Vidyabharati International Interdisciplinary Research Journal ISSN 2319-4979

Assessment of Soil Quality, Physico-Chemical Characteristics and Nutrient Status of Agricultural Soils in Arambhi, Yavatmal District, Maharashtra, India

Dr. P.R. Bhokare
Department of Chemistry, L.R.B.Arts,Commerce &S.S.R.B.Science College, Arni Dist-Yavatmal. (MH)
Corresponding author: bhokarepraful@gmail.com

Dr. R.R. Wankhade
B.B. Arts, B.N. Commerce& B.P. Science College Digras Dist-Yavatmal. (MH)

Abstract
Soil quality and nutrient availability are important determinants of agricultural productivity and long-term sustainability. The present study was undertaken to evaluate the physico-chemical properties, macronutrient status, secondary nutrient status and micronutrient availability of agricultural soils from Arambhi village, Yavatmal District, Maharashtra, India. Five representative surface soil samples (0–15 cm) were collected from agricultural fields and analyzed for pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P), potassium (K), sulphur (S), and micronutrients including zinc (Zn), boron (B), iron (Fe), manganese (Mn), and copper (Cu). Soils were neutral to moderately alkaline (pH 7.05–8.24, mean 7.74) and non-saline (EC 0.15–0.48 dS m^{-1}, mean 0.28). Organic carbon (0.21–0.54%, mean 0.35%) and available nitrogen (75.26–288.51 kg ha^{-1}, mean 163.07) were low, available phosphorus (4.13–25.62 kg ha^{-1}, mean 13.94) was low-to-medium, and available potassium (264.32–640.64 kg ha^{-1}, mean 396.48) was high. Available sulphur ranged from 9.32 to 18.84 ppm (mean 15.53 ppm). Zinc was the main limiting nutrient (0.19–0.65 ppm, mean 0.34 ppm), whereas boron, iron, manganese, and copper were adequate (means: 0.62, 5.38, 8.57, and 0.76 ppm). Integrated nutrient management featuring organic matter addition, balanced N-P fertilization, and targeted zinc supplementation is recommended.

Keywords: *Soil quality; soil fertility; physico-chemical properties; organic carbon; macronutrients; micronutrients; Arambhi; Yavatmal; Maharashtra.*

1. Introduction

Soil is one of the most important natural resources supporting agricultural production, ecological stability, and food security. The productivity of agricultural soils depends not only on their physical characteristics but also on their chemical properties and the availability of essential plant nutrients[1]. Continuous cultivation, intensive agricultural practices, imbalanced fertilizer application and insufficient addition of organic matter can gradually alter soil fertility and affect crop productivity[2].

The agricultural soils of the Vidarbha region of Maharashtra are predominantly influenced by basaltic parent material and include black soils and associated soil groups. Such soils are generally characterized by relatively high clay content and considerable potassium reserves[1,3]. However, deficiencies of organic carbon, nitrogen, phosphorus and certain micronutrients may occur depending on cropping intensity, management practices and local soil conditions[4,6].

Soil testing provides an effective scientific basis for assessing the fertility status of agricultural soils. Parameters such as soil pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P), potassium (K), sulphur (S), and micronutrients such as zinc (Zn), boron (B), iron (Fe), manganese (Mn), and copper (Cu) provide valuable information regarding nutrient availability and potential soil constraints[5,7,11].

Soil pH strongly influences nutrient solubility and availability, whereas electrical conductivity provides an indication of soluble salt concentration. Organic carbon is an important indicator of soil organic matter and contributes to nutrient cycling, soil structure, microbial activity and water-holding capacity[13]. Nitrogen, phosphorus and potassium are primary macronutrients required for crop growth, while sulphur and micronutrients are essential for several biochemical and physiological processes[8,12].

The present investigation was therefore undertaken to assess the soil quality, physico-chemical characteristics and nutrient status of agricultural soils in Arambhi village of Yavatmal District, Maharashtra. The study also aims to identify major nutrient constraints and provide suitable recommendations for sustainable soil fertility management[9,14].

2. Materials and Methods

2.1 Study Area

The study was conducted in agricultural fields located in Arambhi village, Yavatmal District, Maharashtra, India. The region experiences a tropical semi-arid climatic condition characterized by hot summers, seasonal monsoon rainfall and relatively mild winters. Agriculture is an important economic activity in the region, with crops such as cotton, soybean, pigeon pea and sorghum commonly cultivated.

2.2 Soil Sampling

Five representative agricultural soil samples were collected from different fields in Arambhi village. Surface soil samples were collected from a depth of 0–15 cm. The samples were properly labelled, transported to the laboratory, air-dried under suitable conditions, gently crushed, and passed through a 2.0 mm sieve before chemical analysis[15].

2.3 Analytical Methods

The following physico-chemical and nutrient parameters were determined using standard analytical procedures:

- **Soil pH:** Determined in a 1:2.5 soil-to-water suspension using a calibrated digital pH meter[1].
- **Electrical Conductivity:** Determined in a 1:2.5 soil-water extract using a conductivity meter[1].
- **Organic Carbon:** Estimated by the Walkley–Black method[4].
- **Available Nitrogen:** Determined using the alkaline permanganate method of Subbiah and Asija[3].
- **Available Phosphorus:** Extracted using Olsen's reagent and determined spectrophotometrically[5].
- **Available Potassium:** Extracted with neutral 1 N ammonium acetate and measured using a flame photometer[1,19].
- **Available Sulphur:** Determined by the turbidimetric method using barium chloride.
- **Available Zn, Fe, Mn and Cu:** Extracted using DTPA and determined by Atomic Absorption Spectrophotometry[2,18].
- **Available Boron:** Determined by hot-water extraction followed by colorimetric estimation[10,17].

The analytical results were interpreted using the corresponding soil fertility and critical-limit categories.

3. Results and Discussion

The analytical results obtained from the five agricultural soil samples are presented in Table 1. The minimum, maximum, mean values and fertility-status interpretation of the investigated parameters are summarized in Table 2.

Table 1. Physico-Chemical Properties and Nutrient Status of Agricultural Soils of Arambhi

Sample	pH	EC (dS m⁻¹)	OC (%)	N (kg ha⁻¹)	P (kg ha⁻¹)	K (kg ha⁻¹)	S (ppm)	Zn (ppm)	B (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
S1	7.05	0.48	0.21	112.90	25.62	301.28	17.71	0.43	0.44	6.76	3.81	2.00
S2	7.62	0.15	0.36	288.51	4.13	332.64	9.32	0.19	0.37	4.73	14.92	0.35
S3	8.09	0.17	0.33	137.98	4.68	264.32	17.25	0.65	0.81	5.41	5.73	0.41
S4	7.68	0.40	0.54	75.26	22.32	640.64	18.84	0.21	0.99	5.07	5.84	0.41
S5	8.24	0.22	0.33	200.70	12.95	443.52	14.53	0.21	0.48	4.92	12.55	0.61

Table 2. Statistical Summary and Fertility Interpretation

Parameter	Minimum	Maximum	Mean	Interpretation
pH	7.05	8.24	7.74	Neutral to moderately alkaline
EC (dS m⁻¹)	0.15	0.48	0.28	Non-saline
OC (%)	0.21	0.54	0.35	Low
Available N (kg ha⁻¹)	75.26	288.51	163.07	Predominantly low
Available P (kg ha⁻¹)	4.13	25.62	13.94	Low to medium
Available K (kg ha⁻¹)	264.32	640.64	396.48	High

Available S (ppm)	9.32	18.84	15.53	Medium to sufficient
Zn (ppm)	0.19	0.65	0.34	Predominantly deficient
B (ppm)	0.37	0.99	0.62	Generally sufficient
Fe (ppm)	4.73	6.76	5.38	Sufficient
Mn (ppm)	3.81	14.92	8.57	Sufficient
Cu (ppm)	0.35	2.00	0.76	Sufficient

3.1 Soil pH

The soil pH values ranged from 7.05 to 8.24, with an average value of 7.74. Sample S1 recorded the lowest pH (7.05), whereas S5 showed the highest pH (8.24). The results indicate that the agricultural soils of Arambhi are predominantly neutral to moderately alkaline. The relatively alkaline reaction observed in some samples may influence the availability of several essential nutrients, particularly phosphorus and zinc. Under alkaline soil conditions, phosphorus may become less readily available because of its association with calcium-containing compounds, while zinc availability may also decline. Therefore, soil pH should be considered while planning fertilizer and micronutrient management strategies in the study area.

3.2 Electrical Conductivity

Electrical conductivity varied from 0.15 to 0.48 dS m^{-1}, with a mean value of 0.28 dS m^{-1}. All five soil samples recorded EC values considerably below the critical level generally associated with salinity problems. The low EC values indicate that the soils are non-saline and do not presently exhibit significant soluble-salt-related limitations for crop growth. Thus, salinity does not appear to be a major soil-quality constraint in the investigated agricultural fields.

3.3 Organic Carbon

Organic carbon content varied from 0.21% to 0.54%, with a mean value of 0.35%. Sample S1 recorded the minimum OC concentration, whereas S4 recorded the maximum. Most of the samples showed organic carbon levels below 0.50%, indicating a generally low organic carbon status. Low organic carbon can adversely affect soil fertility because organic matter contributes to nutrient cycling, microbial activity, soil aggregation, moisture retention, and the gradual release of nutrients. The low OC status observed in the study area indicates the need for increased incorporation of organic residues, farmyard manure, compost, vermicompost and green-manure crops.

3.4 Available Nitrogen

Available nitrogen showed considerable variation, ranging from 75.26 to 288.51 kg ha^{-1}, with an average concentration of 163.07 kg ha^{-1}. Sample S4 recorded the lowest nitrogen content (75.26 kg ha^{-1}), whereas S2 recorded the highest value (288.51 kg ha^{-1}). The majority of the samples were categorized as low in available nitrogen.

The low nitrogen status may be associated with the generally low organic carbon content of the soils. Organic matter is an important reservoir of soil nitrogen, and insufficient organic matter input can reduce the availability of mineral nitrogen. Therefore, nitrogen management should form an important component of nutrient management practices in the region.

3.5 Available Phosphorus

Available phosphorus ranged from 4.13 to 25.62 kg ha^{-1}, with a mean value of 13.94 kg ha^{-1}. The lowest phosphorus concentration was recorded in S2 (4.13 kg ha^{-1}), while S1 showed the highest value (25.62 kg ha^{-1}). Samples S2 and S3 exhibited particularly low phosphorus availability, whereas S1 and S4 showed comparatively higher concentrations.

The observed variation may be associated with differences in soil properties and fertilizer history among the sampled fields. The relatively alkaline reaction of several samples may also contribute to reduced phosphorus availability through interactions with calcium. Site-specific phosphorus management based on soil-test results is therefore recommended.

3.6 Available Potassium

Available potassium showed a relatively high status in the studied soils. The concentration ranged from 264.32 to 640.64 kg ha^{-1}, with a mean value of 396.48 kg ha^{-1}. The highest potassium concentration was recorded in S4 (640.64 kg ha^{-1}), whereas S3 recorded the lowest value (264.32 kg ha^{-1}). Overall, the soils demonstrated abundant available potassium.

The relatively high potassium status may be related to the nature of the parent material and the presence of potassium-bearing clay minerals associated with basalt-derived soils. Consequently,

indiscriminate application of potassium fertilizers may not be necessary where soil-test results indicate adequate native potassium availability.

3.7 Available Sulphur

Available sulphur concentrations ranged from 9.32 to 18.84 ppm, with a mean value of 15.53 ppm. Sample S2 recorded the lowest sulphur concentration (9.32 ppm), slightly below the stated critical level of 10 ppm, whereas S4 recorded the highest concentration (18.84 ppm). Thus, sulphur availability was generally adequate, although localized sulphur deficiency may occur in individual fields. Regular soil testing should therefore be used to determine the requirement for sulphur-containing fertilizers.

3.8 Zinc

Zinc was identified as the most important micronutrient constraint in the study area. Concentrations ranged from 0.19 to 0.65 ppm, with an average value of only 0.34 ppm. Four of the five samples recorded values below the stated critical level of 0.60 ppm. The lowest concentration was observed in S2 (0.19 ppm), while S3 showed the highest concentration (0.65 ppm). The widespread zinc deficiency may be associated with the alkaline reaction and low organic carbon content of the soils. Zinc deficiency can negatively affect several physiological processes in crops and may ultimately reduce yield. Therefore, zinc supplementation based on soil-test results should be incorporated into the nutrient-management strategy for the study area.

3.9 Boron

Available boron ranged from 0.37 to 0.99 ppm, with a mean value of 0.62 ppm. The highest concentration was observed in S4, while the lowest was recorded in S2. The mean boron concentration was above the stated critical level of 0.50 ppm, indicating generally sufficient boron availability. However, localized variations were observed, and continuous monitoring may be useful for crops sensitive to boron availability.

3.10 Iron

Available iron ranged between 4.73 and 6.76 ppm, with a mean concentration of 5.38 ppm. All samples recorded concentrations above the stated critical value of 4.50 ppm. The results therefore indicate adequate iron availability in the studied agricultural soils. Iron deficiency does not appear to be a major limitation under the existing soil conditions.

3.11 Manganese

Manganese concentrations ranged from 3.81 to 14.92 ppm, with a mean of 8.57 ppm. All samples exceeded the stated critical level of 2.00 ppm. The results indicate sufficient manganese availability throughout the sampled area. However, the considerable variation among samples suggests spatial differences in manganese availability within the agricultural fields.

3.12 Copper

Available copper varied from 0.35 to 2.00 ppm, with an average value of 0.76 ppm. The lowest concentration was recorded in S2, whereas S1 showed the highest concentration. All samples were above the stated critical level of 0.20 ppm, indicating sufficient copper availability in the investigated soils.

4. Soil Fertility Assessment

The combined evaluation of soil properties and nutrient concentrations indicates that the agricultural soils of Arambhi have both favorable characteristics and specific nutrient constraints. The most favorable characteristic is the low electrical conductivity, demonstrating the absence of significant salinity problems. The soils also possess a relatively high reserve of available potassium and generally adequate levels of B, Fe, Mn, and Cu. However, the study identifies low organic carbon, low available nitrogen, variable phosphorus availability, and widespread zinc deficiency as the major fertility constraints.

The relationship among these properties suggests that improvement of soil organic matter should be a major component of long-term soil fertility management. Increasing organic matter can contribute to improved nutrient cycling and may also enhance the efficiency of applied fertilizers.

5. Agronomic Implications and Soil Management Strategies

To enhance soil fertility and crop productivity in Arambhi, an Integrated Nutrient Management (INM) strategy combining organic manures, biofertilizers, and site-specific chemical inputs is

essential. Low organic carbon levels should be restored through regular applications of farmyard manure, compost, vermicompost, and crop residue incorporation. Nitrogen and phosphorus fertilization must be guided by soil tests, utilizing split N applications and phosphorus-solubilizing biofertilizers to maximize efficiency, whereas potassium inputs can be minimized due to naturally high background levels. Critically, widespread zinc deficiencies require targeted correction through soil-applied zinc sulphate or foliar sprays. Adopting this balanced approach will improve overall nutrient-use efficiency, reduce unnecessary input costs, and ensure long-term soil health and crop sustainability.

6. Conclusion

The present investigation provides an assessment of the physico-chemical characteristics and nutrient status of agricultural soils in Arambhi village, Yavatmal District, Maharashtra. The studied soils were characterized by neutral to moderately alkaline pH, low electrical conductivity, low organic carbon, predominantly low available nitrogen, variable phosphorus and high available potassium.

Among the secondary and micronutrients, sulphur was generally adequate, although localized deficiency was observed. Boron, iron, manganese and copper were generally present at sufficient levels. In contrast, zinc was identified as the most widespread micronutrient deficiency, with four of the five samples falling below the stated critical level.

The findings demonstrate that the principal soil-fertility constraints in the study area are low organic carbon, inadequate available nitrogen, variable phosphorus availability and zinc deficiency. Therefore, sustainable soil management should emphasize organic matter enrichment, balanced application of nitrogen and phosphorus, soil-test-based fertilizer use and targeted zinc supplementation.

The adoption of integrated nutrient management practices can help maintain soil fertility, improve nutrient-use efficiency and support sustainable agricultural production in Arambhi and similar agricultural areas of Yavatmal District.

References

1. Jackson, M. L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.
2. 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.
3. Subbiah, B. V., & Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science*, 25(8), 259–260.
4. 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.
5. Soil Analysis Laboratory Dataset (2026). *Comprehensive Assessment of Soil Quality, Physico-Chemical Properties and Nutrient Status of Agricultural Soils in Arambhi, Yavatmal District, Maharashtra, India*.
6. Ramesh, M., et al. (2021). Assessing multi-micronutrients deficiency in agricultural soils of India. *Sustainability, 13*(16), 9136.
7. Ekapure, A. S., Balapnde, S. S., Dongarwar, U., & Jadhao, R. V. (2022). Assessment of micronutrient content and strategies for improvement of micronutrient status in the soils of Bhandara Tehsil, Maharashtra, India. *International Journal of Plant & Soil Science, 34*(24), 863–868.
8. Kuntoji, A., Subbarayappa, C. T., Sathish, A., Ramamurthy, V., & Mallesha, B. C. (2022). Soil quality of different land use systems in southern transect of Bengaluru, Karnataka. *Journal of the Indian Society of Soil Science*.
9. Harsha, M., Sathish, A., & Ananthakumar, M. A. (2021). Assessment of soil quality indicators of Channegowdarapalya micro-watershed, Tumkur, Karnataka. *Journal of the Indian Society of Soil Science*.
10. Lalitha, M., Kalaiselvi, B., Dharumarajan, S., Anil Kumar, K. S., Ramesh Kumar, S. C., Srinivasan, R., Ramamurthy, V., & Hegde, R. (2024). Determining soil quality indicators for alluvial plains in the semi-arid tropics. *Soil Use and Management, 40*, e12929.
11. Morton, C. M., Pullabhotla, H., Bevis, L., & Lobell, D. B. (2023). Soil micronutrients linked to human health in India. *Scientific Reports, 13*, 13591.

12. Meena, S. N., Sharma, S. K., Singh, P., Ram, A., Meena, B. P., Jain, D., Singh, D., Debnath, S., Yadav, S., Dhakad, U., Verma, P., Meena, J. K., & Nandan, S. (2023). Tillage-based nutrient management practices for sustaining productivity and soil health in the soybean-wheat cropping system in Vertisols of the Indian semi-arid tropics. *Frontiers in Sustainable Food Systems, 7*, 1234344.
13. Kumawat, A., Kumar, D., Shivay, Y. S., Bhatia, A., Rashmi, I., Yadav, D., & Kumar, A. (2023). Long-term impact of biofertilization on soil health and nutritional quality of organic basmati rice in a typic ustchrept soil of India. *Frontiers in Environmental Science, 11*, 1031844.
14. Bamboriya, J. S., Purohit, H. S., Naik, B. S. S., Pramanick, B., Bamboriya, S. D., Doodhawal, K., Sunda, S. L., Medida, S. K., Gaber, A., Alsuhaibani, A. M., & Hossain, A. (2023). Monitoring the effect of integrated nutrient management practices on soil health in maize-based cropping system. *Frontiers in Sustainable Food Systems, 7*, 1242806.
15. Gautam, M., Kumar, S., Kumar, A., Kumar, S., Jayant, H., Sachan, R., & Kumar, M. (2023). Assessment of soil fertility status under the barren land soil of the Central Plain Zone of Uttar Pradesh, India. *International Journal of Environment and Climate Change, 13*(10), 483–490.
16. Renuka, K. P., Kumar, Y., Shahi, S. P., Kumar, S., & Charankumar, G. R. (2024). Assessment of soil fertility status of the soils of KVK-Muzaffarnagar, Uttar Pradesh, India. *International Journal of Plant & Soil Science, 36*(5), 315–322.
17. Sahay, R., Maurya, R. C., Singh, C., Singh, S. K., Mishra, R. K., Srivastava, P., Sharma, N. K., Singh, D., & Yadav, J. K. (2024). Assessment of micronutrient deficiencies in agricultural soils of Hasanganj and Auras Blocks, Unnao District, Uttar Pradesh, India: Implications for sustainable farming. *Journal of Experimental Agriculture International, 46*(12), 793–800.
18. Krishna Murthy, R. K., Nagaraju, B., Govinda, K., Uday Kumar, S. N., Basavaraja, P. K., Saqeebulla, H. M., & Gangamrutha, G. V. (2024). Soil test crop response nutrient prescription equations for improving soil health and yield sustainability—a long-term study under Alfisols of southern India. *Frontiers in Plant Science, 15*, 1439523.
19. Nthebere, K., Tata, R. P., Bhimireddy, P., Chandran, L. P., Gudapati, J., Admala, M., Sinha, N. K., Srikanth, T. B., & Prasad, K. (2025). Impact of conservation agriculture on soil quality and cotton–maize system yield in semi-arid India. *Sustainability, 17*(3), 978.