degradation. Consequently, the efficiency of applied fertilisers has declined, necessitating integrated nutrient-management practices involving organic manures, chemical fertilisers and biofertilisers to sustain soil fertility and crop productivity.

The availability of micronutrients to plants is governed by several soil properties, including soil pH, organic carbon content, calcium carbonate content, texture, moisture regime and land-use pattern. These factors significantly influence nutrient transformations, mobility and plant availability. Therefore, understanding the spatial distribution of soil nutrients is essential for developing site-specific nutrient-management strategies.

Soil is a vital, non-renewable natural resource that supports agricultural production, maintains environmental quality and sustains ecosystem functions. It serves as a reservoir of essential plant nutrients and plays an important role in regulating biogeochemical cycles. However, increasing pressure on limited land resources, coupled with improper management practices, has resulted in widespread soil degradation and poses serious challenges to sustainable agriculture. Enhancing soil productivity through scientific soil-resource assessment and sustainable management practices has therefore become a major priority.

According to Sharma and Dogra (2011), soil functions as both a source and a sink for atmospheric gases, highlighting its critical role in environmental regulation. Excessive exploitation of agricultural soils has progressively depleted available nutrients, making modern agriculture increasingly dependent on synthetic fertilisers. However, the excessive and imbalanced use of chemical fertilisers has led to several adverse effects, including depletion of soil organic carbon, decline in beneficial microbial populations, increased soil acidity or alkalinity and deterioration of soil physical properties (Rakshit, 2019).

Micronutrients such as zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) are indispensable for normal plant growth and development, despite being required in small quantities. Deficiencies of these micronutrients may arise from inherently low concentrations, chemical fixation, biological immobilisation, adverse soil reactions or spatial and temporal variability in soils. Such deficiencies adversely affect crop growth, nutrient-use efficiency and yield. Under these conditions, micronutrient-efficient crop cultivars can produce significantly higher yields than inefficient cultivars, even when fertiliser application is limited (Rengel & Marschner, 2005).

Advances in Global Positioning System (GPS) and Geographic Information System (GIS) technologies have greatly improved the assessment and mapping of spatial variability in soil fertility. GPS-based soil sampling combined with GIS enables accurate characterisation of nutrient distribution at field and village levels, facilitating site-specific nutrient management and precision agriculture (Ramzan & Wani, 2018). Furthermore, the Nutrient Index Value (NIV) approach provides a simple and reliable method for classifying soil-fertility status and identifying nutrient-deficient areas. Nutrient indexing supports efficient fertiliser recommendations, improves nutrient-use efficiency, enhances crop productivity and minimises environmental degradation associated with indiscriminate fertiliser use (Malo *et al.*, 2023).

Recent district-scale work in Assam demonstrated that GPS- and GIS-based soil nutrient mapping can support the identification of spatial nutrient constraints and the formulation of site-specific nutrient-management strategies (Ramachandran *et al.*, 2025).

A recent review likewise emphasised the role of GIS in integrating and visualising spatial soil information for fertility management and precision decision-making (Lanki & Onwu, 2024).

Digital soil-mapping and geospatial approaches have also been applied to delineate micronutrient variability and support targeted management across diverse agricultural landscapes (Dasgupta *et al.*, 2023; Singh *et al.*, 2024; Iyer & Krishnan, 2024).

Muradpur village was selected for this study because it represents an intensively cultivated agricultural area with diverse cropping systems, continuous fertiliser use and limited information on the spatial distribution of soil micronutrients. Although several studies have reported soil-fertility mapping at district and regional scales, detailed village-level assessments integrating GPS- and GIS-based spatial analysis with nutrient indexing remain limited in this region. This lack of high-resolution information restricts the development of site-specific nutrient-management strategies for farmers. Assessment of soil micronutrient status and nutrient indexing is therefore needed to support balanced fertilisation, soil health and sustainable agricultural production in intensively cultivated areas.

Therefore, the objectives of the present study were to assess the spatial variability of available soil micronutrients in the PDKV-adopted Muradpur Model Village using GPS-based soil sampling, GIS mapping and the Nutrient Index Value (NIV) approach; to generate detailed fertility maps; and to identify nutrient-deficient areas. This village-level evaluation was intended to provide location-specific information to support balanced fertilisation, improve nutrient-use efficiency and promote sustainable agricultural production.

2. Materials and Methods

2.1 Study Area and Soil Sampling

The present investigation was carried out in the PDKV-adopted Muradpur Model Village, located in Chikhli Tehsil of Buldhana district, Maharashtra, India, during 2024–2025. Geographically, the village is situated at 20°20′56.75″ N latitude and 76°15′55.04″ E longitude, at an average elevation of approximately 306 m above mean sea level (MSL). The village covers a total geographical area of 529.64 ha, of which 506.70 ha is under cultivation, indicating that agriculture is the principal land use and the primary source of livelihood for the local population. The total population of the village is 956.

The climate of the study area is classified as semi-arid tropical and is characterised by hot summers, a distinct monsoon season and mild winters. The south-west monsoon is the major source of rainfall, and the village receives an average annual rainfall of approximately 700 mm, most of which occurs from June to September. The average temperature ranges from approximately 12–15 °C during winter to 40–45 °C during summer, creating suitable conditions for the cultivation of both Kharif and Rabi crops. Major crops grown in the village include cotton, soybean, pigeon pea, sorghum, wheat, chickpea and other seasonal crops.

The soils of Muradpur village are predominantly deep black soils (Vertisols) developed from the basaltic lava flows of the Deccan Trap. These soils are generally clayey in texture, possess high water-holding capacity and exhibit characteristic shrink–swell behaviour owing to the dominance of smectitic clay minerals. The soils are generally neutral to moderately alkaline in reaction and contain varying amounts of calcium carbonate. Their fertility status varies with cropping intensity, fertiliser use, organic-matter management and topographic position.

To obtain a representative assessment of soil fertility, the entire cultivated area of the village was systematically divided into eight sampling blocks, designated A, B, C, D, E, F, G and H in Table 1. Division into blocks facilitated uniform coverage of the study area and ensured that spatial variability in soil properties was adequately represented. Soil samples were collected from farmers' fields distributed across all blocks using a systematic sampling approach.

A total of 84 geo-referenced surface soil samples were collected from a depth of 0–20 cm, which corresponds to the active root zone of most agricultural crops and is commonly used for soil-fertility evaluation. The exact location of each sampling site was recorded using a Global Positioning System (GPS) receiver. Geo-referencing enabled precise spatial identification of each sample and provided a reliable database for future monitoring and preparation of soil-fertility maps. The spatial distribution of the sampling locations is shown in Fig. 1.

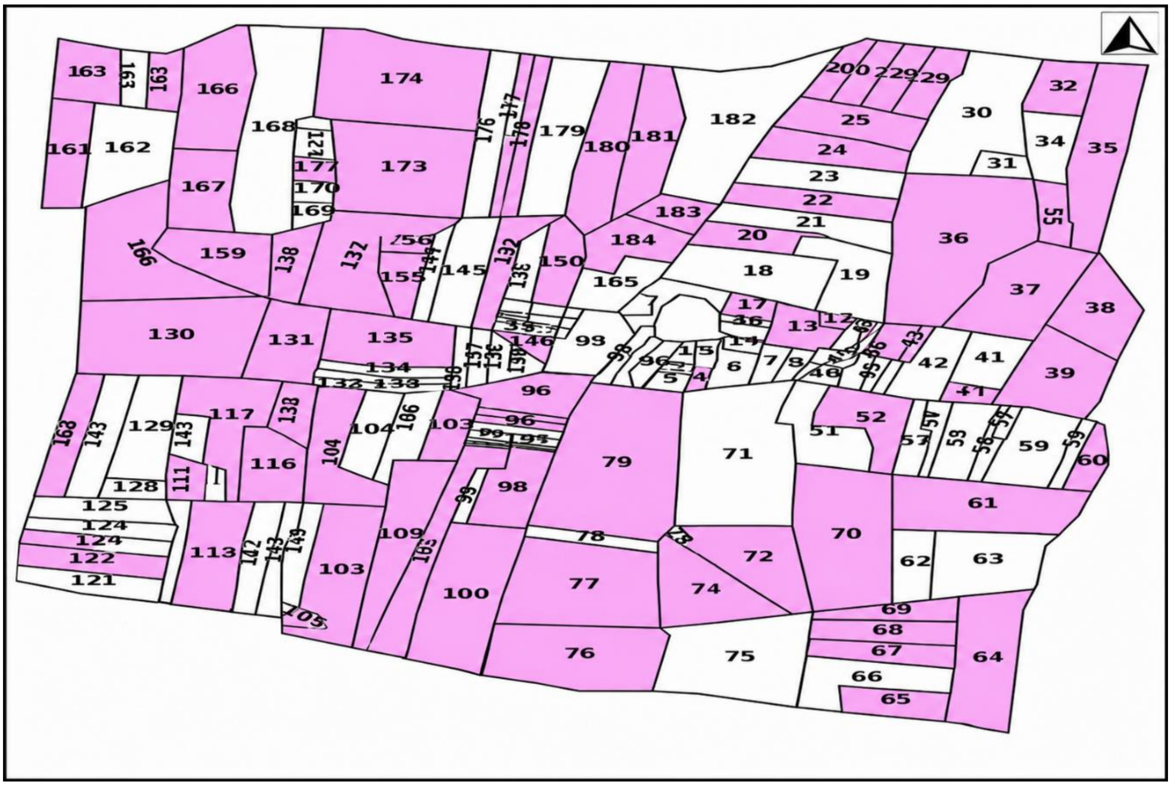


Fig. 1. Map showing survey wise georeferenced soil samples collected from Muradpur village in the Buldhana district

Before each sample was collected, surface litter, crop residues, stones and other foreign materials were carefully removed. Soil from several locations within each selected field was collected using a stainless-steel auger and thoroughly mixed to form a representative composite sample. Approximately 500 g of composite soil was collected from each sampling site, labelled with the sample number, block identification, GPS coordinates and farmer details, and transported to the laboratory for analysis.

In the laboratory, the soil samples were spread on clean trays and air-dried at room temperature in the shade to avoid alteration of their chemical properties. The dried samples were gently crushed with a wooden mortar and pestle to break large clods without affecting the natural soil particles. The processed samples were passed through a 2-mm stainless-steel sieve to remove gravel, roots and coarse fragments. The sieved samples were stored in clean, labelled polyethylene bags for determination of soil physicochemical properties and available micronutrient contents. For estimation of soil organic carbon, a representative portion of each sample was further ground and passed through a 0.5-mm sieve to obtain a uniform fine fraction suitable for analysis.

The geo-referenced soil-sampling approach adopted in this study provides a reliable database for evaluating the spatial distribution of soil-fertility parameters and available micronutrients. Such information is valuable for preparing nutrient-index maps, identifying nutrient-deficient areas and developing site-specific nutrient-management (SSNM) strategies for sustainable crop production in the PDKV-adopted Muradpur Model Village.

Table 1. Block wise soil samples collected from Muradpur village of Buldhana district

Sr. No	Name of block	No of samples
1	A	10
2	B	10
3	C	15
4	D	11
5	E	10
6	F	10
7	G	10
8	H	8
	Total	**84**

Source: Yogesh et al.,2025

Soil pH was measured using a pH meter in a 1:2.5 soil-to-water suspension, following Jackson (1973). Electrical conductivity was measured using a conductivity meter at a 1:2.5 soil-to-water ratio, following Jackson (1973). Soil organic carbon was analysed using the wet-oxidation technique of Walkley and Black (1934), and free $CaCO_3$ was determined by the rapid titration method of Piper (1966). Available zinc, iron, copper and manganese were extracted with 0.005 M diethylenetriaminepentaacetic acid (DTPA), and their concentrations were determined using an atomic absorption spectrophotometer (Lindsay & Norvell, 1978). Soil nutrient indices were calculated using the Index Rating formula of Ramamoorthy and Bajaj (1969).

$$\boldsymbol{NI} = \frac{[\boldsymbol{NVL}\times\mathbf{0.5}+\boldsymbol{NL}\times\mathbf{1}+\boldsymbol{NM}\times\mathbf{1.5}+\boldsymbol{NMH}\times\mathbf{2}+\boldsymbol{NH}\times\mathbf{2.5}+\boldsymbol{NVH}\times\mathbf{3}]}{\boldsymbol{Total\ number\ of\ samples}}$$

Where NVL, NL, NM, NMH, NH and NVH represent the numbers of samples in the very low, low, medium, moderately high, high and very high nutrient classes, respectively.

Table 2. Categorization of available nutrient and Nutrient index value (Six tier system)

	Category					
Parameters	**Very Low**	**Low**	**Medium**	**Moderately high**	**High**	**Very high**
Avail. Zn (mg kg^{-1})	<0.30	0.31-0.60	0.61-0.90	0.91-1.2	1.21-1.80	> 1.80
Avail. Fe (mg kg^{-1})	<2.50	2.50-4.50	4.51-6.50	6.51-8.50	8.51-10.50	>10.50
Avail. Cu (mg kg^{-1})	<0.20	0.20-0.40	0.41-0.60	0.61-0.80	0.81-1.0	>1.0
Avail. Mn (mg kg^{-1})	<1.0	1.10-3.0	3.10-5.0	5.0-7.0	7.10-9.0	>9.0
NIV	**0.5-0.75**	**0.76-1.25**	**1.26-1.75**	**1.76-2.25**	**2.26-2.75**	**2.76-3.00**

The six-tier categories for available micronutrients in Table 2 correspond to acutely deficient, deficient, latently deficient, marginally sufficient, adequate and high classes, following Shukla and Behera (2019) and Dhaliwal *et al.* (2020). Micronutrient-status areas were delineated as very low, low, medium, moderately high, high and very high using the latitude, longitude and analytical data for each sampling site, and thematic maps were prepared using a geographic information system (GIS).

The six-tier classification system (very low, low, medium, moderately high, high and very high) was adopted to provide a more detailed assessment of soil-fertility status than conventional three-category classifications. This approach improves the identification of nutrient variability, supports precise delineation of deficiency and sufficiency zones and facilitates site-specific nutrient-management recommendations.

3. Results and Discussion

3.1 Soil Reaction (pH), Electrical Conductivity (EC), Organic Carbon (OC), and Calcium Carbonate ($CaCO_3$) Status

A total of 84 geo-referenced surface soil samples collected from eight blocks (A–H) of the PDKV-adopted Muradpur Model Village were analysed to assess soil reaction (pH), electrical conductivity (EC), organic carbon (OC) and calcium carbonate ($CaCO_3$) status. The analytical results and their distribution among the blocks are presented in Table 3 and Fig. 2.

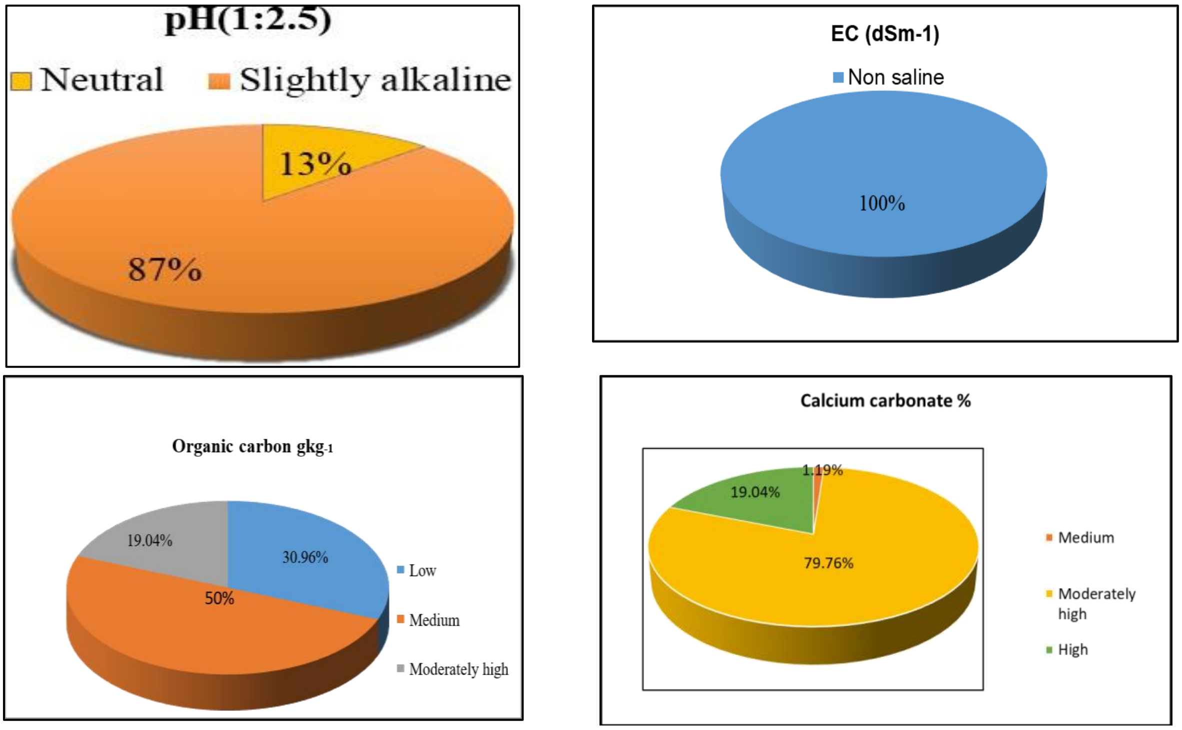


Fig. 2. Percent distribution of pH, EC, OC and Calcium carbonate status in soils of Muradpur village of Buldhana district

Soil pH varied from 7.09 to 8.25, with an overall mean of 7.81, indicating that the soils of Muradpur village were neutral to slightly alkaline in reaction. The observed pH range suggests a favourable soil environment for cultivating the major field crops grown in the region. The slightly alkaline nature of the soils may be attributed to their development from Deccan Trap basaltic parent material, the presence of exchangeable basic cations and moderate calcium carbonate content. Soil pH is one of the most influential chemical properties governing nutrient availability, microbial activity and overall soil fertility. Although the recorded pH values are generally suitable for crop production, slightly alkaline conditions may reduce the availability of certain micronutrients, particularly zinc and iron, thereby increasing the possibility of nutrient deficiencies under intensive cultivation.

The electrical conductivity (EC) of the soil samples ranged from 0.15 to 0.37 dS m^{-1}, with an overall mean of 0.24 dS m^{-1}. The highest mean EC was recorded in Block C (0.27 dS m^{-1}), whereas the lowest mean EC was observed in Blocks D and G (0.22 dS m^{-1}). The EC values of all soil samples were well below the critical limit of 1.0 dS m^{-1}, indicating that the soils were non-saline and free from soluble-salt hazards. The low EC values suggest minimal salt accumulation throughout the study area, thereby providing a favourable environment for seed germination, root growth, nutrient uptake and normal crop development (Jibhakate *et al.*, 2009). The slight variation in EC among blocks may be associated with differences in irrigation practices, fertiliser application, drainage conditions and local topography (Mathurkar, 2020).

Table 3. Status of pH (1:2.5), EC (dSm^{-1}), Organic carbon ($g\ kg^{-1}$) and Calcium carbonate content (%) of various blocks of Muradpur model village

Sr. no.	Block	No. of sample	pH (1:2.5)		EC (dSm^{-1})		OC (gkg^{-1})		Caco3 (%)	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	A	10	7.09-8.12	7.75	0.16-0.36	0.25	3.70-6.60	4.88	1.79-5.14	3.88
2	B	10	7.32-8.24	7.9	0.18-0.30	0.24	2.50-6.60	4.28	3.45-6.31	4.46
3	C	15	7.30-8.16	7.91	0.16-0.37	0.27	2.60-6.40	4.52	2.48-6.79	4.24
4	D	11	7.39-8.25	7.91	0.15-0.31	0.22	3.20-6.43	5.00	2.26-6.93	4.25
5	E	10	7.35-8.15	7.92	0.16-0.31	0.26	2.45-6.30	4.23	2.74-6.67	4.39
6	F	10	7.46-8.07	7.69	0.16-0.32	0.25	2.90-7.10	5.09	2.38-6.09	4.30
7	G	10	7.32-8.12	7.78	0.15-0.32	0.22	2.00-6.75	4.69	2.53-6.58	4.21
8	H	8	7.32-8.09	7.67	0.18-0.30	0.25	3.60-6.85	5.03	2.18-6.74	4.04
	Total	**84**	**7.09-8.25**	**7.81**	**0.15-0.37**	**0.24**	**2.00-7.10**	**4.71**	**1.79-6.93**	**4.24**

Source: Yogesh et al.,2025

The organic carbon (OC) content varied considerably among the sampled soils, ranging from 2.00 to 7.10 g kg⁻¹, with an overall mean of 4.71 g kg⁻¹. Based on the average values, the soils of Muradpur village were classified as low to moderately high in organic carbon. The variation in organic carbon among blocks may be attributed to differences in cropping systems, residue-management practices, application of farmyard manure (FYM), decomposition rates and cultivation intensity. Organic carbon is a key indicator of soil quality because it improves soil structure, enhances water-holding capacity, increases cation-exchange capacity, supports beneficial microbial activity and acts as a reservoir of essential plant nutrients. The moderate organic carbon status observed in the study area indicates that, although the soils possess reasonable fertility, increased application of organic manures, compost and green manures, together with crop-residue incorporation, would further improve soil health and sustain long-term productivity.

The calcium carbonate ($CaCO_3$) content of the soils ranged from 1.79 to 6.93%, with an overall mean of 4.24%, indicating that the soils were moderately calcareous. The presence of calcium carbonate is characteristic of black soils developed from basaltic parent material under semi-arid climatic conditions (Deb *et al.*, 2012). Moderate levels of $CaCO_3$ influence several soil chemical properties, particularly soil reaction and nutrient availability. Higher calcium carbonate content generally increases soil alkalinity and may reduce the solubility and availability of micronutrients such as zinc, iron, manganese and copper through precipitation and adsorption reactions. Consequently, calcareous soils often require careful nutrient management to prevent micronutrient deficiencies and maintain balanced crop nutrition.

Overall, the soils of Muradpur Model Village were characterised by a neutral to slightly alkaline reaction, non-saline conditions, low to moderately high organic carbon status and moderate calcium carbonate content. These physicochemical properties provide a favourable basis for agricultural production; however, the combined effects of slightly alkaline pH and moderate $CaCO_3$ content may influence micronutrient availability. Therefore, regular soil testing, balanced fertilisation, incorporation of organic amendments and adoption of site-specific nutrient-management practices are essential for sustaining soil fertility and improving crop productivity.

3.2 Micronutrient Status and Nutrient Index Values

3.2.1 Available Zinc Status and Nutrient Index Value

The classification and distribution of available zinc (Zn) in the soils of Muradpur Model Village are presented in Table 4 and Fig. 3. DTPA-extractable zinc varied considerably among the soil samples, ranging from 0.40 to 2.20 mg kg⁻¹, with an overall mean of 1.10 mg kg⁻¹. Based on the average concentration, the soils of the study area were classified as having medium to moderately high available-zinc status.

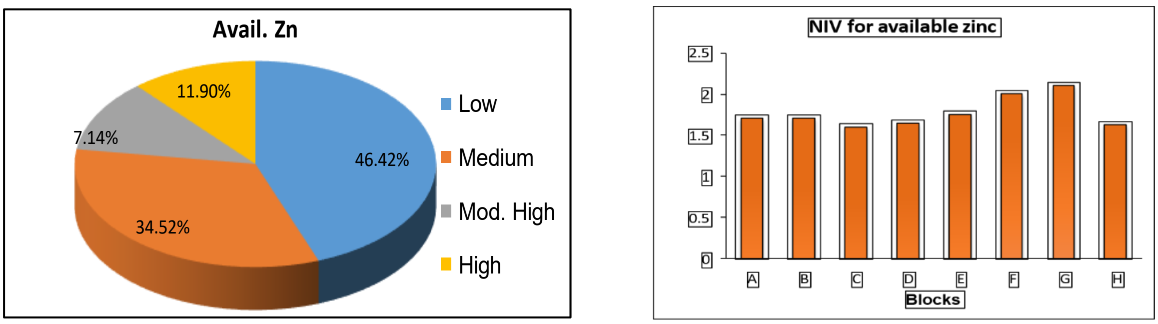


Fig. 3. Percentage distribution and nutrient index for available Zinc of Muradpur village of Buldhana

Among the 84 soil samples analysed, 6 samples (7.14%) were categorised as low in available zinc, 39 samples (46.42%) were in the medium category, 29 samples (34.52%) were classified as moderately high and 10 samples (11.90%) were in the high category. The predominance of samples in the medium category indicates that zinc availability is generally adequate for crop production in most parts of the village. However, the occurrence of low-zinc soils in a few locations suggests the possibility of zinc deficiency, particularly under intensive cropping systems and continuous cultivation without adequate micronutrient replenishment. The availability of micronutrient cations is generally low in alkaline soils, and crops grown on these soils may suffer from hidden hunger (Malewar, 2005).

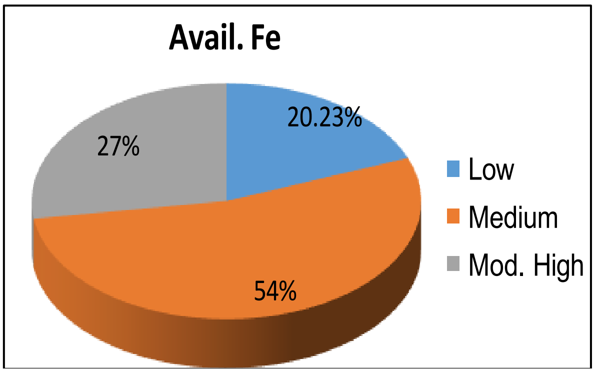
Table 4. Status of Available Zinc (mg kg⁻¹) and its NIV in various blocks of Muradpur village

Sr. no.	Block	No. of sample	Avail. Zn (mg kg⁻¹)		Number of soil samples						
			Range	Mean	VL	L	M	Mod. H	H	VH	NIV
1	A	10	0.77-1.70	1.20	0	0	6 (60)	4 (40)	0	0	1.70
2	B	10	0.71-1.36	1.02	0	0	6 (60))	4 (40)	0	0	1.70
3	C	15	0.40-2.20	0.92	0	3 (20)	8 (53.33)	2 (13.33)	2 (13.33)	0	1.60
4	D	11	0.45-1.96	0.94	0	2 (18.18)	5 (45.50)	3 (27.30)	1 (9.09)	0	1.64
5	E	10	0.54-1.98	1.01	0	0	6 (60)	3 (30)	1 (10)	0	1.75
6	F	10	0.69-2.12	1.36	0	0	2 (20)	6 (60)	2 (20)	0	2.00
7	G	10	0.65-1.96	1.40	0	0	2 (20)	4 (40)	4 (40)	0	2.10
8	H	8	0.58-1.58	1.02	0	1 (12.50)	4 (50)	3 (37.50)	0	0	1.62
	Total	**84**	**0.40-2.20**	**1.10**	**0**	**6 (7.14)**	**39 (46.42)**	**29 (34.52)**	**10 (11.90)**	**0**	**1.75**

The Nutrient Index Value (NIV) for available zinc was 1.75, classifying the soils of Muradpur Model Village in the medium fertility category for zinc. The medium nutrient index indicates that, although most soils contain sufficient zinc for normal crop growth, a considerable proportion of fields may require zinc fertilisation to prevent deficiencies and sustain crop productivity (Magare *et al.*, 2022). The relatively low availability of zinc in certain locations may be attributed to slightly alkaline soil reaction, moderate calcium carbonate content, low to moderate organic carbon status and continuous crop removal of zinc, all of which reduce zinc solubility and availability in soil (Katkar *et al.*, 2019).

3.2.2 Available Iron Status and Nutrient Index Value

The available iron (Fe) status of Muradpur village soils is presented in Table 5 and Fig. 4. DTPA-extractable iron ranged from 3.18 to 11.34 mg kg^{-1}, with a mean of 7.07 mg kg^{-1}, indicating a moderately high iron status. Of the 84 soil samples, 16 (19.04%) were low, 45 (53.57%) were medium and 23 (27.38%) were moderately high in available iron. The Nutrient Index Value (NIV) was 1.54, classifying the soils in the medium fertility category. Similar results were reported by Mahashabde and Patel (2012), who recorded DTPA-extractable iron concentrations of 9.5–14.8 mg kg^{-1} in soils of Shirpur Tehsil, and by Hadole *et al.* (2020).



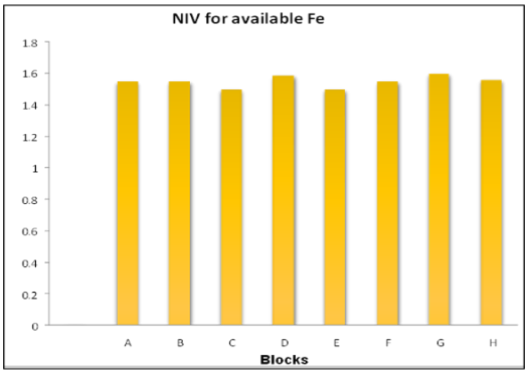
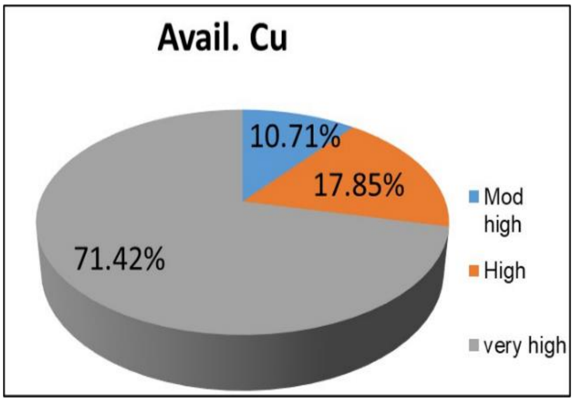


Fig. 4. Percentage distribution and nutrient index for available Iron of Muradpur village of Buldhana

3.2.3 Available Copper Status and Nutrient Index Value

The available copper (Cu) status of Muradpur village soils is presented in Table 6 and Fig. 5. DTPA-extractable copper ranged from 0.64 to 2.75 mg kg^{-1}, with a mean of 1.71 mg kg^{-1}, indicating a very high overall status. Among the 84 soil samples, 9 samples (10.71%) were classified as moderately high, 15 samples (17.85%) as high and 60 samples (71.42%) as very high in available copper. The Nutrient Index Value (NIV) was 2.80, placing the soils in the very high fertility category for copper. Copper is an essential micronutrient involved in several enzymatic and metabolic processes in plants, primarily as a component of proteins (Shorrocks & Alloway, 1988; Hadole *et al.*, 2020; Reddy & Naidu, 2016).



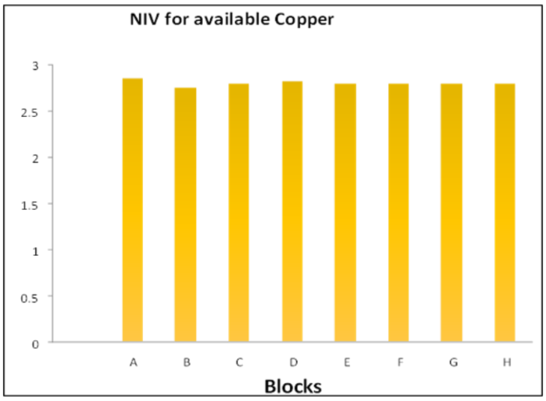


Fig. 5. Percentage distribution and nutrient index for available Copper of Muradpur village of Buldhana

Table 5. Status of Available Iron (mg kg⁻¹) and its NIV in various blocks of Muradpur village

Sr. no.	Block	No. of sample	Avail. Fe (mg kg⁻¹)		Number of soil samples						
			Range	Mean	VL	L	M	Mod. H	H	VH	NIV
1	A	10	3.21-10.63	6.95	0	2 (20)	5 (50)	3 (30)	0	0	1.55
2	B	10	3.47-11.16	7.12	0	3 (30)	4 (40)	3 (30)	0	0	1.55
3	C	15	2.97-10.89	6.86	0	3 (20)	9 (60)	3 (20)	0	0	1.50
4	D	11	3.34-11.11	7.28	0	1 (9.09)	7 (63.64)	3 (27.27)	0	0	1.59
5	E	10	3.69-10.49	6.90	0	3 (30)	4 (40)	3 (30)	0	0	1.50
6	F	10	3.23-11.34	7.07	0	2 (20)	5 (50)	3 (30)	0	0	1.55
7	G	10	3.51-10.70	7.29	0	1 (10)	6 (60)	3 (30)	0	0	1.60
8	H	8	3.18-10.44	7.09	0	1 (12.50)	5 (62.50)	2 (25)	0	0	1.56
	Total	**84**	**3.18-11.34**	**7.07**	**0**	**16 (19.04)**	**45 (53.57)**	**23 (27.38)**	**0**	**0**	**1.54**

Table 6. Status of Available Copper (mg kg⁻¹) and its NIV in various blocks of Muradpur village

Sr. no.	Block	No. of sample	Avail. Cu (mg kg⁻¹)		Number of soil samples						
			Range	Mean	VL	L	M	Mod. H	H	VH	NIV
1	A	10	0.75-2.75	1.77	0	0	0	1 (10)	1 (10)	8 (80)	2.85
2	B	10	0.71-2.68	1.66	0	0	0	2 (20)	1 (10)	7 (60)	2.75
3	C	15	0.68-2.61	1.61	0	0	0	1 (6.66)	4 (26.67)	10 (66.67)	2.80
4	D	11	0.68-2.15	1.67	0	0	0	1 (9.09)	2 (18.18)	8 (72.73)	2.82
5	E	10	0.64-2.31	1.68	0	0	0	1 (10)	2 (20)	7 (70)	2.80
6	F	10	0.69-2.42	1.73	0	0	0	1 (10)	2 (20)	7 (70)	2.80
7	G	10	0.79-2.55	1.70	0	0	0	1 (10)	2 (20)	7 (70)	2.80
8	H	8	0.69-2.72	1.87	0	0	0	1 (12.50)	1 (12.50)	6 (75)	2.81
	Total	**84**	**0.64-2.75**	**1.71**	**0**	**0**	**0**	**9 (10.71)**	**15 (17.85)**	**60 (71.42)**	**2.80**

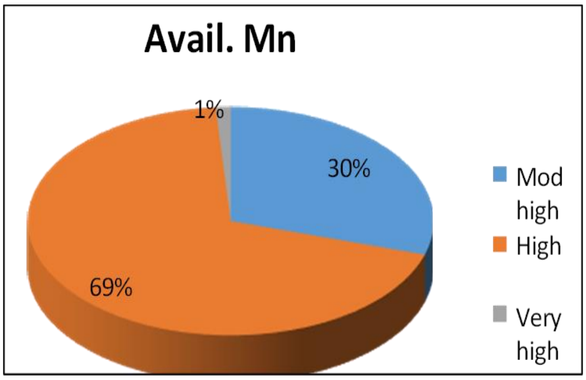
Table 7. Status of Available Manganese (mg kg^{-1}) and its NIV in various blocks of Muradpur village

Sr. no.	Block	No. of sample	Avail. Mn (mg kg^{-1})		Number of soil samples						
			Range	Mean	VL	L	M	Mod. H	H	VH	NIV
1	A	10	6.69-11.94	9.04	0	0	0	3 (30)	7 (70)	0	2.35
2	B	10	6.86-15.63	9.83	0	0	0	1 (10)	9 (90)	0	2.45
3	C	15	5.96-14.64	9.71	0	0	0	5 (33.33)	10 (66.67)	0	2.33
4	D	11	6.05-15.28	9.97	0	0	0	4 (36.40)	7 (63.64)	0	2.32
5	E	10	6.52-15.05	9.11	0	0	0	5 (50)	5 (50)	0	2.25
6	F	10	6.94-15.74	10.25	0	0	0	2 (20)	8 (80)	0	2.40
7	G	10	6.88-16.47	10.41	0	0	0	2 (20)	7 (70)	1 (10)	2.45
8	H	8	6.68-11.22	9.05	0	0	0	3 (37.50)	5 (62.50)	0	2.31
	Total	**84**	**5.96-16.47**	**9.67**	**0**	**0**	**0**	**25 (29.76)**	**58 (69.04)**	**1 (1.19)**	**2.35**

3.2.4 Available Manganese Status and Nutrient Index Value

The classification and distribution of available manganese (Mn) in the soils of Muradpur Model Village are presented in Table 7 and Fig. 6. DTPA-extractable manganese ranged from 5.96 to 16.47 mg kg^{-1}, with an overall mean of 9.67 mg kg^{-1}, indicating high to very high manganese status in the study area.

Among the 84 soil samples analysed, 25 samples (29.76%) were classified as moderately high, 58 samples (69.04%) as high and only 1 sample (1.19%) as very high in available manganese. The Nutrient Index Value (NIV) was 2.35, placing the soils in the high fertility category for manganese. The results suggest that manganese is sufficiently available in most parts of the study area and is unlikely to limit crop production under the existing soil and management conditions. The results agree with Shelke *et al.* (2024), who reported similar available-manganese levels in Nagpur district, Maharashtra, and with the findings of Kashiwar *et al.* (2019) and Mandavgade *et al.* (2015) for the Vertisol-dominated agro-ecological region.



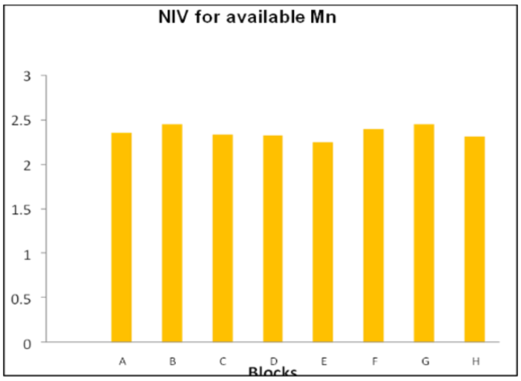


Fig. 6. Percentage distribution and nutrient index for available Manganese of Muradpur village of Buldhana

4. Conclusions

The soils of the PDKV-adopted Muradpur Model Village were predominantly neutral to slightly alkaline, non-saline, low to moderately high in organic carbon and moderately calcareous. These conditions were generally favourable for crop production, although the combined influence of soil reaction and calcium carbonate may affect micronutrient availability. Zinc and iron recorded medium nutrient index values, indicating the need for continued monitoring and carefully balanced nutrient management. Copper was present at very high levels in most samples, whereas manganese showed high availability across the study area. Differences among the eight sampling blocks demonstrated clear spatial variation in soil chemical properties and micronutrient status. The geo-referenced sampling database and nutrient-index maps therefore provide a practical baseline for village-level soil-fertility assessment and site-specific nutrient-management planning. Regular soil testing, judicious fertiliser use and greater incorporation of organic inputs should be prioritised to maintain soil fertility, improve nutrient-use efficiency and support sustainable crop production. Management decisions should account for block-level variation rather than relying on uniform micronutrient recommendations for the entire village.

5. Limitations

The assessment was based on 84 surface soil samples collected from one village during a single study period. Seasonal variation in nutrient availability was not evaluated, and the analysis was limited to selected chemical properties and DTPA-extractable micronutrients. Crop response, yield, soil biological properties, macronutrient status, management history, irrigation practices and crop-wise nutrient removal were outside the study scope. Multi-season sampling and crop-response validation would improve the practical interpretation of the nutrient-index results.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement and reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgement of the author(s). All AI-assisted outputs, including content, references and interpretations, were carefully reviewed, revised, verified and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Dasgupta, S., Debnath, S., Das, A., Biswas, A., Weindorf, D. C., Li, B., Shukla, A. K., Das, S., Saha, S., & Chakraborty, S. (2023). Developing regional soil micronutrient management strategies through ensemble learning-based digital soil mapping. *Geoderma, 433*, Article 116457. https://doi.org/10.1016/j.geoderma.2023.116457

Deb, D. L., Sakal, R., & Datta, S. P. (2012). Micronutrients. In N. N. Goswami, R. K. Rattan, G. Dev, G. Narayanasamy, D. K. Das, S. K. Sanyal, D. K. Pal, D. L. N. Rao, & J. C. Tarafdar (Eds.), *Fundamentals of soil science* (2nd ed., pp. 461–490). Indian Society of Soil Science. https://isss-india.org/other-publications.aspx

Dhaliwal, S. S., Shukla, A. K., Sharma, V., Behera, S. K., Choudhary, O. P., Chaudhary, S. K., Kumar, A., Patra, A. K., Prakash, C., Sikaniya, Y., & Tripathi, A. (2020). *Status of sulphur and micronutrients in soils of Punjab: Blockwise atlas*. Punjab Agricultural University and ICAR–Indian Institute of Soil Science.

Hadole, S. S., Lakhe, S. R., Sarap, P. A., Kadu, P. R., Katkar, R. N., Kharche, V. K., Mathurkar, A. R., Ingole, A. J., & Nandurkar, S. D. (2020). Assessment of the fertility status of different land-use systems in Nagpur District. *PKV Research Journal, 44*(2), 47–52. https://www.pdkv.ac.in/pkv_journal/PKV_Res_J._44_2.pdf

Iyer, R. T., & Krishnan, M. T. (2024). Spatial prediction of soil micronutrients using supervised self-organizing maps. *Journal of Agriculture and Food Research, 15*, Article 101033. https://doi.org/10.1016/j.jafr.2024.101033

Jackson, M. L. (1973). *Soil chemical analysis*. Prentice-Hall of India.

Jibhakate, S. B., Raut, M. M., Bhende, S. N., & Kharche, V. K. (2009). Micronutrient status of soils of Katol Tahasil in Nagpur District and their relationship with some soil properties. *Journal of Soils and Crops, 19*(1), 143–146.

Kashiwar, S. R., Kundu, M. C., & Dongarwar, U. R. (2019). Assessment and mapping of soil nutrient status of Sakoli Tehsil of Bhandara District of Maharashtra using GIS techniques. *Journal of Pharmacognosy and Phytochemistry, 8*(5), 1900–1905. https://www.phytojournal.com/archives/view-pdf/9873/8-4-784

Katkar, R. N., Lakhe, S. R., Hadole, S. S., & Sarap, P. A. (2019). Assessment of spatial variability of major and micronutrients in soils of Akola District of Maharashtra, India. *PKV Research Journal, 43*(1), 69–76. https://pdkv.ac.in/pkv_journal/PKV_Res_J._43_1_.pdf

Lanki, A. D., & Onwu, C. A. (2024). Geographic information system (GIS) application in soil fertility management: A review. *Journal of Global Agriculture and Ecology, 16*(2), 29–40. https://doi.org/10.56557/jogae/2024/v16i28592

Lindsay, W. L., & Norvell, W. A. (1978). Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal, 42*(3), 421–428. https://doi.org/10.2136/sssaj1978.03615995004200030009x

Magare, P. N., Farkade, B. K., & Deshmukh, D. (2022). Assessment of micro- and secondary-nutrient indices in soils of Amravati District under Agro-Ecological Sub-Region 6.3a (K5Dm4), Maharashtra. *The Pharma Innovation Journal, 11*(5), 1068–1074.

Mahashabde, J. P., & Patel, S. (2012). DTPA-extractable micronutrients and fertility status of soil in Shirpur Tahasil region. *International Journal of ChemTech Research, 4*(4), 1681–1685. https://sphinxsai.com/2012/oct-dec/chempdf/CT%3D63%281681-1685%29OD12.pdf

Malewar, G. V. (2005). Micronutrient stresses in soils and crops: Serious sickness and clinical approaches for sustainable agriculture. *Journal of the Indian Society of Soil Science, 53*(4), 484–499. https://www.ijour.net/article/jisss-53-4-007

Malo, S. K., Rahaman, S., & Saha, S. (2023). Assessment of soil fertility status using soil nutrient index (SNI) with special reference to pH, SOC, EC, N, P, K and S of Jabalpur Block in Jabalpur District, M.P., India.

Research Review International Journal of Multidisciplinary, 8(12), 114–126. https://doi.org/10.31305/rrijm.2023.v08.n12.017

Mandavgade, R. R., Waikar, S. L., Dhamak, A. L., & Patil, V. D. (2015). Evaluation of micronutrient status of soils and their relation with some chemical properties of soils of northern tahsils (Jintur, Selu and Pathri) of Parbhani District. *IOSR Journal of Agriculture and Veterinary Science, 8*(2, Version I), 38–41.

Mathurkar, A. R. (2020). *Soil resource appraisal of different land-use systems in Nagpur District* [Master's dissertation, Dr. Panjabrao Deshmukh Krishi Vidyapeeth].

Piper, C. S. (1966). *Soil and plant analysis: A laboratory manual of methods for the examination of soils and the determination of the inorganic constituents of plants*. Hans Publishers.

Rakshit, A., Meena, V. S., Parihar, M., Singh, H. B., & Singh, A. K. (Eds.). (2019). *Biofertilizers for sustainable agriculture and environment*. Springer. https://doi.org/10.1007/978-3-030-18933-4

Ramachandran, S., Bandyopadhyay, S., Reza, S. K., Padua, S., Das, B., Barpatra, D., Jena, R. K., Ray, P., Mourya, K. K., Hota, S., Ray, S. K., & Baruah, U. (2025). Assessment and mapping of soil nutrient status using GPS and GIS techniques for sustainable agriculture in Barpeta District, Assam, India. *Asian Journal of Soil Science and Plant Nutrition, 11*(1), 343–358. https://doi.org/10.9734/ajsspn/2025/v11i1487

Ramamoorthy, B., & Bajaj, J. C. (1969). Available nitrogen, phosphorus and potassium status of Indian soils. *Fertiliser News, 14*(8), 25–36.

Ramzan, S., & Wani, M. A. (2018). Geographic information system and geostatistical techniques to characterize spatial variability of soil micronutrients, including toxic metals, in an agricultural farm. *Communications in Soil Science and Plant Analysis, 49*(4), 463–477. https://doi.org/10.1080/00103624.2018.1431264

Reddy, K. S., & Naidu, M. V. S. (2016). Characterization and classification of soils in a semi-arid region of Chennur Mandal in Kadapa District, Andhra Pradesh. *Journal of the Indian Society of Soil Science, 64*(3), 207–217. https://epubs.icar.org.in/index.php/JISSS/article/view/66409

Rengel, Z., & Marschner, P. (2005). Nutrient availability and management in the rhizosphere: Exploiting genotypic differences. *New Phytologist, 168*(2), 305–312. https://doi.org/10.1111/j.1469-8137.2005.01558.x

Sharma, R. C., & Dogra, S. (2011). Characterization of the soils of the lower Himalayas of Himachal Pradesh, India. *Nature Environment and Pollution Technology, 10*(3), 439–446. https://neptjournal.com/upload-images/NL-35-22-%2822%29-B-1709.pdf

Shelke, S. A., Kadu, P. R., Balpande, S. S., Ghodpage, R. M., Meshram, K. A., Deshmukh, R. B., & Thakre, S. N. (2024). Assessment of soil fertility status of Salaimendha Village of Nagpur, Maharashtra. *International Journal of Advanced Biochemistry Research, 8*(Special Issue 9), 403–405.

Shorrocks, V. M., & Alloway, B. J. (1988). *Copper in plant, animal and human nutrition*. Copper Development Association. https://agris.fao.org/search/en/providers/122438/records/647751b6a3fd11e430393a4b

Shukla, A. K., & Behera, S. K. (2019). All India Coordinated Research Project on micro- and secondary nutrients and pollutant elements in soils and plants: Research achievements and future thrusts. *Indian Journal of Fertilisers, 15*(5), 522–543.

Singh, P. D., Sharma, J., Kumar, P., Srinivasan, S., & Masakapalli, S. K. (2024). Mapping of on-field soil nutrient variabilities as a guiding force for smart farming: A case study from FarmerZone Sentinel-1 from three potato agroecological zones of India. *Environmental Monitoring and Assessment, 196*, Article 785. https://doi.org/10.1007/s10661-024-12945-z

Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science, 37*(1), 29–38. https://doi.org/10.1097/00010694-193401000-00003

Yogesh D Thutte, AB Age, SM Bhoyar, GS Laharia, AS Taru, SD Jadhao, Shubhangi J Dhage and VG Kakde. (2025). Assessment of macronutrients status and nutrient indexing of PDKV adopted Muradpur model village in Buldhana District. *International Journal of Advanced Biochemistry Research; 9(8): 1508-1513*

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