Public Health

Making our water safe to drink

Canada's drinking water has become a subject of concern since the May outbreak of *Escherichia coli* O157:H7 infection in Walkerton, Ont. Because patients might have questions about water quality, physicians should understand how our drinking water is disinfected. Most of the information in this article has been adapted from the chapter on drinking water by Nigel Bunce.[1]

The 2 main sources of drinking water are groundwater and surface water. Groundwater is recovered from underground aquifers at depths ranging from a few to hundreds of metres. This water is typically replaced very slowly and may be depleted if used too rapidly. Surface water, drawn from lakes and rivers, almost always has more suspended materials and requires more extensive processing. Groundwater tends to be less contaminated because soil bacteria has had time to decompose organic matter in the water, and the soil itself filters particulate matter.

There are 4 steps in a typical treatment program. During **primary settling**, water is contained in a large holding basin where particulate matter settles. **Aeration** then agitates the water to promote the oxidation of substances that would consume chlorine added later in the process. With **filtration**, sand or other filtering agents are used to remove the finest particles. Finally, any remaining microorganisms are killed during the **disinfecting** stage. Chlorine is the most popular disinfecting agent because its residual activity protects against contamination throughout the distribution system. Dissolved chlorine dissociates into hypochlorous acid and the hypochlorite ion. Hypochlorous acid is the stronger disinfectant because, being neutral, it penetrates the cell membrane of microorganisms.[2]

Chlorine treatment has several drawbacks, however. Taste and odour are concerns in industrialized areas, where water may be contaminated with phenols. Chlorinated phenols have a penetrating odour that, even at parts per million, can make water unusable for cooking or drinking. There is also growing concern about possible health risks associated with ingesting chlorination by-products (e.g., chloroform). Results of studies suggesting an increased risk of bladder and colon cancers, as well as adverse reproductive and developmental effects,[3–5] led an expert working group to conclude that it is "possible to probable" that chlorination by-products pose a significant cancer risk.[6,7] Health Canada is working with provincial ministries to assess the need to reduce the levels of these by-products in drinking water and the options for doing this.[8]

Alternatives to chlorination include ozonization and ultraviolet radiation. During ozonization, which is used in several Quebec communities, including Montreal, ozone is prepared by passing a high voltage electric discharge through very dry air and then absorbing the ozone in water. The process appears to inactivate organisms by causing physicochemical damage to DNA.[2] Ozone is slightly more effective than chlorine and produces no chlorine derivatives, but it must be made on site (it cannot be stored or transported), and the process is expensive. In addition, because ozone decomposes rapidly in water and leaves no residual posttreatment, chlorination is still required.

Ultraviolet radiation at wavelengths below 300 nm damages DNA.[2] The radiation must penetrate the water to be successful, so particulate matter, coloured material and dissolved organic compounds (which compete for ultraviolet radiation) should be minimal.

Organic compounds such as herbicides, insecticides and industrial compounds in drinking water are a growing concern. More than 360 chemical compounds have been identified in the Great Lakes, many of which are persistent toxins (e.g., benzopyrene and dichlorodiphenyl trichloroethane [DDT]). Expensive processes such as activated carbon filters and packed-tower aeration of volatile organic compounds may effectively remove some of these compounds. However, the specific hazards posed by ingesting trace amounts of these compounds have not yet been established.

Nitrate contamination of water from livestock and human excrement, other organic waste, or chemical fertilizers is a concern because of its toxicity.[9] Nitrite ions can combine with hemoglobin to produce methemoglobin, and severe cases of methemoglobinemia can deprive the brain of hemoglobin and oxygen delivery and cause mental retardation in infants.

For further information the interested reader may consult the Centre for Science in the Public Interest, National Action, Nutrition Action Healthletter, June, 2000, at **www.cspinet.org** — *Erica Weir*, CMAJ

References

1. Bunce N. Drinking water. In: *Environmental chemistry*. Winnipeg: Wuerz Publishing; 1991. p. 183-214.
2. RD Letterman, editor. *Water quality and treatment: a handbook of community water supplies*. 5th edition. New York: McGraw-Hill; 1999.
3. Cantor KP, Lynch CF, Hildesheim ME, Dosmeci M, Lubin J, Alvanja M et al. Drinking water source and chlorination byproducts. I. Risk of bladder cancer. *Epidemiology* 1998;9:21-8.
4. Hildesheim ME, Cantor KP, Lynch CF, Dosmeci M, Lubin J, Alvanja M, Craun G. Drinking water source and chlorination byproducts. II. Risk of colon and rectal cancers. *Epidemiology* 1998;9:29-35.
5. Dodds L, King W, Woolcott C, Pole J. Trihalomethanes in public water supplies and adverse birth outcomes. *Epidemiology* 1999;10:233-7.
6. Mills CJ, Bull RJ, Cantor KP, Reif J, Hrudey SE, Huston P. Workshop Report. Health risks of drinking water chlorination by-products: report of an expert working group. *Chronic Dis Can* 1998;19:91-102.
7. Wigle DT. Safe drinking water: a public health challenge. *Chronic Dis Can* 1998;19:103-7.
8. Health Canada's resource page on chlorinated water and its health effects. Available: www.hc-sc.gc.ca/ehp/ehd/bch/water_quality/chlorinated_water.htm (accessed 2000 June 12).
9. Johnson CJ, Kross BC. Continuing importance of nitrate contamination of rural groundwater and wells. *Am J Ind Med* 1990;18:449-56.