A Regional Assessment of Occurrences, Sources and Fate of Nitrate in Groundwater of Alberta

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Domestic groundwater wells in Alberta

- Over 20% of Albertans drink groundwater = 600,000 people in rural Alberta

- Well water quality in circa 240,000 landowner wells is not regulated
  - Only 10% test their groundwater quality annually
  - 15% of samples tested exceed bacterial guidelines

- Septic setback distance from well: 10-100m

Objective

• Determine the extent to which elevated nitrate concentrations occur in Alberta groundwater

• Determine the sources of nitrate

• Determine the fate of nitrate (e.g. extent of denitrification)

Figure: Groundwater sampling conducted by a team from AEP

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Alberta Heath Services (AHS) dataset

- ~79,000 water chemistry samples
  - Landowner submitted samples
  - Years: 2001 – 2015
  - Major ions, TDS, pH, depth, location…

Landowner collects well water sample and submits to AHS:

Well water quality is analyzed by ACFT.

Figure: Map of Alberta with AHS sampling sites.

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Nitrate occurrence and distribution in Alberta groundwater

<34 % of all groundwater samples contained nitrate, predominantly at low concentrations (<4 mg/L);

The maximum allowable concentration (MAC: <45 mg/L) for nitrate was exceeded in <4% of the samples.

Elevated nitrate concentrations occur predominantly in the south-east quadrant of the province, where agricultural landuse is predominant.

Figure: mean nitrate concentration in shallow groundwater (<50 m) per section

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Ground Water Observation Well Network (GOWN)

- GOWN includes 340 active observation wells located mainly in the southern half of the province.
- Wells completed in various shallow aquifers.
- Groundwater samples obtained and analyzed for nitrate concentrations and isotope compositions, among others.

Figure: Map of Alberta with GOWN sampling sites.

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Nitrate concentrations versus well depth

- Elevated nitrate concentrations predominantly observed in shallow groundwater (<60 m)
- Nitrate contents low to negligible in groundwater > 100m

Figure: Nitrate concentrations in groundwater obtained from AHS (left) and GOWN wells (right) versus well depth

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- Isotope analyses reveal that nitrate is derived from nitrification of soil organic N and urea and NH₄-based fertilizers and from manure.

- Increasing δ¹⁵N and δ¹⁸O values of NO₃⁻ indicate that some samples are affected by denitrification.

Figure: Isotopic composition of groundwater nitrate

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Potential for nitrate attenuation

- Analysis of aqueous geochemistry groundwater data was used to assess redox conditions in the respective aquifers;
- The majority of the aquifers are very reducing suggesting that nitrate would be rapidly denitrified.

Figure: Assessment of redox conditions in Alberta groundwater

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Figure: Classification of redox zones
Conclusions

• “Only” <34% of Alberta’s groundwater contains nitrate, and <4% of the groundwater samples exceed the MAC for nitrate;

• **Nitrate** is predominantly derived from nitrification of soil organic N and urea and NH₄-based fertilizers and from manure;

• Nitrate is **frequently undergoing denitrification** according to stable isotope data;

• In many aquifers, groundwater is **too reducing for nitrate to be stable** and persist.

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