Comprehensive Assessment of Heavy Metal Contamination and Health Risks in Groundwater of Vadodara and Bharuch, Gujarat

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Abstract

Groundwater contamination by heavy metals poses significant environmental and public health risks. This study assesses groundwater contamination in the Vadodara and Bharuch Districts of Gujarat, India, focusing on seasonal variations in heavy metal concentrations and associated health risks. Groundwater samples from 57 sites were collected during the Pre-Monsoon, Monsoon, and Post-Monsoon seasons over the 2020-2021 cycle. Heavy metals, including Cd, Ag, Cu, As, Hg, Pb, Ba, Mn, Fe, Cr, Ni, and Zn, were analyzed. Water quality indices such as the Metal Index (MI), Heavy Metal Pollution Index (HPI), and Degree of Contamination (Cd) were calculated to evaluate contamination levels. Additionally, the Hazard Quotient (HQ), Hazard Index (HI), and carcinogenic risk (CR) were assessed for health risks through ingestion and dermal pathways. Results revealed significant seasonal variations, with notable increases in heavy metal concentrations during the Monsoon and sustained high levels in the Post-Monsoon season. Key findings include elevated MI and HPI values, particularly in Koyli and Jambusar, indicating severe contamination. The Cd values reflected substantial contamination during the Monsoon, with Dabhasa and Ratanpur showing high values. The HQ and HI assessments indicated a substantial risk to public health due to Cu and Pb ingestion during and after the Monsoon. Carcinogenic risk assessments highlighted increased risks for As, Cd, Cr, Ni, and Pb, with cumulative risks exceeding permissible thresholds in several locations. This research underscores the need for continuous monitoring and effective management strategies to mitigate heavy metal pollution, ensuring the safety and sustainability of groundwater resources.

Keywords

Heavy metals, Seasonal variations, Health risk assessment, Water quality indices, Carcinogenic risk, Environmental monitoring.