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Hydrogeochemical Assessment of Stream Waters in Parts of Yadadri Bhuvanagiri and Rangareddy Districts, Telangana: Insights into Multipurpose Utilization and Sustainable Management

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Abstract

This study presents a detailed hydrogeochemical assessment of stream waters parts of Yadadri Bhuvanagiri and Rangareddy districts, Telangana, emphasizing the interplay of geological and anthropogenic factors shaping water quality. Nine higher-order stream samples reveal slightly alkaline pH (7.5–8.0) and variable total dissolved solids (395.85–2008.5 mg/L), reflecting rock water interaction alongside contamination from agricultural runoff and industrial effluents. Piper diagram analyses classify waters predominantly as Ca-Cl type (Type V), with sample C3 showing Ca-Mg-Cl characteristics (Type III), underscoring influences of ion exchange and pollution. Gibbs diagrams confirm rock–water interaction and evaporative enrichment as key processes governing solute chemistry. Irrigation suitability indices (SAR: 1.05–23.50; %Na: 9.55–61.58) indicate mostly low to moderate sodium hazards, although high-SAR samples warrant careful management. Industrial water quality assessment identifies challenges from elevated TDS, hardness, and chloride levels, suggesting pretreatment needs to mitigate scaling and corrosion risks. Elevated chloride, sulfate, and nitrate levels highlight anthropogenic impacts, signaling potential public health concerns. This comprehensive evaluation advocates for integrated water resource management incorporating continuous monitoring, targeted remediation, and land-use regulation to ensure sustainable multipurpose utilization and safeguard environmental and human health in this region.

Keywords: Hydrogeochemistry, Stream Water Quality, Sustainable Water Management, Multipurpose Water Use, Rock–Water Interaction

Introduction

Assessing surface water quality is essential for the sustainable management of water resources, as it directly influences their suitability for domestic, agricultural, and industrial applications (Trigun and Sahoo, 2022 and 2024; Choudhary *et al.*, 2025; Ravi *et al.,* 2026). In the present study, stream water samples from the Yadadri Bhuvanagiri and Rangareddy Districts of Telangana were systematically collected from the higher order streams flowing on the diverse geology of the area. The study area encompasses significant lithological units primarily Neoarchean to Paleoproterozoic granitoids of the Peninsular Gneissic Complex, Neoproterozoic sedimentary rocks, and associated Archean supracrustals which impart distinct mineralogical signatures to stream water chemistry through weathering and dissolution processes (Trigun and Sahoo, 2022; 2024).

Prominent rock types such as hornblende-biotite granite gneiss, banded magnetite quartzite, amphibolite, pegmatite, limestone, and sandstone influence the hydrochemical framework. These inputs are further modulated by agricultural runoff, urbanization, industrial activities, and expanding infrastructure, resulting in variable concentrations of major solutes and deterioration of water quality in many semi-arid and urban environments (Hem, 1985; Rao *et al.,* 2012; Aslam and Reshma, 2024; Arun *et al.*, 2024; Sahoo *et al.,* 2024, 2025; Sane *et al.,* 2025). Major ions such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, HCO_3^{-}, and SO_4^{2-} serve as critical indicators in regional water quality assessment and facies classification (Todd and Mays, 2004). Evaluating the relationships among these ions, rather than isolated measurements, provides a robust framework for interpreting prevailing water chemistry (Wilcox, 1955; Ayers and Westcot, 1985). Similar hydro-geochemical and groundwater quality investigations have been carried out in different parts of India including Odisha, Chhattisgarh, Karnataka, Maharashtra, and Kerala using hydrochemical indices, GIS techniques, and statistical approaches (Panigrahi and Das, 2022; Chatterjee *et al*., 2022; Jaunjalkar and Murkute, 2023; Nayak and Hota, 2024)

Supporting parameters such as pH (7.5–8.0), electrical conductivity (EC: 615–3090 µS/cm), total dissolved solids (TDS: 395–2008 mg/l), and total hardness (TH: 280–950 mg/l) as measured across nine stream water samples reflect both geogenic and anthropogenic controls. The assessment benchmarks

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