Int.J.Curr.Microbiol.App.Sci (2026) *15*(1): 190-193

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 15 Number 1 (2026)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2026.1501.023

Soil Chemical Characteristics and Nutrient Status of Gadag District, Karnataka: Implications for Sustainable Soil Management

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Keywords

Soil fertility, organic carbon, nitrogen deficiency, phosphorus availability, potassium status.

Article Info

Received: 05 November 2025
Accepted: 18 December 2025
Available Online: 10 January 2026

A B S T R A C T

Gadag district (Northern Dry Zone of Karnataka) features predominantly red and red–brown soils developed on metamorphic and volcanic parent materials. Recent local surveys and micro-watershed studies show soils with neutral to slightly alkaline pH, low organic carbon and available nitrogen, medium phosphorus, and generally adequate to high potassium and sulfur — a pattern typical of semi-arid, rainfed regions where crop removal and low organic additions have depleted N and C reserves. This article summarises key findings from field studies and state surveys and draws practical implications for nutrient management and soil health in Gadag.

Introduction

Gadag district, located in the northern dry zone of Karnataka, is characterized by red and red–brown soils formed under semi-arid climatic conditions. The region's agriculture is predominantly rainfed, making soil fertility a key factor influencing crop productivity. Understanding the chemical properties of these soils—such as pH, organic carbon, and nutrient content—is essential for managing soil health and ensuring sustainable agricultural practices. This study presents an overview of the soil chemical characteristics and nutrient status of Gadag district, highlighting major fertility constraints and suggesting measures for effective soil management.

Materials and Methods

Study area and methods (overview)

Gadag lies in northern Karnataka's semi-arid belt. Soil studies in the district use a mix of pedon descriptions, grid sampling for soil fertility mapping, physico-chemical laboratory analysis (pH, electrical conductivity, organic carbon, available N–P–K, CEC), and mineralogical examinations (sand/clay fractions, XRD for clay minerals). Micro-watershed studies (e.g., Bailmadapura, Kanaginahala and other sub-watersheds) provide detailed, locally representative data at pedon and grid scales.

Main chemical characteristics

pH and salinity

pH in Gadag soils is generally neutral to slightly alkaline in many places (reflecting the calcareous influence and semi-arid climate), though local micro-variations exist depending on parent material and management. Electrical conductivity (EC) is typically low (non-saline) across most sampled areas.

Organic carbon and nitrogen

Organic carbon (OC) is commonly reported as low to medium, and available nitrogen (N) is low across many surveys. This is a critical limitation for crop productivity since low OC reduces nutrient-holding capacity, soil structure, and microbial activity.

Micro-watershed analyses explicitly found low OC and low available N in large parts of sampled areas.

Phosphorus, Potassium and Sulfur

Available phosphorus (P) tends to be low to medium, while potassium (K) is often medium to high, reflecting parent material rich in K-bearing minerals and lesser P fixation in some textured soils.

Sulfur (S) levels have been reported as high in specific watershed studies, though S status can vary with cropping and fertilizer history.

Cation exchange capacity (CEC) and clay mineralogy

Soils in Gadag show a range of CEC values according to clay content and mineralogy.

Mineralogical studies in Kanaginahala and nearby sub-watersheds indicate the presence of typical clay minerals and a dominance of sandy–loam to clay-loam textures in many pedons; where clay content is higher, CEC and nutrient retention improve.

Patterns & causes — why these chemical traits occur

Semi-arid climate + rainfed cropping: Low biomass return and frequent mono/cereal cropping reduce organic matter replenishment, leading to low OC and N.

Parent material: Local geology (metamorphic rocks, gneisses, basalts in places) supplies K but not always plant-available P; clay mineralogy affects P fixation and CEC.

Intensive nutrient removal without balanced replenishment: Farmers applying biased fertilizer regimes (e.g., emphasizing NPK blends without organic amendments or micronutrients) create specific nutrient imbalances. These drivers appear across micro-watershed surveys.

Table.1 Soil fertility status for cluster villages

Parameter	Range	Name of the cluster villages			
		Chikkasavanur	Shirol	Singatara yanakeri	Kalakeri
pH	6.5-7.5	6.71 – 8.96	6.63 – 8.85	6.8 – 8.5	8.1 – 9.6
EC (dsm^{-1})	1	0.15 – 0.38	0.16 – 0.41	0.15 – 0.36	0.22 – 1.28
OC (%)	0.5 – 0.75	0.16 – 0.34	0.41 – 0.58	0.14 – 0.39	0.15 – 0.58
Available N (Kg. /Ac.)	112 - 224	25 - 65	20 - 70	15 - 65	45 – 132
Available P_2O_5 (Kg. /Ac.)	9.0 – 12.0	0.50 – 2.50	0.5 - 2.5	0.5 - 2.5	1.0 – 6.5
Available K_2O (Kg. /Ac.)	50 - 120	30 – 84	31 - 89	24 - 75	59 - 125
Available S (Kg. /Ac.)	10 – 20	1.0 – 7.0	1.0 – 9.0	1.0 – 6.0	2.0 – 12.0
Available Zinc (ppm)	6	0.11 – 0.36	0.12 – 0.54	0.13 – 0.84	0.11 – 0.38
Available Iron (ppm)	4.5	0.13 – 0.98	0.31 – 1.46	0.21 – 1.33	0.26 – 0.41
Available Mn (ppm)	2	0.23 – 0.86	0.21 – 1.03	0.19 – 1.26	0.15 – 1.13
Available Cu (ppm)	0.2	0.05 – 0.17	0.05 – 0.16	0.03 – 0.12	0.04 – 0.15
Available Bo (ppm)	0.5	0.16 – 0.28	0.15 – 0.31	0.09 – 0.23	0.05 – 0.28

Implications for crop management and soil health

Address organic carbon and N deficiency: Prioritise organic matter inputs (farmyard manure, compost, crop residues, green manures) and legume rotations to rebuild OC and biological N. Low OC is the single most limiting soil chemical factor in many sampled areas.

Site-specific fertilizer application: Use soil test–based application — add P where soils test low, and avoid unnecessary K where tests already show adequate levels. Consider sulfur application in pockets where crop response is observed despite reported regional adequacy.

Improve P availability: Where P is held by fixation, combine P fertilisers with measures that increase OC and microbial activity (biofertilisers, organic amendments) and use placement methods (banding) for efficiency.

Erosion and moisture management: Conservation practices (contour bunds, mulching, cover crops) help retain residue and protect OC and nutrients from loss — important in the district's sloping and degraded areas.

Research gaps and recommendations for future work

Fine-scale mapping of micronutrients (Zn, B, Fe, Mn) across Gadag taluks — many surveys focus on macro-nutrients.

Longitudinal monitoring after interventions (organic amendments, crop diversification) to quantify recovery rates of OC and soil N.

Integration of remote sensing + soil testing for scalable, farmer-friendly fertilizer recommendations (already trialled in parts of northern Karnataka).

In conclusion, soil chemistry in Gadag district reflects the realities of semi-arid, predominantly rainfed agriculture: soils often have adequate K but low organic carbon and nitrogen, with P commonly limited. Addressing these issues requires coordinated soil testing, balanced fertilizer use, and investment in organic matter — combined with extension services to help farmers adopt site-specific nutrient management and soil health practices.

Continued local research (micro-watershed and pedon-level studies) has been and remains critical to design realistic, low-cost interventions for the district.

Author Contributions

Manjanath Patgar: Investigation, formal analysis, writing—original draft.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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How to cite this article:

Manjanath Patgar. 2026. Soil Chemical Characteristics and Nutrient Status of Gadag District, Karnataka: Implications for Sustainable Soil Management. *Int.J.Curr.Microbiol.App.Sci.* 15(1): 190-193.
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