Drinking Water Disinfection Byproducts

Background

Diarrheal diseases associated with poor water sanitation remain a leading cause of death in the developing world, particularly among children.[1] Starting just after 1900, chlorine disinfection of municipal drinking waters largely vanquished the outbreaks of cholera, typhoid and other waterborne diseases by the 1940s.[2] In fact, the benefits of chlorine disinfection predated the development of vaccines and antibiotics. Chlorination of drinking water represents one of the greatest achievements in public health.[3]

Municipal drinking water systems introduce chlorine into drinking water to eliminate or inactivate ("kill") harmful organisms in a process called disinfection. During this process, chlorine also reacts with naturally occurring organic matter that may be present in drinking water. This can result in the formation of disinfection byproducts.

What are Disinfection By-Products?

Disinfection byproducts, or DBPs, are chemicals that form when disinfectants such as chlorine react with organic matter such as algae, decaying plants, leaves and other materials naturally present in water which will eventually become drinking water. The most common types of drinking water disinfectants are chlorine, ozone, chlorine dioxide and chloramines. Each type of disinfectant forms different types of DBPs. The two most common categories of DBPs are trihalomethanes (THMs) and haloacetic acids (HAAs) formed in chlorinated drinking water. These can also form at lower levels with other types of disinfectants.

What determines the concentration of DBPs in the water system?

There are hundreds of different DBPs that can be formed in drinking water. The amount of naturally occurring organic matter in your source water largely determines its DBP level. However, the water system design and the way a system is operated can also affect the DBP level. Ground water systems (underground water obtained from wells) usually have very low levels of naturally occurring organic matter, so the level of DBPs formed in the water is low. Surface water systems (water obtained from streams, lakes, and reservoirs) often have higher naturally occurring organic matter and can have an increased amount of DBPs.

Image from mytapscore.com

What are the regulations on DBPs?

The U. S. Environmental Protection Agency (EPA) has established monitoring requirements and maximum contaminant levels (MCLs) for the following DBPs:

- Total Trihalomethanes (TTHMs) which is the sum of four compounds. TTHMs may be present at 0.080 milligrams per liter (mg/L) of water or less.

- The five most common HAAs are referred to as HAA5. HAA5 may be present at 0.060 mg/L of water or less.
- Bromate is formed primarily during ozone disinfection. Bromate may be present at 0.010 mg/L of water or less.
- Chlorite is formed during chlorine dioxide disinfection. Chlorite may be present at 1.0 mg/L of water or less.

The MCLs are enforceable regulatory standards with which public water systems must comply.

Image from crystalclearwaterva.com

Could DBPs be harmful to my health?

Some people who drink water containing THMs in excess of the MCL over many years may experience problems with their liver, kidneys or central nervous system and may have an increased risk of getting cancer. Likewise, people who drink water containing HAA5 in excess of the MCL over many years may have an increased risk of getting cancer. If your water contains elevated DBPs, you may be exposed to DBPs:

- By drinking tap water: Ingestion of chlorinated drinking water is the most common route of exposure.
- Inhalation: Some DBPs can evaporate or "volatilize" into the air in your home when you take a shower or while washing dishes. The hotter the water, the more likely that DBPs will be released into the air.
- Dermal: Only very small amounts of DBPs get into the body through the skin absorption, and the amount typically absorbed does not constitute a significant risk of exposure.

How often is monitoring for DBPs required?

The frequency of monitoring varies depending on the size of the public water system population served, source water type and the type of disinfectant used. Past levels of DBPs may also result in either an increase or decrease in monitoring. Monitoring can be required daily, monthly, quarterly, annually or once every three years.

What happens when the MCL for a DBP is exceeded?

A MCL violation is issued to any public water system that exceeds the MCL for one or more of the regulated DBPs. If the MCL is exceeded, the water provider must notify its customers of the exceedance and take action to lower the levels to below the MCL.

What can the water supplier do to reduce the amount of DBPs formed?

Many water suppliers may be able to reduce the amount of DBPs formed without reducing public health protection by one of the following methods:

- Reduce or remove organic materials that react with chlorine to produce DBPs.
- Reduce contact time or the concentration of chlorine in the distribution system.
- Ensure adequate cleaning and turnover of storage tanks and elimination of stagnant water.
- Modify the location where chlorine is added or include booster chlorination.
- Use a different type of authorized disinfectant.

Are there DBPs present in my water?

Your public water supplier is required to test for regulated DBPs in your drinking water periodically and is required to send information in the form of a consumer confidence report (CCR) about the quality of their water to customers each year on July 1.

What should I do if DBP levels in my water are elevated?

Use less water: Reduce shower and bath times to minimize exposure to volatilized DBPs.

Use cooler water: Volatile DBPs are more likely to get into the air in your home when the water being used is hot.

Provide adequate ventilation: Volatile DBPs can accumulate in the air in your home, especially in an enclosed area. Open windows or vent air to the outside during and after water use, use the exhaust fan, and spend less time in the bathroom after the water has been used.

Bottled water: Bottled water companies are required by the FDA to test the water regularly to make sure it meets standards and to identify the source of the water on the product label.

Water filters: NSF International, a non-profit organization certifies drinking water treatment devices for removal of some DBPs.

For more information on Drinking Water Disinfection By-Products:

Learn more: General Information and Facts (navy.mil);
Learn more: Drinking Water Disinfection | CDC;
Learn more: Chlorination Byproducts | CDC;
Learn more: Public Water Systems Disinfection Byproducts and Use of Monochloramine | US EPA;

[1] Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. World Health Organization. WHO Press, Geneva, Switzerland, 2009. http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf.

[2] History of Drinking Water Treatment. A Century of U.S. Water Chlorination and Treatment: One of the Ten Greatest Public Health Achievements of the 20th Century. Centers for Disease Control and Prevention. https://www.cdc.gov/healthywater/drinking/history.html

[3] Drinking Water Disinfection Byproducts (DBPs) and Human Health Effects: Multidisciplinary Challenges and Opportunities, Xing-Fang Li and William A. Mitch, *Environmental Science & Technology* 2018 *52* (4), 1681-1689