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Investigating Dominant Geochemical Processes in Groundwater using Stable Isotope and Major Ion Chemistry in the Sundarbans

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The Sundarbans occupying a major part of the Ganga-Brahmaputra-Meghna Delta hosts densely populated areas affected by frequent hydrological calamities, enhanced by anthropogenic, environmental and climatic stresses. The groundwater signature of the area is significantly controlled by physicochemical modifications from surface water, groundwater and aquifer matrix interactions governed by complex hydrogeochemical and biogeochemical processes. Previously studies have been conducted explicitly at the delta front to understand the processes concerning saline water incursion within the coastal aquifers. However, this study characterizes the entire delta hydrogeology through a thorough examination of the major and minor elements, together with a stable isotopic study of groundwater from multi-depth inland and coastal aquifers which acutely discerns the varying groundwater geochemical signatures of the region and reveals the underlying hydrogeochemical mechanisms. Lithologs are used to visualise the comprehensive hydrostratigraphy of the region, which reveals groundwater-bearing sandy aquifers intervened by clayey aquitards that increase in number towards the west and in thickness towards the south nearing the Bay of Bengal. Characterization of the aquifer-aquitard framework aids in identifying the spatially variable groundwater layers that are categorically divided into 3 depths – Shallow (<150m), Intermediate (150-250m) and Deep (>250m). Shallow aquifers are distinguished from deeper aquifers by distinct geochemical and stable isotope signatures where deeper groundwater is enriched in Na^{+}, δD and $\delta^{18}O$ values. Further graphical and statistical analyses disclose domination of cation exchange processes within deeper aquifer systems where groundwater has a higher residence time. The shallow and intermediate aquifers are mostly characterized by silicate weathering and controlled by meteoric recharge. A spatially variable signature is also identified, where groundwater shows a variation in its physicochemical signature from northeast to southwest. The numerous tidally influenced river channels, subsurficially connected to the delta aquifer system further control the groundwater signature of the region at places. In the delta front, the coastal aquifers are distinguished by the mixing of infiltrated seawater with indigenous fresh groundwater, yielding mixed brackish water signatures. This study aids in the overall characterization of the aquifers of the Sundarbans, which is essential for recognizing potable water resources for sustainable management and abstraction practices.