International Journal of Advanced Biochemistry Research 2025; SP-9(12): 1182-1184

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(12): 1182-1184
www.biochemjournal.com
Received: 02-09-2025
Accepted: 10-10-2025

Niranjana KS
Research Scholar, Department of P.G. Studies & Research in Environmental Science, Kuvempu University, Jnana Sahyadri, Shankaraghatta, Shivamogga, Karnataka, India

Yogendra K
Assistant Professor, Department of P.G. Studies & Research in Environmental Science, Kuvempu University, Jnana Sahyadri, Shankaraghatta, Shivamogga, Karnataka, India

Ashok LB
Associate Professor, KSNUAHS, Shimoga, Karnataka, India

Mahadevan KM
Professor, Department of PG Studies & Research in Chemistry, Director, P.G Centre, Kadur, Kuvempu University, Chikmagaluru, Karnataka, India

Corresponding Author:
Niranjana KS
Research Scholar, Department of P.G. Studies & Research in Environmental Science, Kuvempu University, Jnana Sahyadri, Shankaraghatta, Shivamogga, Karnataka, India

Soil quality assessment through minimum data set under maize land use system hilly zone of Karnataka, India

Niranjana KS, Yogendra K, Ashok LB and Mahadevan KM

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i12So.6681

Abstract
The present study aimed to assess soil quality under a maize land use system in the hilly zone of Karnataka, India, using a minimum data set (MDS) approach and principal component analysis (PCA). The specific objectives were to identify key soil indicators influencing soil quality and to compute a soil quality index (SQI) for major maize-growing districts. Soil samples were collected from maize fields of Shivamogga, Chikkamagaluru, and Kodagu districts at a depth of 0-15 cm. A total of 24 physical, chemical, and biological soil attributes were analyzed following standard procedures. Principal component analysis was applied to reduce data redundancy and select key indicators for MDS development. Seven principal components with eigenvalues greater than one explained 85.95% of the total variance. The selected MDS indicators included soil organic carbon (SOC), maximum water-holding capacity (MWHC), available potassium, exchangeable magnesium, sand content, available boron, and earthworm population density. The computed SQI values ranged from 0.36 ± 0.06 in Shivamogga to 0.44 ± 0.03 in Kodagu, indicating overall low soil quality under continuous maize cultivation. Among the indicators, SOC contributed the highest proportion to SQI, highlighting its critical role in maintaining soil health. The low SQI values suggest degradation of soil quality due to intensive maize-based cropping systems. The study concludes that adopting appropriate soil management practices such as organic amendments, balanced fertilization, liming, and erosion control is essential to improve soil quality and sustain maize productivity in the hilly regions of Karnataka.

Keywords: Soil quality index, minimum data set, principal component analysis

Introduction
Soil quality, defined as the capacity of soil to function effectively for crop production, nutrient cycling, and environmental sustainability, is influenced by physical, chemical, and biological properties. Intensive cropping systems, particularly maize, exert significant pressure on soil resources due to high nutrient uptake, leading to depletion of essential macro-and micronutrients. Assessing soil quality using a minimum data set (MDS) of indicators allows for practical and efficient monitoring of soil health (Brejda *et al.*, 2000; Singh *et al.*, 2013) [3, 7]. Principal component analysis (PCA) is a widely used multivariate technique to reduce dimensionality and identify key soil indicators influencing overall soil quality (Karlen and Stott, 1994) [6]. This study aims to evaluate the soil quality index (SQI) under maize cultivation in hilly regions of Karnataka using PCA and to identify key indicators for soil management interventions.

Materials and Methods
Study Area and Soil Sampling
The study was conducted in the hilly districts of Shivamogga, Chikkamagaluru, and Kodagu, Karnataka. Soil samples were collected from maize fields at 0-15 cm depth and analyzed for physical (sand, silt, clay, bulk density, maximum water-holding capacity, porosity), chemical (pH, EC, SOC, CEC, available N, P, K, exchangeable Ca and Mg, S, Fe, Mn, Cu, Zn, B), and biological (soil microbial biomass carbon, dehydrogenase enzyme activity, earthworm population density) properties following standard methods (Anderson and Ingram, 1993; Jackson, 1973) [2].

Principal Component Analysis (PCA) and Soil Quality Index (SQI)

A total of 24 soil attributes were subjected to PCA to reduce redundancy and identify uncorrelated components explaining most of the variance. Seven principal components (PCs) with eigenvalues >1 were selected, collectively explaining 85.95% of total variance. Soil attributes with the highest factor loadings from each PC were chosen for MDS: SOC (PC-1), MWHC (PC-2), available K (PC-3), exchangeable Mg (PC-4), sand (PC-5), available B (PC-6), and EWPD (PC-7). SQI was calculated using linear scoring:

y = x−st−s(‘more is better’ for all attributes except sand)y = \frac{x-s}{t-s} \quad (\text{‘more is better’ for all attributes except sand})y = t−sx−s(‘more is better’ for all attributes except sand)

Where *y* is the score of the soil property, *x* is its measured value, *s* is the lowest value, and *t* is the highest value. Scores were multiplied by PCA-derived weighting factors for each PC to obtain SQI.

Results and Discussion

Soil Physical, Chemical, and Biological Properties

The soils of Shivamogga, Chikkamagaluru, and Kodagu were sandy loam to sandy clay loam with low bulk density, medium acidity, low salinity, high SOC, medium available N and K, low available P, and adequate micronutrients. Significant differences in soil properties were observed among districts.

Principal Component Analysis

PCA identified seven PCs with eigenvalues >1, collectively explaining 85.95% of total variance. SOC was the most important indicator, followed by clay, exchangeable calcium, available K, boron, dehydrogenase activity, and EWPD. The scree plot depicted the relationship between eigenvalues and PCs, confirming the selection of MDS for SQI computation.

Soil Quality Index (SQI)

The SQI ranged from 0.36 ± 0.06 (Shivamogga) to 0.44 ± 0.03 (Kodagu), classified as low (<0.50). The contributions of individual indicators to SQI were: SOC 39.98%, clay 12.63%, exchangeable Ca 12.34%, available K 12.19%, B 7.65%, dehydrogenase activity 6.51%, and EWPD 6.51%. Shivamogga and Chikkamagaluru had comparable SQI values, while Kodagu showed slightly higher soil quality due to differences in selected soil attributes.

SOC emerged as the most critical indicator of soil quality, consistent with previous studies (Brejda *et al.*, 2000; Singh *et al.*, 2013) [3, 7]. MWHC reflects soil water retention capacity, critical in hilly terrains for maintaining crop productivity. Nutrient indicators (K, Mg, B) were influenced by intensive maize cultivation and selective fertilizer use. EWPD and dehydrogenase activity represent biological health of soil, which contributes to nutrient cycling and organic matter decomposition. Low SQI values indicate that maize cultivation without proper soil management depletes soil quality in hilly regions. Improvements in organic matter, nutrient supplementation, liming, and erosion control are essential to enhance SQI.

Table 1: The results of principal component analysis and communalities to evaluate the soil quality index under maize land use system

Soil attributes	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7	Communalities
pH	0.413	0.044	0.539	-0.31	0.208	0.232	0.498	0.903
EC	-0.182	0.032	-0.325	-0.721	-0.013	-0.050	-0.022	0.663
SOC	0.970	-0.061	-0.047	0.12	0.004	-0.105	0.054	0.976
CEC	0.010	0.663	-0.049	-0.469	0.096	-0.472	0.170	0.924
N	-0.164	-0.28	-0.264	-0.525	-0.282	-0.375	-0.498	0.919
P_2O_5	0.125	0.211	0.777	-0.087	0.173	0.472	0.084	0.931
K_2O	0.314	-0.123	0.026	0.159	0.058	0.257	0.828	0.895
Ca	0.012	-0.049	0.845	0.165	-0.09	-0.115	-0.105	0.777
Mg	-0.027	0.076	0.758	-0.001	-0.045	-0.396	0.250	0.802
S	0.727	-0.067	0.222	-0.065	0.445	0.153	0.123	0.824
Fe	0.301	-0.089	-0.016	0.041	0.145	0.806	0.007	0.818
Mn	0.461	-0.073	0.001	0.275	0.701	0.133	-0.069	0.807
Cu	0.404	-0.123	-0.006	0.672	0.457	0.077	0.185	0.878
Zn	-0.174	-0.019	-0.327	0.818	0.015	0.025	-0.015	0.809
B	0.144	0.168	0.068	0.058	0.844	0.161	-0.317	0.895

Soil attributes	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7	Communalities
Sand	-0.142	-0.403	-0.492	-0.259	-0.498	-0.400	-0.264	0.969
Silt	0.042	0.529	0.341	0.201	0.655	0.114	-0.164	0.906
Clay	0.083	0.932	0.053	-0.06	0.022	0.053	0.126	0.902
BD	-0.031	-0.694	0.327	0.398	0.261	0.264	0.058	0.889
MWHC	-0.161	0.796	0.124	0.236	-0.132	0.312	0.108	0.856
Porosity	-0.091	0.434	-0.052	-0.042	0.079	-0.094	0.813	0.878
EWPD	-0.069	0.211	-0.557	0.118	-0.378	-0.058	0.302	0.612
SMBC	0.965	0.133	0.080	0.044	-0.072	0.079	0.072	0.974
DHEA	-0.244	0.16	-0.108	0.110	-0.130	0.835	0.214	0.872
Eigen values	6.29	3.75	2.87	2.54	1.91	1.70	1.57	
Variance (%)	26.20	15.64	11.94	10.60	7.96	7.08	6.54	
Cum. Variance (%)	26.2	41.84	53.77	64.37	72.33	79.40	85.95	

(PC-Principal component, EC-Electrical conductivity, SOC-Soil organic carbon, CEC-Cation exchange capacity, N-Available nitrogen, P_2O_5-Available phosphorus, K_2O-Available potassium, Ca-Exchangeable calcium, Mg-Exchangeable magnesium, S-Available sulphur, Fe-DTPA extractable iron, Mn-DTPA extractable manganese, Cu-DTPA extractable copper, Zn-DTPA extractable zinc. B-Available boron, BD-bulk density, MWHC-Maximum water holding capacity, EWPD-Earthworm population density, SMBC-Soil microbial biomass carbon, DHEA-Dehydrogenase enzyme activity)

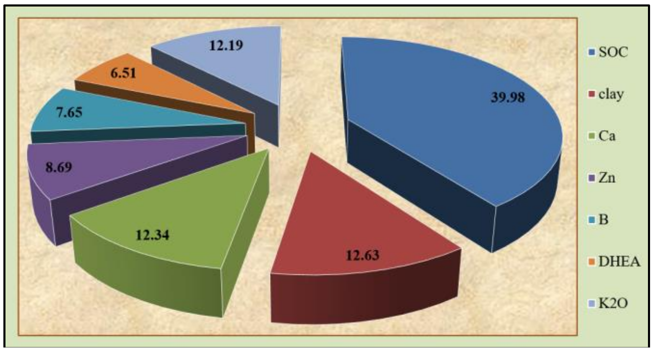

Fig 1: Per cent contribution of MDS indicators towards SQI under maize land use system

Conclusion

Seven soil indicators—SOC, MWHC, K, Mg, sand, B, and EWPD—reliably explain soil quality under maize cultivation in hilly Karnataka. The SQI of Shivamogga and Chikkamagaluru districts was low, highlighting the need for better soil management practices. Strategic interventions, including organic amendments, nutrient balancing, and erosion control, are recommended to improve soil health and maize productivity in the region.

References

1. Andrews SS, Karlen DL, Mitchell JP. A comparison of soil quality indexing methods for vegetable production systems in northern California. Agric Ecosyst Environ. 2002;90(1):25-45.
2. Anderson JM, Ingram JSI. Tropical soil biology and fertility: A handbook of methods. 2nd ed. Wallingford (UK): CAB International; 1993.
3. Brejda JJ, Moorman TB, Karlen DL, Smith JL, Dao TH. Identification of regional soil quality factors and indicators. Soil Sci Soc Am J. 2000;64(6):2115-2124.
4. Cho KM, Zoebisch MA, Ranamukhaarachchi SL. Land use dependent soil quality in northeast Thailand. In: Proceedings of the 13th International Soil Conservation Organization Conference; 2004; Brisbane, Australia. p. 1-6.
5. Jackson ML. Soil chemical analysis. New Delhi (India): Prentice Hall of India; 1973. p. 1-498.
6. Karlen DL, Stott DE. A framework for evaluating physical and chemical indicators of soil quality. In: Doran JW, Coleman DC, Bezdicek DF, Stewart BA, editors. Defining soil quality for a sustainable environment. Soil Science Society of America Special Publication No. 35. Madison (WI): SSSA; 1994. p. 53-72.
7. Singh AK, Bordoloi LJ, Kumar MH, Parmar B. Land use impact on soil quality in eastern Himalayan region of India. Environ Monit Assess. 2013;185(4):314-325.
8. Xu M, Zhao Y, Liu G, Argent RM. Soil quality indices and their application in the hilly loess plateau region of China. Aust J Soil Res. 2006;44(3):245-254.