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Dissolved gas and isotopic tracers of denitrification
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We present results from field studies in California (USA) where tritium-helium age
dating is used in conjunction with major gases (N₂, O₂, CH₄, CO₂), noble gases (He, Ne, Ar, Kr,
Xe), and stable isotopes (¹⁵N/¹⁴N, ¹⁸O/¹⁶O) in order to document nitrate loading and denitrification
associated with confined animal agricultural operations and septic systems. Preliminary results
show that in-field extraction of the full suite of dissolved gases will be possible using a new Gas
Extraction System under development to augment the current Noble Gas Mass Spectrometry and
Membrane Inlet Mass Spectrometry techniques.

Ascribing observed groundwater nitrate levels to specific current and past land use
practices is often complicated by uncertainty in groundwater age and the degree and locus of
denitrification. Groundwater age dating at dairy field sites using the H³⁻He method indicates that
the highest nitrate concentrations (150-260 mg/L-NO₃) occur in waters with apparent ages of <5
yrs, whereas older waters contain excess N₂ from saturated zone denitrification [1]. At a
residential septic system site in Livermore, CA, waters with young apparent ages (<1 yr)
proximal to leach line drainage have lower nitrate concentrations and elevated nitrate δ¹⁵N and
δ¹⁸O values consistent with denitrification, but little evidence for excess N₂, indicating that
denitrification is occurring in the unsaturated zone.

Degassing of groundwater can complicate efforts to calculate travel times [2] and to
quantify denitrification. Degassed groundwater underlying dairy operations is formed by two
distinct mechanisms: (1) recharge of manure lagoon water affected by biogenic gas ebullition [3]
and (2) saturated zone denitrification producing N₂ gas above solubility in groundwater. Gas loss
due to both mechanisms is evident in the concentrations of noble gases and major gases in dairy
groundwater samples.

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