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Decadal hydrogeochemical trends and water quality analysis of the Tiznit Basin aquifer, West central Morocco

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Groundwater sustainability depends not only on water quantity, but on long-term water quality preservation. In semi-arid regions groundwater quality is challenged by the combined effect of natural geological conditions, precipitation variability, and anthropogenic pressures, rarely captured in snapshot water quality analysis. Here, we present two decades (2004 – 2025) of groundwater quality evolution in Tiznit basin with the aim of understanding the shift in water quality and moving beyond water quality status of one-year data assessment. A total of 87 samples from 15 wells and 7 springs were analysed using groundwater suitability indices of Water Quality Index (WQI), Entropy-Weighted Water Quality Index (EWQI) and Irrigation Water Quality Index (IWQI). Spatial analysis of land-use land-cover coupled with multivariate statistics, Kruskal-Wallis and Mann–Kendall and Theil–Sen trend tests were conducted to assess trends, significance and geospatial variations in water quality indices at the basin-scale. The hydrochemical and geochemical modeling results indicate a basin-wide transition from Ca-Mg-HCO_3 to Na-Cl groundwater types, consistent with widespread evaporite dissolution, carbonate near-equilibrium to oversaturation, and locally sturdier cation exchange processes. WQI, EWQI and IWQI results reveal a consistent temporal shift towards unsuitable and restricted water quality, respectively, for both drinking and irrigation. Between 2022 and 2025, change maps reveal contrasting responses; ΔEWQI shows multiple wells deteriorating in the downstream, whereas ΔIWQI indicates more frequent local improvements, mainly in upstream areas. Chloride, Electrical conductivity (EC), and pH show significant increasing trends ($p<0.01$) with Sen's slope indicating rapid salinity enrichment of 107.44mg/l/ yr, 345.35 µS/cm/yr and 0.08 pH unit/yr, respectively. Multivariate and spatial analyses identify low-lying agricultural areas as the most degraded zones. The study demonstrates that by combining long-term trends with short window change mapping identifies where degradation is persistent and where conditions are improving, supporting targeted monitoring and management in priority hotspots.



