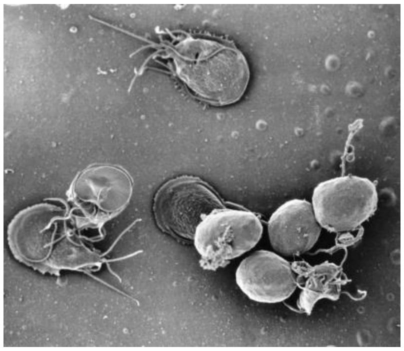
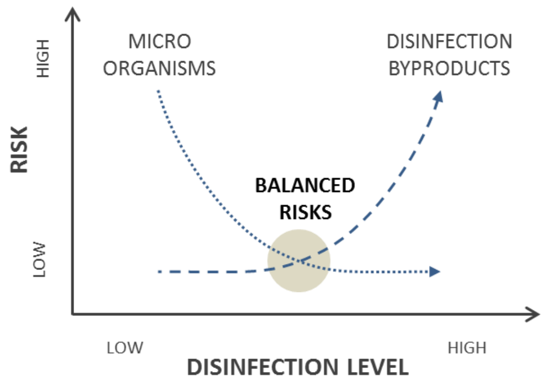
DRINKING WATER CHLORINATION: what are the risks?

Drinking untreated water is not recommended. Microorganisms like *e. coli*, *cryptosporidium* and *giardia lamblia* can be present due to contamination by human sewage and animal wastes, and can cause diarrhea, vomiting and cramps.[1] Ground water is sometimes less prone to these microorganism as the soil above acts as a filter, but they can still be present.[2] Chlorination, along with other treatment steps, is commonly used to disinfect drinking water because it kills a wide variety of micro-organisms. Chlorine has been used since the early 1900's and is responsible for the virtual elimination of typhoid fever in North America.[3]



Giardia Lamblia

However, safe drinking water has two important characteristics: it should be free from disease causing organisms, and levels of harmful chemicals should be below defined thresholds.[4] In 1974, newly available techniques allowed water quality scientists to measure chloroform and other trihalomethanes in drinking water. They linked levels of these unexpected chemicals to the reaction of chlorine with natural organic matter in the source water, which created additional chemical byproducts.[5] Since then, hundreds of these disinfection byproducts (DBPs) have been identified, many of which have harmful health effects when ingested at high levels, including increased risks of cancer.[6,7]



There is, in fact, a balance between the use of chlorine-based additives to kill harmful organisms in drinking water and the levels of harmful chemicals created as byproducts in the disinfection process.[8]

Levels of unwanted disinfection byproducts in drinking water are difficult to predict. The formation of DBPs is complex and varies among different chemicals. For example, the formation of trihalomethanes (THMs) increases at high pH levels and decreases at low pH levels, while the opposite is true of haloacetic acids (HAAs).[9] Levels of THMs can increase as the water moves from the treatment plant through the distribution system to the tap, while mean concentrations of HAAs may decrease.[10] Other factors that influence levels of DBPs include water temperature, the amount of organic material present in the water (which tends to be higher in surface water than in ground water and can fluctuate seasonally), chlorine dose, contact time, and bromide ion concentration.[11]

Drinking water guidelines have been established in Canada for some of the commonly occuring DBPs:

Chemical	**Guideline (mg/L)**	**Disinfection agent or byproduct**	**Health Considerations/Comments**
Chlorate	1.0	Byproduct of chlorine dioxide	Thyroid gland effects.
Chloramines	3.0	Disinfection agent	Reduced body weight gain, immunotixcity effects (formed when chlorine and ammonia present).
Chlorine	--	Disinfection agent	Low toxicity at levels found in drinking water.
Chlorine dioxide	--	Disinfection agent	Changes rapidly to chlorite.
Chlorite	1.0	Byproduct of Chlorine dioxide	Neurobehavioural effects, decrease brain weight, altered liver weight.
2,4-Dichlorophenol	1.9	Byproduct of chlorine	Cellular changes in liver (note: levels above 0.0003 have high odor and so unlikely to drink water).
Haloacetic acids	0.08	Byproduct of chlorine	Some chemical in this group are associated with liver cancer (dichloroacetic acid), other organ cancers (dichloroacetic acid, dibromoacetic acid, and trichloroacetic acid), liver and other organ effects (monochloroacetic acid).
N-nitrosodimethylamine	0.00004	Byproduct of chlorine and chloramines	Liver cancer (classified as probable carcinogen).
2,3,4,6-tetrachlorophenol	0.1	Byproduct of chlorine	Developmental effects, embryotoxicity (note: levels above 0.001 have high odor so unlikley to drink water).
2,4,6-trichlorophenol	0.005	Byproduct of chlorine	Liver cancer (classified as probable carcinogen).
Trihalomethanes (total)	0.1	Byproduct of chlorine	Liver effects, kidney and colorectal cancer (classified as a possible carcinogen).

Adapted from Guidelines for Canada Drinking Water Quality Summary Table[12]

CAREX Canada has estimated the lifetime excess cancer risk associated with some common DBPs measured in Ontario drinking water in 2011.[13] Average levels of chloroform and bromodichloromethane (both of which are THMs) are associated with lifetime excess cancer risks of 25.6 per million and 21 per million. The average level of dichloroacetic acid, one of the HAAs, is associated with a lifetime excess cancer risk of 17 per million. These excess risk estimates are higher than 1 per million, so more detailed risk analyses could be conducted to firmly establish the number of people at risk and their exposure level.

> **We want to move forward in improving environmental quality: the air we breathe, the land we walk on, the water we drink, the food we eat; that's who we are as a people. If our earth is health, we are healthy.[14]**

Finding a balance between the risks from harmful microorganisms, and the risks from high levels of DBPs requires management actions at key points in the waters' journey from source to tap.

WATER QUALITY MONITORING. Operators of water treatment plants regularly test the water quality, but do not always test for disinfection byproducts. If DBPs have not been measured previously, a monitoring plan should be developed to support a risk assessment for the people receiving the treated water.

SOURCE WATER PROTECTION. Cleaner source water needs less intense water treatment and presents lower short-term and long-term health risks.[15] Microorganisms can enter surface and ground water through manure in agricultural runoff, or from poorly located or maintained septic systems. Reducing contamination of the source water can help reduce the amount of disinfection required.

WATER TREATMENT TECHNOLOGY. Chlorine-based disinfectants interact with natural organic matter suspended in the incoming water and form DBPs. Most treatment plants take steps to reduce the organic matter before disinfectants are added. For example, flocculation is a process that clumps tiny floating particles together, making it easier to filter them out of the water. Making sure treatment processes are in place and working properly can help to reduce the formation of DBPs. There are also alternatives to using chlorine-based additives, such as ultra violet light or ozone treatement – if DBPs have been measured at levels of concern, consult a water treatment specialist to review the current system and options for lowering DBP levels.

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