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Data and Modelling Analysis Considerations for Nitrate Plume Assessment in Alberta Tills

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Nitrate in Alberta Tills

The fate and transport of nitrate in Alberta till units can be challenging to assess and predict. Nitrate plumes are common in Alberta and can stem from existing feedlot operations, fertilizer storage yards, agricultural fertilizer application or even private septic systems. Nitrate concentration is regulated by CCME (2012) and Health Canada (2017) for drinking water (methemoglobinemia) and ecological discharges (methaemoglobinemia and/or osmoregulation).

Till Fate and Transport Mechanisms

Along with typical groundwater contaminant transport mechanisms (advection and mechanical dispersion), for the typical till-rich environments in Alberta, additional transport mechanisms (i.e., matrix-diffusion, and denitrification) should also be evaluated. Transport though till environments will be diffusion dominated, and as such, effective and total porosity, as well as the effective mass transfer rate must be characterized. Further, to identify active zones of denitrification, it must be determined whether site conditions are favourable (e.g., anaerobic, electron donors, nutrients, etc.) and whether observed changes in concentration can be attributed to denitrification. The good news is that conditions have been found to be favourable for Sulphur-rich tills in Alberta.

Transport Assessment Requirements and Approach

To develop an effective characterization of nitrate fate and transport, the approach needs to evaluate multiple types of subsurface soil and groundwater data, including complementary types of geochemical and isotope constituents, bacteria presence and abundance, physical hydraulic conductivity values, etc. Given the challenges of proving subsurface conditions everywhere, the strength of the interpretation will be on the demonstration of multiple lines of evidence that consistently support a nitrate fate and transport hypothesis.

Experience has shown that migration through Alberta till units toward a potential receptor can take decades or centuries, depending on the till thickness and site-specific groundwater flow and transport parameters. Analysis of subsurface transport and fate conditions must be thoroughly evaluated to be confident in predicted risk levels as well as appropriate remediation and/or risk management initiatives.

Summary

This presentation will demonstrate the important field data collection, data analysis techniques, and simulation approaches required to effectively evaluate nitrate transport in Alberta tills. Case study examples will be utilized to help illustrate the recommended processes and approaches.

References

Alberta Environment and Sustainable Resource Development (ESRD). 2014. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Policy Division. Edmonton. 48pp. esrd.alberta.ca/water/education-guidelines/documents/EnvironmentalQualitySurfaceWaters-Jul14-2014A.pdf

Aravena R. and W.D. Robertson. Use of Multiple Isotope Tracers to Evaluate Denitrification in Groundwater: Study of Nitrate from a Large-Flux Septic System Plume. 1998. Ground Water 36 (6): 975-982.

Canadian Council of Ministers of the Environment (CCME). 2011. Protocols Manual For Water Quality Sampling in Canada. Publication No. ISBN 978-1-896997-7-0 PDF.

Canadian Council of Ministers of the Environment. 2012. Canadian water quality guidelines for the protection of aquatic life: nitrate-nitrogen. Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment, Winnipeg

Farm Practices Guidelines Series for Livestock Producers in Manitoba, Residual Soil nitrate-nitrogen-N Limits: Guidance for Soil Sampling and Nitrogen Management in Complex Landscapes, Manitoba, March 2018

Health Canada (2017). Guidelines for Canadian Drinking Water Quality Summary Table. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario

Hendry M.J., Hydraulic Conductivity of a Glacial Till in Alberta. 1982. Ground Water 20 (2): 162-169.

Hendry M.J., R.G.L. McCready and W.D. Gould. Distribution, Source and Evolution of Nitrate in a Glacial Till of Southern Alberta, Canada. 1984. Journal of Hydrology 70 (1984): 177-198.

Hendry M.J., J.A. Cherry and E.I. Wallick. Origin and Distribution of Sulfate in a Fractured Till in Southern Alberta, Canada. 1986. Water Resources Research 22 (1): 45-61.

Lorenz, K., Iwanyshyn, M., Olson, B., Kalischuk, A., and Pentland, J. 2014. Livestock Manure Impacts on Groundwater Quality in Alberta: 2008 to 2011 Progress Report. Alberta Agriculture and Rural Development, Lethbridge, Alberta, Canada. 316 pp.

Natural Regions Committee. 2006. Natural Regions and Subregions of Alberta. Compiled by Downing D.J. and W.W. Pettapiece. Government of Alberta. Pub. No. T/852. ISBN: 0-7785-4573-3. http://albertaparks.ca/media/2942026/nrsrcomplete_may_06.pdf

Robertson W.D., B.M. Russell, and J.A. Cherry. Attenuation of Nitrate in Aquitard Sediments of Southern Ontario. Journal of Hydrology 180 (1996) 276-281.

Robertson W.D., T.A. Moore, J. Spoelstra, L. Li, R.J. Elgood, I.D. Clark, S.L. Schiff, R. Aravena and J.D. Neufeld. Natural Attenuation of Septic System Nitrogen by Anammox. 2012. Ground Water 50 (4) 541-553.

Rivett M.O., S.R. Buss, P. Morgan, J.W.N. Smith, and C.D. Bemment. Nitrate attenuation in groundwater: A review of biogeochemical controlling processes., Water Resources Research 42 (2008) 4215-4232.