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Multi-isotope constraints on nitrate sources and cycling in the Lomagundi Dolomite aquifer, Zimbabwe

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Sustainable management of groundwater resources is challenging in agricultural regions underlain by karstic systems where groundwater quality and quantity monitoring is limited. Declining and erratic rainfall in semi-arid regions have increased reliance on groundwater irrigation which possibly obscures the delineation of dissolved nitrate sources and turnover. Surface water, groundwater and spring water were analysed over one dry and two wet seasons for hydrochemistry and multi-isotopic tracers ($^{15}N_{NO3}$,$^{18}O_{NO3}$, ^{3}H, ^{13}C, $^{18}O_{H20}$, $2H_{H20}$) around the Lomagundi Dolomite aquifer, Zimbabwe. Sampling points were classified as karst and non-karst based on local hydrogeology. Elevated NO_3^- concentrations (up to 90 mg/L) were observed in karstic groundwater with more than 50% in both karst and non-karst samples exceeding local standard. Water chemistry was mainly dominated by Mg-Ca-HCO_3 water types. d-excess in both karstic and non-karstic groundwater showed evaporative enrichment relative to long term mean rainfall d-excess. Tritium activities in both karstic and non-karstic samples indicated modern recharge. Meteoric recharge was therefore dominant but also modified by irrigation return flow inputs. Combined d-excess and NO_3/Cl^- ratios showed possible agricultural inputs related to seasonal dominance of irrigation return flow. While redox conditions were mostly anoxic, denitrification was only distinct in non-karstic groundwater. Normalised nitrate concentrations decreased with increased $\delta^{15}N_{NO_3^-}$ in non-karstic groundwater samples. Karstic NO_3^- dynamics were suggestive of overprinting by both source mixing and aquifer-specific controls. Possible denitrification was likely confined to micro-scale anoxic zones and obscured by seasonal dynamics. This highlights the complex interplay of recharge dynamics, land-use and aquifer characteristics in controlling nitrate transformation in karstic aquifers in semi-arid regions.