# Disinfection Byproduct Removal

CLEAR COMFORT


## Abstract

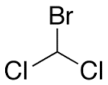
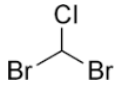
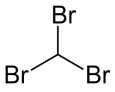
Toxic disinfection byproducts, such as Haloacetic Acids (HAAs) and Trihalomethanes (THMs) in recreational water are created by the interaction of a disinfectant, such as chlorine or bromine and organic matter. **Using the Clear Comfort system in a local YMCA swimming pool, a 91.5% reduction in HAA and an 84.8% reduction in THM was observed.** Notably, 68.9% of the known carcinogen chloroform was removed from this particular body of pool water with the Clear Comfort system.

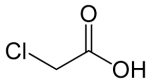
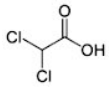
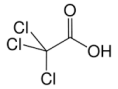
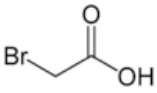
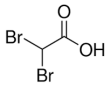

## Overview

Chlorination is commonly used in public swimming pools to prevent bacteria and other recreational water illness from harming swimmer patrons. Although chlorination of recreational water provides protection from most aquatic microorganisms, there is a growing concern of human exposure to chlorinated disinfection byproducts (DBPs) created in these facilities. Initially proposed in 1953, numerous clinical studies have documented physiological ailments (i.e., lifeguard lung and asthma) among swimmers especially in indoor swimming environments. These DBPs are created from the interaction between free chlorine and swimmer induced compounds such as urine, saliva, skin sweat, lotions etc. Trihalomethanes (THMs) and haloacetic acids (HAAs) are two categories of well documented and studied DBPs directly linked to negative health impacts in humans. The objective of this study was to assess the effectiveness of the Clear Comfort system in the removal of THMs and HAAs directly from swimming pool water.

## Volatile DBPs Identified in this Study

Disinfection byproducts identified in this study are listed in the following table. THMs are regulated in accordance to the U.S. Safe Water Drinking Act in 1979. All DBPs can be absorbed by the body either by inhalation, swallowing of pool water and/or through dermal contact.

| **TRIHALOMETHANE** (THM) | | |
|---|---|---|
| **Chloroform** |  | Known carcinogen |
| **Dichlorobromo-methane** |  | Kidney, liver and brain damage, increased risk of cancer |
| **Chlorodibromo-methane** |  | Mild irritant, increased risk of cancer |
| **Bromoform** |  | Irritant, known carcinogen |

| **HALOACETIC ACIDS** (HAA) | | |
|---|---|---|
| **Chloroacetic Acid** |  | Skin and eye irritant, poisonous, increased risk of cancer |
| **Dichloroacetic** |  | Known developmental toxin to lungs, liver reproductive system |
| **Trichloroacetic Acid** |  | Skin and eye irritant, poisonous, increased risk of cancer |
| **Bromoacetic Acid** |  | Corrosive to skin, eyes, and respiratory system |
| **Dibromoacetic Acid** |  | Corrosive to skin, eyes, and respiratory system |

*Source: EPA*

## Experimental Procedures

Samples were collected 18 inches below the water surface in sealed glass bottles with no head space and transported to the University of Colorado, Boulder for analysis. DBP vials were prepared in accordance with EPA Method 551.1 (THM/HAN) and 552.2 (HAA). Six milligrams of ammonium chloride, used as a chlorine quenching agent, was added to a 60ml septum capped vial to achieve a concentration of 0.1mg/mL NH4Cl.

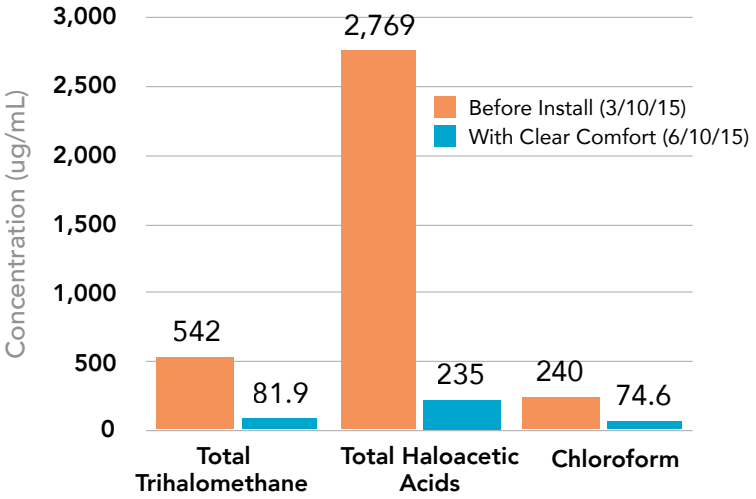
The cap was removed from the prepared DBP vial and the vial was slowly filled until just before overflowing. Extra caution was taken to prevent excess air, bubbles and headspace, entering the sample vials. Samples were kept refrigerated and in the dark at 4°C prior to analysis.

For THMs, a 50 mL volume of the sample was extracted using MTBE. A small 2uL sub-sample of the extract was analyzed into a GC equipped with a fused silica capillary column for separation and a linearized electron capture detector for analysis. For HAAs, a 100mL volume of sample was adjusted to a pH of 5.0 and extracted using a pre-conditioned miniature anion exchange column. Samples were eluted using a small volume of acetic methanol and esterfied directly using a small volume of the co-solvent, MTBE. The MTBE esters were then identified and measured using capillary gas chromatography with an electron capture detector (GC/ECD).

## Results and Discussion

Trihalomethanes and haloacetic acids are two very common, well documented and toxic categories of disinfection byproducts found in public swimming pools. After installation, the Clear Comfort system removed 91.5% of the total HAAs and 84.8% of THMs as indicated on the table below. 68.9% of the known human carcinogen, chloroform, was also removed from the pool water. Chloroform is proven to cause central nervous system depression, irreversible cardiac effects and is a known carcinogen.

### Disinfection Byproduct Removal Results with Clear Comfort




With the number of public swimming pools in the United States reaching over 300,000, the number of people exposed to human derived DBPs is extremely high. Because of the increased risk to public health, the National Swimming Pool Foundation and the Centers for Disease Control and Prevention have publicly documented numerous instances where patrons have become ill after swimming in indoor facilities, exposing themselves to the harmful effects caused by DBPs. While protection from microbiological hazards in swimming pools using chlorine or bromine is important, the need for removal of DBPs is critical in order to create a healthier swimming experience.

### REFERENCES

**"Basic Information about Disinfection Byproducts in Drinking Water: Total Trihalomethanes, Haloacetic Acids, Bromate, and Chlorite."** Water: Basic Information about Regulated Drinking Water Contaminants. United States Environmental Protection Agency, 13 Dec. 2013. Web.

Florentin A, et al. (2011) **Health effects of disinfection by-products in chlorinated swimming pools.** Int J Hyg Environ Health 214(6):461-9

Richardson S., et al. (2010) **What's in the pool? A comprehensive identification of disinfection by-products and assessment of mutagenicity of chlorinated and brominated swimming pool water.** Environ Health Perspect 118(11):1523–1530

Zwiener, C., et al. (2007) **Drowning in disinfection byproducts? Assessing swimming pool water** Environ. Sci. Technol., 41, pp. 363–372