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Spatial variations of hydrogeochemistry and its controlling factors in the Satluj River Basin, Himalayas, India

AKHTAR JAHAN[1], MOHD USMAN KHAN[2], NACHIKETA RAI[1], ABHAYANAND SINGH MAURYA[1], MR. TANVEER DAR[1] AND SUDHIR KUMAR[3]

[1]Indian Institute of Technology

[2]Earth sciences, IIT Roorkee

[3]National Institute of Hydrology

Presenting Author: jahanakhtar94@gmail.com

With comprehensive and systematic analysis, this study focuses on the chemical composition (major and trace elements), spatial variations of water quality and controlling factors in the Satluj river. The value of the average total dissolved solids (TDS) is 143 mg/l, ranging from 107 to 350 mg/L which is slightly greater than the global average of 120 mg/L. The results indicated that waters in the Satluj river are mildly alkaline with high concentrations of Ca^{2+} and HCO_3^-. The pattern of cationic and anionic dominance based on mean value (mg/L) in the river are in the following sequence $Ca^{2+} > Mg^{2+} > Na^+ > K^+$ and $HCO_3^- > SO_4^{2-} > Cl^- > NO_3^-$ respectively. And out of the total cationic budget of the river, Ca^{2+} alone contributes 70.10%, Mg^{2+} account for 15.95% and Ca^{2+} together with Mg^{2+} account for 86.05%. The dominant anion of the river is HCO_3^- which accounts for 54.99% followed by SO_4^{2-}, Cl^- and NO_3^- with 39.26%, 3.12%, and 2.61 % respectively. The Piper diagram shows the main water type to be a Calcium bicarbonate (Ca-HCO3 type), and mixed type Ca-Mg -Cl type. From the Gibbs boomerang model, we conclude that the hydrochemistry of the river water is characterized by relatively moderate TDS and $Na^+ / (Na^+ + Ca^{2+})$ and $Cl^- / (Cl^- + HCO_3^-)$ ratios, evidencing the dominancy of rock weathering as a major controlling factor. The Na-normalized ratio end-member diagram indicates that the weathering of silicates and carbonates is relatively significant, with a trend toward carbonate dissolution apex, suggesting that carbonate weathering plays a crucial role in the major ion chemistry of the river as compared to silicates. The dissolved trace elements including Mn, Cr, Fe, Co, Ni, Cu, Zn, As, Cd, and Pb exhibited wide variations, which were indicative of diverse geological and environmental characteristics. The drinking and irrigation suitability from ionic compositions revealed that the water quality of Satluj river was naturally good. The current study provides a baseline for further research work dealing with the fluvial system in the Himalayas.