NITRATES IN DRINKING WATER

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Lately, we have been hearing more and more about nitrate levels in drinking water causing issues with municipal water supplies. In the United States, more public water supplies have been closed due to the violation of drinking water standards for nitrate than from any other contaminant.[1] The Township of Strathroy-Caradoc's Environmental Services Director Mark Harris is certainly familiar with the quandary. With deteriorating groundwater quality and reduced capacity caused by lowering groundwater tables, public health and safety concerns were becoming critical for the Strathroy Water Works Department. Four out of 13 wells frequently had nitrate concentrations above limits set by the Ontario Drinking Water Standards. As an alternative to their well system, the municipality decided to replace the well supplies with a $20 million dollar connection to the Lake Huron Primary Water Supply System.[2]

Even with the big price tag, Strathroy was lucky to be close enough to the Lake Huron water supply route to London to be able to tap in. Other areas suffering from nitrate contamination, like Abbotsford British Columbia,[3] must look to other solutions to meet the drinking water needs of its constituents.

A Ubiquitous Contaminant

Nitrate entry into groundwater is ubiquitous in Canada; levels are usually below the safe limit, but areas of intensive agriculture are prone to levels above the safe limit, including south coastal British Columbia, the Maritime provinces, and areas under heavy manure application, irrigation, or faulty septic systems.[4]

Nitrogen exists in the environment in many forms and changes as it moves through the nitrogen cycle. Nitrogen is essential for all living things. It is used by living organisms to produce a number of complex organic molecules, like amino acids, proteins, and nucleic acids.[5]

The amount of stored nitrogen found in the atmosphere is about one million times larger than the total nitrogen contained in living organisms. Other major stores of nitrogen include organic matter in soil and the oceans. Despite its abundance in the atmosphere, nitrogen is usually the one nutrient needed for plant growth. Because of this, it is the nutrient most applied in the largest quantities for lawn and garden care, and crop production.

The primary inorganic sources of nitrogen are found in potassium nitrate and ammonium nitrate, widely used as fertilizers. Since they are very soluble and do not bind to soils, these

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1 *Agriculture Practices and Nitrate Pollution of Water*, Devinder K. Bhumbla, Soil and Water Specialist, West Virginia University Extension Service <www.caf.wvu.edu/~forage/nitratepollution/nitrate.htm>.

2 Submission for Public Works Project of the Year 2007 OPWA Awards Program (Structures – greater than $10 million) <www.watersupply.london.ca/Notice/Pipeline_Award_Submission.pdf>.

3 Water Stewardship Information Series, Nitrate in Groundwater, British Columbia Ministry of Health <www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/ground_fact_sheets/pdfs/no3(020715)_fin2.pdf>.

4 *The Health of our Soils: Toward sustainable agriculture in Canada*, D.F. Acton and L.J. Gregorich (editors), Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada Publication 1906/E, 1995 <www.agr.gc.ca/nlwis-snite/index_e.cfm?s1=pub&s2=hs_ss&page=5>.

5 <www.britannica.com/eb/article-9055947/nitrogen>.

nitrates have a high potential to migrate to groundwater. Because they do not evaporate, nitrates/nitrites are likely to remain in water until consumed by plants or other organisms. However, nitrate is highly leachable and readily moves with water through the soil profile. If there is excessive rainfall or over-irrigation, nitrate will be leached below the plant's root zone and may eventually reach ground water.[6]

Potential Health Issues

Nitrate does not normally cause health problems unless it is reduced to nitrite. However, excessive concentrations of nitrate-nitrogen or nitrite-nitrogen in drinking water can be hazardous to health. Most nitrogenous materials in natural waters tend to be converted to nitrate, so all sources of combined nitrogen, particularly organic nitrogen and ammonia, should be considered as potential problems.[7]

Nitrate has been implicated in methemoglobinemia and also a number of currently inconclusive health outcomes. These include proposed effects such as cancer (via the bacterial production of N-nitroso compounds), hypertension, increased infant mortality, central nervous system birth defects, diabetes, spontaneous abortions, respiratory tract infections, and changes to the immune system.[8]

Methemoglobinemia is a blood disorder in which the body cannot recycle hemoglobin after it is damaged. Hemoglobin is the oxygen-carrying molecule found in red blood cells. In some cases of methemoglobinemia, the hemoglobin is unable to carry oxygen effectively to body tissues. Babies with this condition have bluish mucous membranes which is why it is referred to as the "blue baby syndrome."[9]

In freshwater or estuarine systems close to land, nitrate can reach high levels that can potentially cause the death of aquatic species. Consequently, as nitrates form a component

6 Natural Resources, Cornell Cooperative Extension, *Nitrogen: The Essential Element*, Nancy M. Trautmann and Keith S. Porter, Center For Environmental Research and Robert J. Wagenet Dept. of Agronomy, Cornell University <http://pmep.cce.cornell.edu/facts-slides-self/facts/nit-el-grw89.html>.

7 *Nitrates in Drinking Water*, Brian Oram, Professional Geologist (PG), Wilkes University, Center for Environmental Quality, Environmental Engineering and Earth Sciences <www.water-research.net/nitrate.htm>.

8 "Drinking-Water Nitrate, Methemoglobinemia, and Global Burden of Disease: A Discussion," Lorna Fewtrell, *Environmental Health Perspectives*, Volume 112, Number 14, October 2004 <www.ehponline.org/members/2004/7216/7216.html>.

9 Jaffe ER, Hultquist DE. Cytochrome b5 reductase deficiency and enzymopenic hereditary methemoglobinemia. In: Scriver CR, Beaudet AL, Sly WS, et al, eds. *The Metabolic and Molecular Basis of Inherited Disease,* 7th ed., New York, NY: McGraw-Hill <health.nytimes.com/health/guides/disease/methemoglobinemia/overview.html>.

of total dissolved solids, they are widely used as an indicator of water quality.

The European Community has been taking measures concerned with nitrogen pollution in waters for over 20 years. Initial directives applied mainly to water for human consumption. More recently, directives have placed increased emphasis on the environmental effects of excess nitrogen, in particular eutrophication.

The Canadian Drinking Water Standards set the limits for nitrate in drinking water at 10 milligrams per litre (10.0 mg/L) and one milligram per litre (1.0 mg/L) for nitrite. Where both nitrate and nitrite are present, the total of the two should not exceed 10.0 mg/L.

Removing Nitrate from Water

There are no simple ways to remove nitrate from water. Nitrate in water is present as highly soluble salts. Standard water treatment practices, such as sedimentation, filtration, chlorination, or pH adjustment with lime application, do not impact nitrate concentrations in water. Because nitrate does not evaporate the way chlorine does, boiling, freezing, or letting water stand does not reduce the nitrate level. In fact, boiling water for more than 10 minutes can make the nitrate more concentrated. Boiling water in an aluminum pan may also convert nitrate to nitrite. Water with high nitrate levels can be used safely for bathing, and for washing clothes and dishes, but is not recommended as a source of drinking water.

If excessive nitrates are in a region's drinking water supply, there are two basic choices: find an alternate water supply, or use some type of treatment to remove the nitrate. Nitrate can be removed from drinking water by three methods: distillation, reverse osmosis, and ion exchange.[12]

In the reverse osmosis process, pressure is applied to water to force it through a semi-permeable membrane. As the water passes through, the membrane filters out most of the impurities. According to manufacturers' literature, from 85 to 95 percent of the nitrate can be removed with reverse osmosis. Actual removal rates may vary, depending on the initial quality of the water, the system pressure, and water temperature.

Ion exchange for nitrate-nitrogen removal operates on the same principle as a household water softener. In a standard water softener, calcium and magnesium ions are exchanged for sodium ions. However, for the nitrate removal process,

10 Nitrates <ec.europa.eu/environment/water/water-nitrates/index_en.html>.

11 Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines <www.ene.gov.on.ca/envision/techdocs/4449e.htm>.

12 Colorado State University Extention Agriculture, 0.517, Nitrates in Drinking Water, J.R. Self and R.M. Waskom.

special anion exchange resins are used, exchanging chloride ions for nitrate and sulfate ions in the water as it passes through the resin.[13]

While it may be technically possible to treat contaminated groundwater, it can be difficult, expensive and not totally effective. Water treatment equipment may reduce water nitrate levels but prevention is the best way to ensure clean water.

Recognizing the Problem

Recognizing the problem is a first step. The City of Ottawa has found its own groundwater nitrate problems, which were identified in the Cumberland Water and Wastewater Alternative Servicing Solutions Study completed in July 2003. Elevated nitrate levels were found in a number of well sources. Possible causes of the presence of elevated nitrate in wells were attributed to thin soil cover over bedrock, and included a combination of septic systems, road salting, and water softeners.[14] By identifying the source of the problem, remedial action can be planned.

Part of the solution lies with careful application of fertilizers and manure at rates matching plant needs. Overloading nitrogenous fertilizers actually kills the biota in the soils that helps to provide nitrogen to the soil. By using lower amounts of fertilizers, front lawns, golf courses, and crops can still be as productive as those produced under heavily fertilized soils, because of the healthier environment for the microbes. If landowners add large amounts of fertilizer in the beginning, then they are forced to use more and more each year.[15] By using only moderate to low amounts of fertilizer at the beginning, we avoid getting caught in this addictive cycle.

Reacting to a study by provincial and federal scientists that showed nitrate levels are much too high in P.E.I.'s drinking water and will get worse if farming practices don't change, one farm group is supporting a move away from the chemical fertilizers blamed for the problem. The group is promoting the potential to turn easily available fish waste into organic fertilizer.

In Europe, where nitrate contamination is widespread, high nitrate uptake crops are being grown. These crops literally lock the nitrates within the plant. The crops are then harvested and burned for fuel. Another practice is a passive system – essentially a narrow trench between the contaminated area and a water body – which is filled with a mixture of natural materials. As groundwater, runoff, and field drainage waters pass through the natural materials, the nitrates are converted to nitrogen gas by micro-organisms that attach themselves to, or live in between, the materials.[17]

Mount Brydges, another Strathroy-Caradoc community, is still on wells and often under advisories, warning residents not to allow children under six months old to drink the water because of elevated nitrate levels. Strathroy-Caradoc's Environmental Services Director, well familiar with the issue after the Strathroy process, is quoted as saying, "With no one in the village replacing their septic systems since a groundwater study completed four years ago, Mount Brydges groundwater quality is likely getting worse."[18]

We know that nitrogen is an important and necessary part of the nutrient cycle. We also know that human activity heavily impacts this cycle. Over time, we are seeing a reduction in additions of nitrates from agricultural sources yet, as we see in Mount Brydges, it is time to fix those aging septic systems and assure best practices in manure management. We also need to see further provincial and federal support for putting this needed infrastructure into place. Helping assure that such communities do not further contaminate their own water supplies is an important long-term investment. Becoming self reliant now, for our municipal water supplies – making sure the source of our water is safe – will mean water on the table today and into the future. MW

13 Drinking Water: Nitrate-Nitrogen, Did You Know, Know Now Fact Sheet, G1784, University of Nebraska-Lincoln <www.ianrpubs.unl.edu/epublic/live/g1784/build/g1784.pdf >.

14 <www.ottawa.ca/city_services/major_projects/cumberland/cumberland_completion_en.shtml>.

15 Nitrate Pollution of Groundwater, prepared by: Lee Haller, Patrick McCarthy, Terrence O'Brien, Joe Riehle, and Thomas Stuhldreher, Alpha Water Systems, Inc. (AWS) <www.reopure.com/nitratinfo.html>.

16 "Nitrates a growing problem for P.E.I.," CBC News <www.cbc.ca/canada/prince-edward-island/story/2007/04/16/nitrates-water.html>.

17 <www.eugris.info/displayProject.asp?ProjectID=4564&Aw=NITRABAR&Cat=Project>.

18 "Progress made on Mt. Brydges water," *The Age Dispatch,* May 22, 2008; Drinking Water Advisory for Infants in Mount Brydges, March 25, 2008 <healthunit.com/article.aspx?id=13771>.