Hydrogeochemical Characterization of the Southern Sector of the Guarani Aquifer System: Insights into Flow Dynamics and Mixing Processes

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The Guarani Aquifer System (SAG) spans across Brazil, Argentina, Paraguay, and Uruguay, exhibiting a complex architecture influenced by basin framework and geological structures that segment the aquifer into four large compartments. The currently accepted conceptual model depicts a regional flow from north to south, overpassing the geological structures. This study aims to characterise geochemically and isotopically the southern sector of the SAG in Brazil. The aquifer is partially outcropping, with a confining volcanic layer with varying thickness. Chemical and isotopic analyses were conducted on samples from 73 wells, revealing predominant Ca-Na bicarbonate water types, with local occurrences of sodium-sulphate and calcium-chloride facies. Principal component analysis identified four eigenvectors (EV) explaining 85% of the variance. The load of each variable for the EVs were associated with distinct water types, validating previously identified endmembers and explaining the hydrochemical variability of the system. EV1 represented the most saline groundwater, characterized by sulphide enrichment, originating from deep well bypassing SAG lithologies, indicating a mixture of long-residence SAG and pre-SAG aquitards water. EV3 depicted typical SAG water with depleted δ18O, high alkalinity, and pH, evolving towards sodium bicarbonate facies. EV2 and EV4 reflected low-mineralized waters influenced by post-SAG formations, with volcanic signatures in EV2 indicated by Ca-Mg load. The δ18O is close to present-day precipitation, indicating recent recharge. Comparison with findings by Ortega et al. (2022) in Argentina revealed similar isotopic signatures but more evolved water facies. The results corroborate the accepted flow model from southern Brazil towards the southwest and the vertical water mixing between SAG and pre-SAG formations. End-member mixing analysis will be conducted to quantify source contributions and further understand mixing processes.