Characterization and Modelling of Chromium Contaminated Aquifer for Remediation: A Case Study of Rania-Khan Chandpur Site, India

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Multiple chromite ore processing residue (COPR) dump hotspots are situated in the Rania and Khan Chandpur villages, Kanpur Dehat district of Uttar Pradesh in India. The ensuing chromium (Cr) contamination of the soil-water system necessitates urgent attention to fulfill regulatory obligations aimed at safeguarding the deteriorating ecosystem services and human health. The objective of the research is to characterize the contaminated site using hydro-geophysical and geochemical investigations for providing effective remediation strategies. The surface elevation data was prepared by leveraging high-resolution LiDAR and IfSAR data gathered through remote sensing surveys. Subsequently, undisturbed cores of both COPR and soil were analyzed to determine their hydraulic and contaminant transport properties. These analyses provided crucial insights into the behavior of water and contaminants within the soil-water system. Furthermore, extensive field investigations were conducted followed by electrical resistivity tomography (ERT) to map the spatial and vertical contamination extent, essential for assessing the extent of Cr contamination and its impact. In Khan Chandpur, chromate leachate stratification persists, propelled by underlying advective flow, resulting in extreme Cr concentrations (>10mg/L) in 95% of monitoring wells. Conversely, Rania exhibits multiple active chromate plumes driven by diffusive fluxes, yielding high Cr concentrations (>5 mg/L and <10 mg/L) in 35-40% of monitoring wells. ERT-generated 3D maps clearly depict the contaminated subsurface spreading radially within Rania and Khan Chandpur villages which is indicated by a resistivity of < 5 Ohm.m. The coupled groundwater flow and contaminant transport modeling predicted that preferential flows paths and its impacted area. Further, based on this study results a remediation (ex., phytoremediation) is going to be designed for subsequent clean up of the aquifer. This will enable to protect drinking water sources from any further contamination and to provide safe drinking water.