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Differentiating between anthropogenic and natural nitrate sources to groundwater in arid regions using artificial sweeteners, isotopes, and major ion chemistry

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Recently, the subsoils of arid-region ephemeral stream floodplains (arroyos) in the northern Chihuahuan Desert were discovered to contain large naturally occurring nitrate (NO_3^-) reservoirs (floodplain: ~38,000 kg NO_3-N/ha; background ~59 kg NO_3-N/ha). These reservoirs may be mobilized through land use change or natural stream channel migration. Natural NO_3^- sources makes differentiating between anthropogenic and natural groundwater NO_3^- challenging in arid regions. In an area with multiple anthropogenic NO_3^- sources such as landfills, sewage lagoons, and sewer line releases as well as natural reservoirs of NO_3^-, I used a wide suite of geochemical tracers to differentiate NO_3^- sources. These tracers included contaminants of emerging concern (CEC) such as pharmaceuticals, artificial sweeteners, and organic wastewater indicators, as well as nitrogen and carbon isotopes and major ion chemistry. Based on elemental ratios and isotope analyses, at sites with very high NO_3^- concentrations (>25 mg/L NO_3^-N) NO_3^- is sourced from naturally occurring subsoil NO_3^- deposits. Nitrogen isotope results indicate that denitrification is fairly limited in the field area. As such, both anthropogenic and natural NO_3^- in groundwater will likely persist into the future. Neotame, a relatively recently approved (2002) artificial sweetener known to break down rapidly in the environment, was used to identify locations of very recent (<15 ybp) or ongoing wastewater fluxes to the aquifer. This study shows that CEC are often more useful indicators of recent recharge than traditional geochemical tracers, given the ubiquity of CEC in groundwater even at tritium-dead sites. Based on a synthesis of geochemical analyses, NO_3^- sources were classified as being largely from anthropogenic (62%), ephemeral stream floodplain subsoil NO_3^- (16%), background (12%), and unknown (10%). This work provides a template for future studies seeking to differentiate between multiple and potentially mixed natural and anthropogenic NO_3^- sources to groundwater.