

DRINKING WATER QUALITY AND HEALTH

Drinking water should not contain disease-causing microorganisms or harmful chemicals. It should be clear, colourless and odourless. To ensure that drinking water meets the above criteria, Canada has negotiated a set of guidelines with the provinces.

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Guidelines for Canadian Drinking Water Quality

Lists of contaminants that should not be present in drinking water at concentrations exceeding Maximum Acceptable Concentrations (MAC). Some contaminants may still be under review, therefore an Interim MAC (IMAC) has been set. The Guideline also contains Aesthetic Objectives (AO) for compounds that may not have a health impact, but can still be a nuisance.

Frequency of water testing

The frequency of water testing depends upon:

- The quality of the source water
- The number of water sources
- Past frequency of unsatisfactory results
- Adequacy of treatment
- Capacity of treatment plant
- Practice of disinfection
- Size of population
- Ranges of 2 times per year to 90 times per month

Health related parameters

In general, drinking water should be sampled semi-annually for all chemical substances for which MAC and IMAC concentrations have been set.

For private water supplies, it is desirable to ascertain the levels of all health-related parameters when a new water supply is brought into use.

Monitoring of non-health related parameters

- Provide information that will assist in implementing the appropriate treatment
- Some of these parameters may be used as indicators of water quality
- Aid in determining suitability of new water sources

Domestic water quality

Water required for household use is called domestic water

- Municipal water treatment plants are designed to supply homes with a domestic water quality that meets drinking water quality guidelines
- Rural users often have two sources in the house, one for drinking (usually with extensive treatment), and non-potable water for other household needs

What is in water?

- In nature all water contains impurities
- As water moves it dissolves and carries with it the things it contacts
- These may be minerals, man-made chemicals and microorganisms
- At certain levels all of these may be considered contaminants

Contaminants

- A contaminant is considered any physical, chemical, biological, or radio-logical substance or matter that has an adverse effect on air, water, or soil.
- Contamination is the introduction into water of microorganisms, chemicals, toxic substances, wastes, or wastewater in a concentration that makes the water unfit for its next intended use.
- A contaminant in drinking water may make it unpalatable or even unsafe.

Sources of contamination

- Erosion of natural rock and soil formation
- Landfills
- Sewage
- Waste water treatment facilities
- Discharges from industrial processes
- Farmland
- Homes and yards

Categories of contaminants

- Microorganisms
- Radio-nuclides
- Inorganics
- Organics
- Disinfectants
- Disinfection by-products

Effects of contaminants in water

- **Aesthetic** - unappealing taste or odour and staining
- **Cosmetic** - unappealing effects of ones appearance
- **Acute health effects** - occur within hours or days of the time that the person consumes a contaminant.
- **Chronic health effects** - occur after people consume a contaminant for many years

Microorganisms

Not all microorganisms present in water will result in ill health effects. Those that do will likely cause acute health effects.

- Protozoan parasites
- Algae
- Bacteria
- Virus

Protozoan parasites

Cryptosporidium is a parasite that enters lakes and rivers through sewage and animal waste. It causes cryptosporidiosis, a mild gastrointestinal disease. However, the disease can be severe or fatal for people with severely weakened immune systems.

Giardia lamblia is a parasite that enters lakes and rivers through sewage and animal waste. It causes gastrointestinal illness more commonly known as beaver fever (e.g. diarrhea, vomiting, cramps).

Algae

Excess algae growth can impart taste and odour problems to potable water

Blue-green algae toxins are the naturally produced poisons stored in the cells of certain species of blue-green algae (Anabaena, Aphanizomenon and Microcystis). These toxins fall into various categories. Some are known to attack the liver (hepatotoxins) or the nervous system (neurotoxins); others simply irritate the skin.

Bacteria

- Most often cause gastroenteritis.
- Some disease causing bacteria are found naturally in water . These are often referred to as opportunistic pathogens.
- Other disease causing bacteria are found primarily in human and animal fecal waste.

Some illnesses caused by water borne bacterial pathogens.

Bacterial pathogen	Illnesses
Campylobacter jejuni	Gastroenteritis, meningitis, associated with reactive arthritis and Guillain-Barre paralysis
Escherichia coli (several species)	Gastroenteritis, hemolytic uremic syndrome (kidney failure)
Legionella species	Legionnaires Disease, Pontiac Fever
Salmonella species	Gastroenteritis, septicemia, anorexia, arthritis, cholecystitis, meningitis, pericarditis, pneumonia, typhoid fever
Shigella species	Gastroenteritis, dysentery, hemolytic uremic syndrome, convulsions in young children, associated with Reiters Disease (reactive arthropathy)
Vibrio cholerae	Cholera (dehydration and kidney failure)
Yersinia enterocolitica	Gastroenteritis, acute mesenteric lymphadenitis, joint pain

Virus

- Common sources of contamination is from human and animal fecal waste
- Low numbers multiply within the body to cause disease
- Most common health effect is gastrointestinal illness

Some illnesses caused by waterborne viral pathogens

Enteric virus	Illnesses
Astrovirus, Norwalk virus and other calciviruses, Rotavirus	Gastroenteritis
Coxsackievirus A	Meningitis, fever, respiratory disease
Coxsackievirus B	Myocarditis, congenital heart disease, rash, fever, meningitis, encephalitis, pleurodynia, diabetes melitis, eye infections
Echovirus	Meningitis, encephalitis, rash fever, gastroenteritis
Enteric Adenovirus	Respiratory disease, eye infections, gastroenteritis
HEpatitis A and Hepatitis E virus	Hepatitis
Poliovirus	Paralysis

Radio-nuclides

- Certain minerals are radioactive and may emit alpha or beta radiation as well as photons
- Contamination of water with radio-nuclides results from decay and erosion of natural and man-made deposits
- Consuming water over many years which contain radionuclide may have an increased risk of getting cancer.
- Uranium has been linked to kidney problems

Inorganics

Inorganic substances are mineral in origin. Contamination from inorganic compounds may occur from:

- Erosion of naturally occurring deposits
- Corrosion of pipes and plumbing
- Industrial wastes
- Sewage
- Landfill

Health Effects and some common source contamination of some inorganic chemicals

Chemical	Potential Health Effects	Sources of contamination
Arsenic	Skin damage; circulatory system problems; increased risk of cancer	Erosion of natural deposits; runoff from orchards; runoff from glass and electronic production wastes
Cadmium	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints.
Copper	Gastrointestinal distress; liver and kidney damage	Corrosion of household plumbing; erosion of natural deposits
Lead	Delays in physical or mental development of children; kidney problems; high blood pressure	Corrosion of household plumbing; erosion of natural deposits
Mercury	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands
Nitrates	Blue-baby syndrome. Competes for oxygen binding.	Runoff from fertilizer use, sewage; erosion of natural deposits.
Selenium	Hair or fingernail loss; numbness of fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines

Organics

A term used to refer to chemical compounds made from carbon molecules. These compounds may be natural materials (such as animal or plant sources) or man-made materials (such as synthetic organics). Most common sources of organics which have potential health effects are:

- Herbicides and insecticides
- Waste from industrial processes
- Runoff/leaching from landfill

Health Effects and some common source contamination of some organic compounds

Organic	Potential Health Effects	Sources of contamination
Atrazine	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops
2,4-D	Kidney, liver, or adrenal problems	Runoff from herbicide used on row crops
Glyphosate	Kidney problems: reproductive difficulties	Runoff from herbicide use
Lindane	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber and gardens
Methoxychlor	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa and livestock
Benzo(a)pyrene (PAHs)	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines
Dioxin	Reproductive difficulties: increased risk of cancer	Emissions from waste incineration and other combustion: discharge from chemical factories
Polychlorinated biphenyls (PCB's)	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals
Vinyl chloride	Increased risk of cancer	leaching from PVC pipes; discharge from plastic factories
Xylenes	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories

Disinfectants

- Disinfectants are water additives used to control microbes.
- Chlorine, chloramines and chlorine dioxide
- Potential health effects include: eye/nose irritation; stomach discomfort; anemia

Disinfection by-products

- Disinfection byproducts form when disinfectants added to drinking water to kill microbes react with naturally-occurring organic matter in water.
- Bromate; chlorite; haloacetic acids (HAAs); trihalomethanes (THMs)
- Increased risk of cancer; anemia; liver, kidney or central nervous system problems

Common problems in surface water sources

- Disease causing microorganisms
- High levels of dissolved nutrients and organic material
- Blue-green algae blooms

Common problems in ground water sources

- High levels of inorganic material such as iron, manganese, hardness, sodium, arsenic, and sulphates
- Some shallow wells have unique problems the most common being nitrates.

Water Treatment

Because of microbial and chemical problems in surface and ground water, most water sources cannot be consumed without treatment. Some commonly used treatments are:

- Filtration
- Coagulation
- Oxidation
- Sedimentation
- Disinfection
- Distillation

Filtration

- A process for removing particulate matter from water by passage through porous media.
- **Slow sand filtration** - the passage of raw water through a bed of sand at low velocity resulting in substantial particulate removal by physical and biological mechanisms
- **Granular activated carbon (GAC) filtration** - Adsorptive particles or granules of carbon usually have a high capacity to selectively remove certain trace and soluble materials from water. GAC may be colonized by bacteria which may also remove trace and soluble materials by biological mechanisms (BAC)
- **Reverse osmosis and other membranes** - allows the passage of the water but not the dissolved solids, the liquid produced is a demineralized water.
- **Coagulation** - The clumping together of very fine particles into larger particles caused by the use of chemicals (coagulants). The chemicals neutralize the electrical charges of the fine particles and cause destabilization of the particles. Often the first step in surface water treatment. Common coagulants are salts of aluminum and iron.

Oxidation

- Oxidation is the addition of oxygen, removal of hydrogen, or the removal of electrons from an element or compound.
- Oxidation can be effective in converting Fe 2+ and Mn2+ (water soluble forms) to Fe 3+ and Mn 3+ and Mn 4+
- Air, chlorine, potassium permanganate and ozone may be used as oxidants

Sedimentation

A process in which solid particles settle out of the water being treated in a large clarifier or sedimentation basin. Settling time of some particles through 1 m of water:

- Gravel - 1 second
- Fine sand - 2 minutes
- Clay, algae and parasites - 2 hours
- Bacteria - 8 days
- Colloids, virus - 2 to 200 years

Disinfection

- A process designed to kill most microorganisms in water, including essentially all pathogenic (disease-causing) bacteria.
- Chlorine is the most common disinfectant
- Others include chloramines, ozone and ultra violet radiation
- Many virus are resistant to disinfection

Distillation

Distillation is simply the process of heating water to its boiling point, capturing and then condensing the pure steam to form pure distilled water.

- Removes contaminants
- Boiling of the water results in disinfection

Responsibility and stewardship

As users and consumers of water we all must take responsibility in protecting our water supplies. Prevention of contamination is better than a cure for illness