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Nitrate occurrence in groundwater of Alberta, Canada

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Summary

This study assesses the occurrence of nitrate contamination in groundwater across Alberta, Canada, and investigates sources and fate of groundwater nitrate using isotopic tracers and determination of redox states. To map nitrate in Alberta groundwater we used a regional public health database collected by Alberta Health Services of domestic well water quality from 2001-2015 consisting of 60,395 samples from up to 300 m deep aquifers. Nitrate concentrations were detectable (>1 mg NO_3/L) in 14% of samples, with a median concentration of 13 mg NO_3/L. Of these samples with detectable nitrate concentrations, 22% exceeded 45 mg NO_3/L, the Canadian maximum acceptable concentration (MAC) for nitrate in drinking water. Nitrate concentrations are highest (up to 1,330 mg NO_3/L) in shallow groundwater (<50 m) in agriculturally intensive areas along major transportation corridors and decrease with depth. Nitrate was mainly observed in oxic to sub-oxic groundwater whereas 80% of all groundwater samples displayed sulphate-reducing or methanic redox conditions and negligible nitrate. This observation supports the hypothesis that reducing conditions may limit the extent of nitrate contamination in Alberta groundwater. To investigate nitrate sources and fate further, 25 groundwater samples from Alberta's Groundwater Observation Well Network were analyzed for the isotopic composition of water, and nitrogen and oxygen isotope ratios of nitrate. Deviations of water isotope compositions from the local meteoric water line (lower slope) likely result from evaporation during recharge and possibly mixing of infiltrating recharge waters with formation waters. Nitrogen isotope ratios of nitrate ($\delta^{15}N$) range from -10 to +22 ‰ and oxygen isotope ratios ($\delta^{18}O$) of nitrate varied from -15 to +25 ‰, consistent with both anthropogenic (e.g., septic, manure, synthetic fertilizer) and natural contamination sources (e.g., soil N, weathering and nitrification of ammonium bearing clays in glacial till), as well as denitrification occurring in aquifers. As 90% of Alberta's rural population relies on private groundwater wells, research on sources of nitrate contamination and relevance to human health continues.