

## Hydrogeochemical Characterization and Evolution of Groundwater in Hemgir Block, Sundargarh District, Odisha, India

Rasmita Prusty<sup>1</sup>, Duryadhan Behera\*<sup>1</sup>, Sudhir Kumar Dash<sup>2</sup>, Krishna Manjari Jena<sup>1</sup> and Subhasmita Das<sup>1</sup>

<sup>1</sup>Department of Earth Sciences, Sambalpur University, Jyoti Vihar, Burla-768019, Odisha, India

<sup>2</sup>Department of Geology, Government College, Sundargarh-770002, Odisha, India

(Corresponding Author, E-mail: dbehera@suniv.ac.in; ORCID: <https://orcid.org/0000-0002-7964-812X>)

### Abstract

A comprehensive geochemical assessment of groundwater and its suitability for drinking and agricultural applications was conducted in and around the Hemgir block of Sundargarh district, Odisha. A total of 85 groundwater samples were systematically collected during the pre-monsoon season (May 2024) and analyzed for key physico-chemical parameters, including pH, electrical conductivity, total dissolved solids, calcium, magnesium, sodium, potassium, bicarbonate, sulphate, and chloride. The analytical results revealed that the predominant ionic concentrations generally follow the order:  $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^+ > \text{K}^+$  among cations, and  $\text{HCO}_3^- > \text{Cl}^- > \text{NO}_3^- > \text{SO}_4^{2-}$  among anions. The suitability of groundwater for both drinking and irrigation was evaluated using various water quality standards and established classification systems. Hydrochemical facies identified through Piper's Trilinear diagram and Stiff's plot indicated that most groundwater samples belong to the  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$  facies, followed by  $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-Cl}^- \text{-HCO}_3^-$  facies. Calcium and magnesium emerged as the dominant cations, while bicarbonate and chloride were the major anions in the study area. The elevated presence of  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ , and  $\text{HCO}_3^-$  suggests that the groundwater chemistry is primarily influenced by alkaline earth elements and weak acids. Gibbs plot confirmed that sediment/rock-water interaction is the major process governing groundwater composition. Overall, the groundwater quality was found to be suitable for both drinking and agricultural purposes, with calcite dissolution being the primary geochemical process, followed by silicate mineral weathering.

**Keywords:** Groundwater Quality, Geochemical Characterization, Hydrochemical Facies, Rock-Water Interaction, Calcite Dissolution, Silicate Weathering

### Introduction

Ground water is the most important fresh water sources, which help in providing drinking water, agriculture and industries universally (Baksh *et al.*, 2024). Groundwater is the main source of drinking water in most places, especially in developing countries. But natural processes and human activities are putting both the quality and long-term health of groundwater at risk (Gao *et al.*, 2020; Patra *et al.*, 2021). To manage water properly we need to know what chemicals are in groundwater and how they change over time (Zhang *et al.*, 2025). The hydrogeochemical characterization is the study of physical and chemical properties of groundwater to see how it can be used and to find out what geochemical processes are happening that affect the chemistry of water (Promilton *et al.*, 2025). They include things like rock water interaction, mineral dissolution and precipitation, ion exchange, evaporation, and human activities like farming runoff, industrial discharge, and urbanization (Wen *et al.*, 2025; Divya *et al.*, 2026; Jena *et al.*, 2025). Integrating hydrochemical data with geological and hydrological

contexts can yield insights into the origin and transformation of groundwater (Islam, 2023; Chatterjee *et al.*, 2022). The chemistry of groundwater is a dynamic process which depends on lithology, residence time, recharge conditions, and climatic variations. During the process of flowing through different geological structures, the chemistry of the groundwater changes considerably resulting in different hydrochemical facies (Jodhani *et al.*, 2025; Tiwari *et al.*, 2026; Jena *et al.*, 2026), these changes are often understood by using instruments such as piper diagrams, Gibbs plots and geochemical modeling in order to understand processes which control the quality of groundwater. In recent years, growing concerns regarding groundwater pollution, such as salinization, heavy metal, and nitrate enrichment have resulted in a need to carry out more hydrogeochemical studies in detail (Onwe *et al.*, 2023; Chatterjee *et al.*, 2023). These studies are essential in determining the source of contamination and the health hazards, and in coming up with sustainable management of ground water. Thus, this study is dedicated to hydrogeochemical characterization and evolution of groundwater to estimate its quality, the ruling geochemical processes, and offer a scientific background of sustainable use and management of groundwater resources. The current study targets on the hydrogeochemical characterization and evolution of groundwater. To determine the quality of groundwater, identify the