

# **FACT SHEET #2**

## **THE QUALITY OF GROUND WATER**

**PRODUCED BY:**

**CANADIAN GROUND WATER ASSOCIATION**

In collaboration with the

**GEOLOGICAL SURVEY OF CANADA**  
**a division of**  
**NATURAL RESOURCES CANADA**

**GROUND WATER IS A VITAL AND HIDDEN RESOURCE**

- Factors Affecting Ground Water Quality
- Canadian Water Quality Guidelines
- Ground Water Treatment Methods

## **INTRODUCTION**

Ground water is an essential and vital resource for many Canadians. This fact sheet includes information on factors affecting ground water quality, Canadian drinking water quality guidelines, and a summary of ground water quality problems, their causes and possible solutions.

Ground water does not usually contain suspended particles, has practically little or no natural bacteria or organic matter and is often more hygienic than surface water. Most ground water has a nearly constant temperature and is clear and odourless, although it can contain more dissolved minerals than surface water. The concentration and nature of dissolved minerals affects the usefulness of ground water and in some instances treatment may be necessary to improve its quality. Some dissolved minerals are essential for good health while others, if present in excessive amounts, may cause health problems or affect the appearance and palatability of the ground water. This fact sheet is designed to be of particular interest to well drillers and their clients.

## **FACTORS AFFECTING GROUND WATER QUALITY**

Ground water may become contaminated so it is important that wells be constructed following recommended guidelines and be drilled at locations that are remote from sources of contamination. The contamination and protection of ground water is the subject of a separate fact sheet.

Water is an important solvent. As it passes through soil and rocks it slowly dissolves most materials and picks up their various mineral constituents. These dissolved minerals are rarely harmful to health, and in low concentrations, may give the water a pleasant taste. The most common dissolved elements in ground water include sodium, calcium and magnesium, which combine to form bicarbonates, sulphates and chlorides.

The composition of ground water is determined mainly by the length of time it takes to move through the ground and by the character of the sediments and rock materials it comes in contact with.

### **Travel time**

The longer the period of contact between water and the ground, the greater the opportunity for minerals to be dissolved. Water from deep wells has typically had a long travel time and opportunity to dissolve minerals during its journey. In contrast, water from shallow wells has usually had a shorter travel time and therefore often contains lower concentrations of dissolved minerals. The permeability of earth materials also affects the speed ground water can move and consequently, its quality. Ground water moves slowly through clay and because of this slow movement there is more time for minerals to dissolve. Sediments, such as sand, allow ground water to move quickly so there is less time for materials to dissolve and the ground water is usually less mineralized.

### **Chemical composition**

The chemical composition or reactivity of minerals in the ground also affects ground water quality. Sandy sediments have lower dissolved solids than clays, not only because of lower flow rates, but because they are less reactive than clays. Some components of minerals, like sodium, sulphate and chloride are highly soluble; thus ground water passing through deposits containing high concentrations of these substances will have a relatively high mineral concentration.

## CANADIAN WATER QUALITY GUIDELINES

### Units of Measure

The concentration of dissolved substances is normally expressed in milligrams per litre (mg/L), which for potable water can also be referred to as parts per million or ppm. In some cases trace concentrations of dissolved substances will be listed as micrograms per litre ( $\mu\text{g/L}$ ), or parts per billion (ppb). Some water treatment specialists use the term grains per gallon (gpg) as a measure of dissolved mineral concentration. Table 1 summarizes the main units of measure and equivalent terms.

*Table 1: Units of measure.*

Unit of Measure	Equivalent Unit of Measure
milligrams per Litre (mg/L)	parts per million (ppm)
micrograms per Litre ( $\mu\text{g/L}$ )	parts per billion (ppb)
grains per US gallon (g/USgal)	17.1 mg/L (or 17.1 ppm)
grains per 1 gallon (g/lgal)	14.3 mg/L (or 14.3 ppm)

### Explanation of Terms

When ground water is analysed the results should be compared with the latest version of the Guidelines for Canadian Drinking Water Quality, published by Health Canada. Parameters or chemicals which are known to have harmful human health effects are listed with a maximum acceptable concentration (MAC). An interim maximum acceptable concentration (IMAC) or an aesthetic objective (AO) may also be listed. Local health authorities may provide some guidance on other water quality parameters in the form of recommended limits. Definitions of these terms are given in Table 2:

*Table 2: Water Quality Terms and Definitions.*

Term	Definition
Aesthetic Objective (AO)	AOs are for specific parameters which affect water quality based on smell, taste or color. There are substances which fall under aesthetic objectives which in high enough quantities may impose a health risk.
Maximum Acceptable Concentration (MAC)	MACs have been developed for parameters, or substances, which are known or suspected to cause deleterious health effects. This term assumes the parameter would be consumed over a lifetime at that concentration.
Interim Maximum Acceptable Concentration (IMAC)	IMACs are listed for substances for which not enough information is known to determine a Maximum Acceptable Concentration.

### Water Quality Parameters

Table 3 lists selected parameters commonly analysed when determining the potability of ground water. For a more complete list of parameters and guidelines consult your local health unit or refer to the Guidelines for Canadian Drinking Water Quality. Regional variations in ground water quality do occur and these different qualities of water may be acceptable for drinking, cooking and other domestic purposes.

Table 3. Guidelines for Selected Water Quality Parameters. (values are in mg/L, unless otherwise stated)

Parameter	Guideline Concentration	Comments
Arsenic	IMAC 0.025	Has been correlated with a variety of clinical disorders in humans. Naturally high in some areas.
Calcium	Not defined	A constituent of hardness.
Chloride	AO ≤ 250	Excessive chloride gives water a salty taste.
Conductivity	Not defined	A measure of the total amount of dissolved minerals in the water.
Hardness	Not defined	Water supplies with a hardness of greater than 200 mg/L (as calcium carbonate) are considered poor but have been tolerated, those in excess of 500 mg/L are unacceptable for most domestic purposes.
Iron	AO ≤ 0.3	Not a health hazard unless at extreme levels; can result in red or brown stains clothes and fixtures at concentrations above 0.3 mg/L; may promote the growth of iron bacteria.
Sulphide	AO ≤ 0.05	The presence of sulphide in water (as hydrogen sulphide) results in disagreeable taste and odor.
Fluoride	MAC 1.5	May cause objectionable dental fluorosis (characterized by mottling of teeth) if over 1.5 mg/L.
Lead	MAC 0.010	A cumulative general poison classified as being possibly carcinogenic.
Magnesium	Not defined	Contributes to hardness and has an offensive taste.
Manganese	AO ≤ 0.05	Stains laundry and plumbing fixtures. May lead to the accumulation of microbial growths.
Nitrate-Nitrogen	MAC 45 (equal to 10 mg/L as nitrogen)	In high concentrations is most dangerous to pregnant women and bottle-fed infants causing "Blue Baby Syndrome". At concentrations exceeding the MAC, contamination from animal or human waste should be suspected.
Selenium	MAC 0.01	Has been correlated with a variety of clinical disorders in humans. Naturally high in some areas.
Sodium	AO ≤ 200	At concentrations approaching 200 mg/L has an offensive taste. For people suffering from high blood pressure or heart conditions the concentration of sodium in water is an important consideration and would probably have to be less than 20 mg/L. Water softening usually increases sodium content.
Sulphate	AO ≤ 500	Can cause diarrhea and has an objectionable taste.
Total dissolved solids (TDS)	AO ≤ 500	Indicates the total amount of dissolved minerals in water. Over 1000 mg/L is considered high but the effects of TDS depend on the concentration of components; hardness, taste, mineral deposition and corrosion.
Turbidity	MAC 1 (NTU)	Caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter.
Uranium	MAC 0.1	Can cause kidney damage. Naturally high in some areas.
Total Coliform Bacteria	MAC is zero organisms per 100 mL	These organisms are found in the intestines of man and animals and also in soil Bacteria and on vegetation. If up to 10 total coliform organisms per 100 mL are detected the water should be resampled. If coliforms are confirmed the health authority should be advised and corrective action taken.
Faecal Coliform Bacteria	MAC is zero organisms per 100 mL	These organisms are found only in the intestines of man and animals. Their Bacteria presence at any level indicates the water is contaminated with human sewage and/or animal manure and the water is unsafe to drink.
Iron Bacteria	No defined limit	Not necessarily a health hazard but, can cause slime and clogging of well and pumping equipment.
pH	AO 6.5 to 8.5	Results from a balance between dissolved carbon dioxide gas derived from the atmosphere and the dissolved carbonates and bicarbonates derived from carbonate rocks. A pH of 7 is neutral, less than 7 is an acidic solution and greater than 7 is an alkaline solution.

NTU = Nephelometric turbidity units

≤ = Less than or equal to

Adapted from Guidelines for Canadian Drinking Water Quality, 6th Edition, (1996) published by Health Canada.

Well owners should ensure that testing of well water quality is conducted at a regular frequency. It is recommended that bacteriological analyses be completed each year in the spring and fall. Analyses for routine chemistry may be completed less frequently, possibly every five years, or earlier, if a change in quality is apparent. Check with a local health authority regarding the frequency of laboratory analyses, as local conditions may vary. The results of analyses should be compared with the Guidelines for Canadian Drinking Water Quality and an assessment made of the need to treat the water. A smart well owner will review the results of analysis with a reputable water treatment company and obtain independent advice about water treatment from a government agency.

## **GROUND WATER TREATMENT METHODS**

### **The Three Main Types Of Treatment**

When treating water to improve ground water quality there are three main aspects of treatment to consider: disinfection, improving aesthetic qualities and reducing the concentration of harmful chemicals.

Disinfection refers to improving water quality by killing or inactivating disease causing micro-organisms in a water supply. Bacteria like faecal coliform; and viruses like cholera are examples of microbial contaminants that disinfection methods target. Cysts like *Cryptosporidium sp.* and *Giardia lamblia* (primarily a concern for surface water and ground water under the influence of surface water) can be treated when conventional disinfection methods are combined with filtration.

Improving aesthetic qualities is the most common purpose for point of use (POU) and point of entry (POE) water treatment devices. Taste, odour, hardness and color are all aesthetic characteristics of water which can be improved by a variety of filtration methods, demineralization (or softeners) or distillation. Often harmful chemicals are removed by the same means used to treat offensive aesthetic qualities. Common ground water quality problems, probable causes and possible solutions or treatment methods are summarized on Table 4.

## **SUMMARY**

### **Ground Water Quality**

As water moves through the subsurface, it changes in quality. Earth materials naturally filter out most bacteria. Ground water is usually clear, colorless and of excellent sanitary quality. All ground water contains dissolved minerals. These dissolved minerals are rarely harmful to health and the composition of ground water is mainly determined by its travel time and composition of the sediments and rocks it moves through.

Water wells should be constructed at locations remote from potential sources of contamination using approved well construction guidelines. Being proactive about a potential water quality problem is far cheaper and often less time consuming than trying to remedy a contaminated well.

### **Water Quality Guidelines**

It is recommended that wells be regularly sampled and the results of bacteriological and chemical analyses compared with the most recent edition of the Guidelines for Canadian Drinking Water Quality, published by Health Canada.

**Table 4. Common Ground Water Quality Problems, Probable Causes and Possible Solutions.**

<b>Problem</b>	<b>Probable Cause</b>	<b>Possible Solutions</b>
Health problems	Coliform bacteria	Investigate source immediately; chlorination, UV lights, ozonation
Scale deposits on fixtures and appliances, soap scum and high soap consumption	Hard water	Water softener
Red or orange stains on laundry or fixtures; metallic taste, rust particles after water sits	Iron	Water softener, greensand filter, chlorination/filtration
Black stains on laundry or fixtures, metallic/bitter taste in coffee and tea	Manganese	Water softener, greensand filter, chlorination/filtration
Red to brown slime in toilet tank, iron staining, unpleasant taste or odour	Iron bacteria	Shock chlorination of water source and entire system
Acid water, causing corrosion of piping (green staining due to copper corrosion)	Low alkalinity, presence of carbonic acid, sometimes mineral acids such sulphuric acid	Soda ash, neutralizing tank
Rotten egg odour and flavour, silverware may turn black, worse in hot water	Hydrogen sulphide and/or sulphate-reducing bacteria	Greensand filter, chlorination/filtration. Aeration, activated carbon
Cloudy, dirty or muddy appearance	Turbidity	Fine filters (sand or diatomaceous earth), coagulation (alum) & filtration
High blood pressure	Sodium (most dietary sodium does not come from water, so water may not be the cause of the problem)	Reverse osmosis, distillation
Salty taste, corrosive	Chloride	Reverse osmosis, distillation, anion exchange
Gas bubbles escaping from water	Gases such as methane	Aeration, activated carbon
Laxative effects	Sulphate	Reverse osmosis, distillation, anion exchange
Health problems	Arsenic	Reverse osmosis, distillation, activated alumina, ferric hydroxide, anion exchange
Health problems	Uranium	Reverse osmosis, distillation
Oil smell or film on water	Gasoline and/or oil	Investigate and eliminate source first; activated carbon, gravity separation, air stripping.
“Blue babies” in formula fed infants under 6 months	Nitrate	Reverse osmosis, anion exchange, use nitrate-free water or formula preparation

Adapted from Report 68-3 (Fifth Revision 1997), Nova Scotia Department of the Environment. “Before you Construct A Water Well, Facts a Homeowner Should Know”.

## **Water Treatment**

Having determined the nature and chemical composition of a ground water supply a treatment device may be required. Water quality problems and treatment devices are summarized in Table 4. A number of reputable water treatment companies should be consulted for advice and quotations obtained before purchasing water treatment equipment. It is a good idea to obtain independent advice on water treatment methods from a provincial government agency, if possible.

# CANADIAN GROUND WATER ASSOCIATION

## ***MISSION STATEMENT***

To encourage the management and protection of ground water by creating partnerships for public awareness and utilization.

## ***GOALS & OBJECTIVES***

To continually serve as recognized stewards of the ground water resource in Canada.

To promote education of its members and the public.

To promote the development of ground water guidelines and strategies.

**Acknowledgment to Health Canada and the Nova Scotia Department of the Environment for information supplied in this Fact Sheet**

August 1999

Canadian Ground Water Association  
1600 Bedford Highway  
Suite 100 - 409  
Bedford, NS B4A 1E8

Geological Survey of Canada  
601 Booth Street  
Ottawa, ON K1A 0E8  
<http://sts.gsc.nrcan.gc.ca>