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Stable Isotope and hydrogeochemical characteristics of groundwater in the Upper Jhelum Basin, NW Himalayas: Implications for recharge processes

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The Intermontane basin aquifers worldwide, particularly in the Himalayan region, are recharged to a large extent by the adjoining mountains. A comprehensive understanding of the recharge mechanism in intermontane basins is key to groundwater conceptualization and management. We addressed the intermontane aquifer basin hydrology by hydrogeochemical and stable isotope analysis of water samples from 39 deep wells, 59 shallow wells, and springs in the Upper Jhelum Basin, Kashmir, India. The hydrogeochemical facies of the groundwater is mostly of HCO_3-Ca-Mg type. Ca^{2+} and HCO_3^- were identified as the dominant cation and anion, respectively. Several ionic ratios and geochemical modelling using PHREEQC indicated that the most important hydrogeochemical processes to affect groundwater quality were weathering and dissolution of carbonates and silicate minerals, mixing, and ion exchange. The Hierarchical Cluster Analysis groups the samples according to the distance from the mountain-fronts and supports a positive correlation between increasing groundwater mineralization (41-1210µS/cm), and residence time. Analysis and interpretation based on new stable isotope measurements in this work show that that deep groundwater and karst spring recharge through mountain block recharge (MBR) from adjacent mountains with local meteoric water origin, with insignificant evaporation. We have derived the Local meteoric water line (LMWL), and have used water isotopes to demonstrate the elevation of recharge elevation (2300m to 3500m) zones and defined the role of rain, snowmelt and glacial melt in the replenishment of aquifer systems. We propose an original conceptual model applicable to the study basin with implications for other intermontane basins globally to better understand groundwater recharge and flow systems. Based on isotopic signatures and hydro-geochemistry, several discharge patterns in the aquifer system (a) local flow for karst springs at mountain fronts, (b) intermediate flow for shallow groundwater, and (c) regional flow for deep groundwater have also been identified.