

WATER, WATER, EVERYWHERE, BUT IS IT SAFE TO DRINK?

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What is drinking water quality?

Drinking water should not contain disease causing microorganisms (pathogens) or harmful chemicals, and should be clear, colourless and odourless.

Where does our water come from?

There are two major forms of water supplies. There is water taken from below the ground, where the water sits in “under-ground lakes” called aquifers. The second kind is “surface water”, which can come from rivers, lakes, and in Saskatchewan snow and rain is often captured in holes dug in the ground called dugouts.

The quality of the water from a surface water reservoir is typically very different from that in a ground water aquifer. In surface water the most common problems are with the presence of high levels of microbes and dissolved organic matter. Most surface waters are of excellent quality for inorganic chemicals, which are present in moderate quantities. The salt content of surface water is also mostly low.

In contrast, many ground water sources have unacceptably high levels of inorganic ions making the water quite salty. In addition, specific ions require removal including iron, manganese, and in some cases other ions, such as arsenic.

What might be in our water besides water?

- pathogenic microorganisms
- dissolved organic matter
- nutrients
- inorganic compounds
- organic contaminants

How do we make our water safe?

Water needs to be treated to remove particles and excess amounts of inorganic and organic compounds. This must be followed by disinfection to kill potentially harmful microbes.

Ground water treatment processes

Saskatchewan ground water frequently contains excessive amounts of iron (Fe), and manganese (Mn). Iron and manganese give the water a bitter or metallic taste. The water also becomes coloured (typically red/brown), with Fe/Mn deposits staining plumbing fixtures and clothing. High levels of Fe/Mn can also encourage the growth of slime forming bacteria in the water distribution lines and they can foul (make useless) other water treatment units, such as membranes.

Typically water treatment plants will try to remove these compounds. This is then followed by disinfection of the water using chlorine.

Here are some guidelines for iron and manganese removals. If the iron level is less than 0.3 mg/L the treatment plant may only aerate (if anaerobic) and then chlorinate. When the levels are above this a series of steps may be taken which include aeration, prechlorination, coagulation, sedimentation, and rapid sand filtration followed by post-chlorination before the water is distributed.

Some specific treatments may also be used to remove iron and manganese. When the iron and manganese are reduced (which is typical in ground water) they are in the form of Fe²⁺ and Mn²⁺, which are very soluble. A primary treatment method is to oxidize the Fe/Mn using either aeration or oxidation chemicals such as chlorine, which will convert the Fe²⁺ to Fe³⁺ and the Mn²⁺ to Mn³⁺ and Mn⁴⁺. These oxidized forms are insoluble and will form precipitates, which can be

filtered out. Air is ineffective in oxidizing Mn and while chlorine can oxidize Mn to an extent, two other water treatment chemicals, ozone and potassium permanganate, are more effective.

Hardness is also a problem with ground water and a treatment plant may use lime softening to carry this out. Lime softening will also remove iron and carbon dioxide. The addition of lime (calcium hydroxide) raises the pH of the water and some calcium and magnesium salts precipitate out making the water softer.

The water needs to be disinfected before being distributed. This can be carried out in different ways including using hypochlorite salts, such as calcium hypochlorite and sodium hypochlorite. Bleach is hypochlorite that has been dissolved in water. It is also possible to feed chlorine gas directly into the water. There are also other forms of disinfection, such as ozonation, but they are not yet practiced in Saskatchewan.

Surface water treatment processes

Ideally, surface water treatment processes need to remove dissolved organic matter and microbes. If this is done then it is possible to disinfect the water with chlorine in an effective way. If the levels of dissolved organic material are high, then the chlorine reacts with this material as well as trying to kill microbes. When chlorine reacts with the organic material, disinfection by-products are formed. One set of disinfection by-products are called trihalomethanes and a guideline level of 100 micrograms/L have been set for them.

Chlorine is added to kill microbes and this is more effective the lower the level of dissolved organic material is in the water. Very often in a surface water treatment plant the first step of treatment is to add a chemical that makes particles and some dissolved organic material flocculate (forming precipitates). The most common flocculation chemicals are salts of aluminum and iron. The precipitates that form can then be filtered out.

Chemically assisted filtration is the minimum treatment required for surface water in Saskatchewan. That means the addition of a flocculant described above followed by filtration of the water.

There is one treatment process specifically designed to remove dissolved organic material. This process is activated carbon filtration where the dissolved organic material is adsorbed onto the activated carbon. The Activated Carbon can either be composed of tiny particles, Powdered Activated Carbon, or it can be in the form of granules (granular activated carbon). Powdered activated carbon is added to the water and then filtered out in a filtration unit, which is typically composed of sand or some other crushed particle material. Granular activated carbon, in contrast, is put into filters often replacing sand filters. The challenge for rural water treatment plants using the granular activated carbon technique is the limited ability of the material to adsorb dissolved organic material. To use this method effectively the water needs to be relatively low in organic material.

A newer treatment technique to remove dissolved organic material from water is called biological filtration. In this process bacteria are sitting on and within a support material (which could be Granular Activated Carbon or clay based particles). The support material should really be a "hotel" for good bugs. The ideal material would look a bit like Swiss cheese with "pores" that are big enough to house bacteria. The pores therefore need to be no smaller than one micrometre in diameter. The larger the number of pores of suitable size, the greater the number of bacteria that can "live" in a gram or a kg of material. Some granular activated carbon has a lot of pores, but most of the pores are too small to house bacteria and such pores can only adsorb dissolved organic material.

In the biological process dissolved organic substances are adsorbed onto the support material and the bacteria will then use the adsorbed organic material to reproduce and grow cleaning the water in the process! In contrast to granular activated carbon adsorbers, which get exhausted rapidly (cannot adsorb any more material), biological filters can last for many years. Biological filtration is used in some smaller applications in Saskatchewan, but may become a water treatment of choice in the future.

Who is responsible for the safety of your water?

Canada has negotiated a set of guidelines with the provinces, which each province can adopt or change as it sees fit as the mandate for safe drinking water rests with the provinces. Saskatchewan Environment and Resource Management implements the guidelines for municipal supplies and Saskatchewan Health for rural water supplies. Municipalities that treat and distribute water are ultimately responsible for the quality of the water. On-farm use of water from wells and dugouts can only be made safe if the individual owner takes precautions to protect his/her water supply and if they use water treatment methods that will achieve safe drinking water.

It is very difficult for individual rural water users and municipalities to produce safe drinking water using existing equipment. While it is possible to produce water that meets guidelines in terms of coliforms and nitrates in the bigger picture of safe drinking water many other factors play a part. This includes protozoan parasites, viruses and bacteria that are resistant to chlorine, as well as high levels of dissolved organic carbon. New water treatment technologies need to be tested and indeed developed before drinking water can be produced that is safe using international measuring sticks rather than the presently used provincial guidelines.

Why should students learn about safe drinking water?

Water quality is an important issue to all people. Most people trust what comes out of their municipal water treatment plants is safe to drink. The fact is that many people drink water which can produce disease symptoms ranging from mild diarrhea to severe illnesses that can cause death as evidenced in Walkerton, Ontario. The Canadian Water Quality Guidelines and provincial guidelines in Canada are quite limited in scope, but even these guidelines cannot be met in some communities and individual homes.

How do we teach students about safe drinking water?

Water quality is biology, chemistry and physics. These are all related and together directly effect human health.

Physics

Physics is responsible for the movement of water

- When water moves it carries particles, nutrients, organisms and contaminants. Water movement affects the quality of water. People who study the movement of water are hydrologists.

Sunlight penetration in water is physics

- The amount of light affects the plants and animals that live in the water. The growth and numbers of plants and animals that live in water affect the quality of water.

The temperature of water is physics

- The temperature of water affects the amount of oxygen dissolved in the water and the effectiveness of water treatment. Temperature affects the quality of water.

Water treatment is physics

- Most drinking water treatment plants are designed by engineers. In North America most water treatment plants are based on physics and chemistry with little room for biology. In Europe the use of biology as part of the water treatment process is widespread.

Biology

There are many living things in water

- Plants, animals, fish, amphibians, insects, invertebrates, plankton, protozoa, algae, bacteria and viruses all live in water. Which organisms live in the water depends on the physics and chemistry of the water. The people who study the biology of water are biologists, ecologists and limnologists. The people that study microbes, such as viruses, bacteria and protozoa are microbiologists.

Organisms that live in water affect the water quality

- Some algae, bacteria, protozoa and viruses can make you sick if they are consumed in your drinking water.
- Large quantities of plants and algae in water causes increased pH levels as a result of photosynthesis.
- Organic material left in water as organisms die should be removed at water treatment plants before the water is disinfected.
- Microorganisms such as viruses, bacteria and protozoa need to be either removed through physical/chemical/biological means (coagulation followed by filtration for example) or killed using physical (for example ultraviolet radiation) or chemical means (ozonation, chlorination).
- Water that is distributed to a community needs to have a chlorine residual. This will prevent the re-growth of microorganisms in the distribution system. Unfortunately, a common problem in rural areas is a lack of guidance when it comes to maintaining distribution systems. Poorly maintained distribution systems can play havoc with the safety of the drinking water. This simply means even when the water leaving the water treatment plant is of high quality. It is therefore necessary to make sure that both the water treatment system and the distribution system is well cared for.

Chemistry

The chemicals in water affect the water quality

- Nutrients such as nitrogen, phosphorus and iron are required for the growth of most organisms.
- Many of these nutrients are made available through the drainage of water from snow melt and rain into surface water and groundwater.
- Too much of some chemicals results in poor water quality. There are guidelines for drinking water as to the level of nutrients, ions, and metals which are allowed in drinking water.
- Analysis of water to determine chemical components is carried out in chemistry labs.

Many harmful chemicals end up in our water

- Pesticides often end up in water through run-off of agricultural lands.
- Industry often releases harmful compounds into water through poorly treated effluents.
- Chlorination of poor quality water can produce harmful compounds.

Health

Some organisms found in water can make you sick

- Some bacteria, viruses, protozoa and algae when consumed through drinking water can make you sick. Have you heard of Walkerton, Ontario? Have you heard of Hepatitis A or Beaver fever (causing the illness giardiasis)?

Have you heard of blue green algae poisoning?

- A major source of many harmful bacteria, viruses and protozoa is contamination with untreated sewage from humans and livestock.

Many chemicals found in water can affect your health

- High levels of sulphate can have a laxative effect
- High levels of sodium can be a problem for people with low salt diets
- High levels of arsenic have been found to be related to heart disease and various forms of cancer
- High levels of nitrogen in the form of nitrate (NO₃) causes a reduction in oxygen carried by the blood to the tissues. This is usually only a problem for infants.