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# ENVIRONMENTAL Fact Sheet

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## Trihalomethanes: Health Information Summary

Trihalomethanes (THMs) are a group of organic chemicals that often occur in drinking water as a result of chlorine treatment for disinfectant purposes and, therefore, are also known as "disinfection byproducts" or DBPs. THMs are formed when chlorine reacts with naturally occurring organic material found in water such as decaying vegetation. Typically, the following four THMs are found as a result of chlorination: trichloromethane (chloroform), bromodichloromethane (BDCM), dibromochloromethane (DBCM), tribromomethane (bromoform).

Untreated or raw water rarely contains THMs in significant concentrations. Since chloroform is the THM found in highest concentrations and about which the most is known, the bulk of the information contained in this summary will pertain to chloroform.

Chloroform was once used as an anesthetic during surgery. Most chloroform produced today is used to make other chemicals. Chloroform is produced in the bleaching process of the pulp and paper industry and may also be formed in wastewater, which is often chlorinated in order to kill bacteria. Environmental release of chloroform is largely to air during pulp and paper bleaching and chlorination of drinking and wastewater, with a small amount released to water.

Information regarding the production and use of bromoform, BDCM, and DBCM is very limited. Bromoform appears to be produced in small quantities for use as a chemical intermediate and the other two THMs are thought to be produced in small quantities for laboratory use. Environmental release of these three THMs is largely to air during water chlorination.

### Health Effects

#### Absorption and Exposure

Chloroform may be absorbed into the body through ingestion, inhalation, and through the skin. The largest source of human exposure to THMs in the U.S. is from the consumption of chlorinated drinking water. Besides consuming water, other water uses in the home may contribute significantly to total chloroform exposure both from breathing in chloroform vaporized into the air and from it passing through the skin during bathing. Swimming in chlorinated pools will also contribute to the total exposure from the same exposure paths. One study observed that a greater percentage of chloroform passed through the skin when bathing water temperatures were increased. Chloroform does not concentrate in plants; therefore, the contribution from food to total chloroform exposure is small.

### **Short-Term (Acute) Effects**

Evidence of chloroform's acute effects on humans has been obtained primarily during its past use as an inhalation anesthetic. In addition to central nervous system effects, chloroform anesthesia was associated with cardiac arrhythmias and abnormalities of the liver and kidneys. Inhalation exposure experiments with animals revealed that high levels are toxic to the liver and secondarily to the kidneys. Skin contact with undiluted chloroform may cause a burning sensation, redness, and blistering.

Acute effects of exposure to the other THMs are not documented in the literature, but are expected to be similar to chloroform.

### **Long-Term (Chronic) Effects**

Chronic oral exposure of humans to chloroform at high doses results in adverse effects on the central nervous system, liver, kidneys and heart.

Animal studies have shown decreased body weights in rats and mice given chloroform at high oral doses and an increased incidence of respiratory disease at higher doses. At still higher doses given orally, liver abnormalities and decreased size of the reproductive organs were observed in rats. In animal studies investigating effects of chronic exposure to each of the other THMS, liver toxicity was observed. BDCM also caused kidney toxicity.

### **Carcinogenic (cancer-causing) Effects**

Chloroform has been demonstrated by several studies to produce kidney and liver tumors in rats and mice when given orally. In studies of human populations using chlorinated drinking water in which chloroform is the predominant THM, small increases in the incidence of rectal, colon and bladder cancer have been consistently observed, with evidence strongest for bladder cancer. However, because other possible carcinogens were found in this water, it is impossible to identify chloroform as the sole carcinogenic agent. Therefore, chloroform has been classified by the U.S. Environmental Protection Agency (EPA) as a Group B2 or "probable human carcinogen," based on sufficient animal evidence and inadequate human evidence of carcinogenicity. Evidence from animal studies now strongly indicates that chloroform exposure causes cancer only after first producing sustained cell toxicity. Because a certain threshold level of exposure is necessary to cause cell toxicity, cancer from chloroform exposure can only occur if that threshold is exceeded.

Based on the results of animal studies in which BDCM exposure increased tumors of the large intestine, kidney, and liver, and bromoform increased tumors of the large intestine, they are also classified in Group B2. DBCM is classified in Group C, "possible human carcinogen," based on limited animal evidence of an increase in liver tumors.

### **Developmental/Reproductive Effects**

Reports in the scientific literature in which chloroform was administered to animals indicate that chloroform has the potential to cause birth defects, miscarriages, and delays in fetal development. Results have generally been inconclusive regarding exposure to THMs and adverse developmental or reproductive effects in humans. However, the results of a recent study suggest an increased risk of early-term miscarriage from high levels of THMs in tap water, particularly BDCM. Additional studies are underway to determine the significance of the association found in this study.

## Health Standards and Criteria

The EPA has established a Maximum Contaminant Level (MCL) for total THMs in public drinking water systems. MCLs are enforceable drinking water standards determined by balancing the adverse health effects of a particular chemical against the feasibility and costs of treating contaminated water, and in the case of THMs, a consideration of the benefits of chlorination in reducing the risk from acute gastrointestinal diseases. The MCL for total THMs is 80 parts per billion (ppb = micrograms per liter (ug/l)).

Although chloroform is considered to be a probable human carcinogen, sufficient evidence has accumulated to indicate that it causes cancer only if, as previously explained, exposure exceeds the threshold level needed to cause cell toxicity. That threshold exposure has been calculated to be greater than the exposure level at which the most sensitive non-cancer adverse health effect, fatty cyst formation in the liver, may occur. Therefore, exposure at or below the state drinking water standard for chloroform of 70 ppb is not anticipated to result in either adverse non-cancer health effects or cancer.

The standard is based on an average daily intake of two liters (0.53 gallons) of water per day by a 70-kilogram (154 lb.) adult for a chronic time period. It is important to note that the 70 ppb state standard for chloroform is actually only 20 percent of the total safe exposure. This allows for a margin of safety and for water exposures that occur during bathing by inhalation of vaporized chloroform and absorption through the skin.

State drinking water standards developed for the other three THM compounds are 0.6 ppb for BDCM, 60 ppb for DBCM, and 5 ppb for bromoform. The drinking water standards for the four individual contaminants apply only if a water source was not intentionally chlorinated. If the well or water body was chlorinated, the federal MCL for the sum of the four THMs applies.

For more information, please contact the DES Environmental Health Program, 29 Hazen Drive, Concord, NH 03302-0095; (603) 271-4608.

### Suggested Reading and References

*Casarett and Doull's Toxicology: The Basic Science of Poisons*, Sixth Edition. Klaassen, C.D., ed. McGraw-Hill Publishing Co., Inc., New York, 2001.

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Toxicological Profile for Chloroform (Update). Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta, GA. September, 1997.

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Toxicological information on bromodichloromethane. Integrated Risk Information System (IRIS). U.S. EPA, Office of Health and Environmental Assessment.

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Toxicological information on dibromochloromethane. Integrated Risk Information System (IRIS). U.S. EPA, Office of Health and Environmental Assessment.