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Microbials and Disinfection Byproducts (MDBP)

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Information about Chloramine in Drinking Water

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Chloramine Basics

What is chloramine?

Chloramine is a disinfectant used to treat drinking water. It is formed by mixing chlorine with ammonia. Although it is a weaker disinfectant than chlorine, it is more stable and extends disinfectant benefits throughout a water utility's distribution system (a system of pipes water is delivered to homes through). Some water systems use chloramine as a secondary disinfectant to maintain a disinfectant residual throughout the distribution system so that drinking water remains safe as it travels from the treatment facility to the customer. Chloramine has been used by water systems for almost 90 years, and its use is closely regulated.

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Is chloraminated water safe to use?

Chloraminated water that meets the EPA standard is safe for drinking and other general household activities such as bathing, cooking, laundry, and cleaning. The water can also be used for gardening (the water is safe for plants) and for watering lawns with no adverse effects.

As with chlorine, chloramine should be removed from the water used in kidney dialysis machines. However, chloraminated water that meets the EPA standard is safe for kidney dialysis patients to drink, since the digestive process neutralizes chloramine. If you have any questions, please consult your physician.

Chloramine (and chlorine) is toxic to fish and amphibians at levels used for drinking water. Unlike chlorine, chloramine does not rapidly dissipate on standing or by boiling. Therefore, fish owners must neutralize or remove chloramine from water used in aquariums or ponds. Treatment products are readily available at aquarium supply stores.

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Does EPA require systems to use chloramine?

While using chloramine to disinfect drinking water (almost always as a residual disinfectant, not as a primary disinfectant) is a common practice among drinking water systems, there are no EPA requirements that any system use chloramine for water treatment. A system, in consultation and coordination with the State, makes system-specific decisions to meet all treatment requirements and objectives for the system. Some systems may be able to comply by optimizing existing treatment and operation processes, while others may be required to make capital improvements in order to comply. Systems select treatment to meet regulatory requirements based on cost, existing treatment, technical complexity, other treatment objectives, and anticipated future rules and requirements.

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What are the advantages of using chloramine?

There are a number of operational and compliance benefits to using chloramine. Chloramine can provide the following benefits:

- Since chloramine is not as reactive as chlorine, it forms fewer disinfection byproducts. Some disinfection byproducts, such as the trihalomethanes (THMs) and haloacetic acids (HAAs), may

- have adverse health effects and are closely regulated (see separate Q&As on disinfection and disinfection byproducts).
- Because a chloramine residual is more stable and longer lasting than free chlorine, it provides better protection against bacterial regrowth in systems with large storage tanks and dead-end water mains.
 - Chloramine, like chlorine, is effective in controlling biofilm, which is a coating in the pipe caused by bacteria. Controlling biofilm also tends to reduce coliform bacteria concentrations and biofilm-induced corrosion of pipes.
 - Because chloramine does not tend to react with organic compounds, many systems will experience fewer taste and odor complaints when using chloramine.
 - Chloramine technology is relatively easy to install and operate. It is also among the less expensive disinfectant alternatives to chlorine.

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Are there disadvantages to using chloramine?

Drawbacks to the use of chloramine can include potential water quality problems (e.g., nitrification and corrosion) if the treatment process is not carefully controlled and the system's operational practices are not appropriately adjusted for the new disinfectant. Chloramine can change the chemical properties of the water, which can impact corrosion of lead and copper (see Q&A on chloramine impact on lead and copper below). Nitrification in the distribution system can also occur when using chloramine. Nitrification can have a detrimental effect on water quality (such as loss of disinfectant residual). Nitrification results from the bacterial oxidation of ammonia (conversion of ammonia into nitrite and then nitrate) but can be controlled by optimizing the chloramination process or by applying occasional free chlorination practices. Each system considering a switch to chloramine should determine whether or not it has the resources to properly maintain and monitor its water quality so that these issues do not become problems.

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Does the use of chloramine impact lead and copper corrosion?

There are two ways in which the use of chloramine can indirectly affect corrosion of lead and copper. First, when chloramine is used in water treatment as a residual disinfectant, it can change the chemical properties of the water, which subsequently can impact lead and copper corrosion. Certain conditions related to pH, alkalinity, and dissolved inorganic carbonate levels in the water can cause lead to dissolve from pipe material. Second, chloramination, if not properly optimized, can result in nitrification (conversion of ammonia into nitrite and then nitrate) in the presence of bacteria. Nitrification can lower the pH of the water, which can increase corrosion of lead and copper.

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If a water system is considering a switch from chlorination to chloramination as a residual disinfectant, what is EPA doing to help water systems avoid lead and copper corrosion?

EPA has developed a guidance manual, *Microbial and Disinfection Byproduct Rules Simultaneous Compliance Guidance Manual*, that provides recommendations to systems that are switching to a different residual disinfectant in order to minimize increases in the rate of lead and copper corrosion.

- [Simultaneous Compliance Guidance Manual for Stage 2 Rules PDF \(462pp, 3M, About PDF\)](#)

Recommendations from the guide:

- The water system should perform an optimal corrosion control treatment study prior to introducing chloramine into the distribution system.
- Add chemicals to the finished water to form a protective coating on the pipes, such as an orthophosphate corrosion inhibitor.

- Optimize the chloramination process to minimize the possibility of nitrification that can reduce pH and increase corrosion.

Also, in addition to its own research, EPA is evaluating studies from the open literature to determine how changes in treatment can impact the corrosion of lead in pipes and household plumbing.

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What is EPA's standard for chloramine in drinking water?

EPA has a standard (the Maximum Residual Disinfectant Level or MRDL) and a health goal (the Maximum Residual Disinfectant Level Goal or MRDLG) for chloramine. The enforceable MRDL is the highest level of a disinfectant allowed in drinking water. The MRDLG is the level of a drinking water disinfectant, below which there is no known or expected risk to health. EPA sets the standard as close to the health goal as feasible, while considering technology, treatment, cost, and risk tradeoffs. In the case for chloramine, the MRDL and MRDLG are the same.

EPA's Standard for chloramine in drinking water

Maximum Residual Disinfectant Level Goal (MRDLG)	Maximum Residual Disinfectant Level (MRDL)
4 milligrams per liter (mg/L) [4 parts per million (ppm)] measured as chlorine as an annual average	4.0 mg/L (4.0 ppm) measured as chlorine as an annual average

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How many people are using drinking water that has been treated with chloramine?

While EPA does not know the absolute number of people who are using water treated with chloramine, we expect that the number exceeds the 68 million who were identified in a 1998 survey.

Although each State keeps track of its water systems' practices, surveys have been conducted in the past to assess information on chloramine use for the whole nation. One such survey was reported out in the Economic Analysis for the Stage 2 Disinfection Byproduct Rule, which provided an estimate of the number of systems using chloramine prior to the implementation of the Stage 1 and Stage 2 Disinfection Byproduct Rules. Analysis of this survey estimated that at least 68 million people were using water disinfected with chloramine back in 1998. EPA expects chloramine use to increase due to compliance with the Stage 1 and Stage 2 Disinfection Byproduct Rules.

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Disinfection and Disinfection Byproducts

Why is drinking water disinfected?

Disinfecting tap water is critical to protect the public from disease-causing microorganisms. Chlorine is the most commonly used disinfectant. Drinking water is disinfected to kill bacteria, viruses, and other organisms that cause serious illnesses and deaths. Disinfection of drinking water has benefited public health enormously by lowering the rates of infectious diseases (for example, typhoid, hepatitis and cholera) spread through untreated water. In the beginning of the last century, prior to the disinfection of drinking water, tens of thousands of people died from disease-causing microorganisms in the water supply.

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What disinfectants are there?

There are a number of disinfectants that are effective at killing disease-causing microorganisms, including chlorine, chloramine, ozone, chlorine dioxide, and ultraviolet (UV) light. Disinfectant is applied in the treatment facility and again as water is delivered to homes through a system of pipes known as the distribution system. A residual amount of disinfectant has to be maintained throughout the distribution system. Ozone, chlorine dioxide, and UV light, alternatives to chlorine, are very effective treatment facility disinfectants to ensure public health protection. However, ozone or UV light cannot provide a continuous residual in the distribution system. Chlorine dioxide, while it can be used as a residual, is very difficult to maintain and simultaneously comply with other regulatory requirements; therefore its use is generally cost prohibitive. Therefore, water utilities typically use either chlorine or chloramine as residual disinfectants for the distribution system.

Some utilities apply more than one disinfectant through the treatment facility and the distribution system. Application of multiple disinfectants is often beneficial in controlling microorganisms and minimizing the formation of disinfection byproducts of health concern.

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What are disinfection byproducts?

Disinfectants are an essential element of drinking water treatment because of the barrier they provide against waterborne disease-causing microorganisms. However, disinfection byproducts (DBPs) form when disinfectants used to treat drinking water react with naturally occurring materials in the water (e.g., decomposing plant material).

Total trihalomethanes (TTHM – chloroform, bromoform, bromodichloromethane, and dibromochloromethane) and haloacetic acids (HAA5 – monochloro-, dichloro-, trichloro-, monobromo-, dibromo-) are widely occurring classes of DBPs formed during disinfection with chlorine and chloramine. These DBPs generally form at much lower levels when chloramine is used instead of chlorine. The amount of trihalomethanes and haloacetic acids in drinking water from one water system can change from day to day, depending on the season, water temperature, amount of chlorine added, the amount of plant material in the water, and a variety of other factors.

At this time, EPA believes that the best way to control DBPs is both to regulate known byproducts and to limit the quantity of disinfection byproduct precursors (e.g., decomposing plant material) allowed to react with disinfectants. TTHM and HAA5 are useful indicators for measuring DBPs in chlorinated drinking water because they commonly occur at levels that can be easily measured.

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How does chloramine use affect DBPs?

Some water systems may switch to chloramine to comply with the regulations and control disinfection byproduct levels. Since chloramine is not as reactive as chlorine with organic material in water, it produces substantially lower concentrations of the regulated disinfection byproducts, but it may increase exposure to other disinfection byproducts, such as N-nitrosodimethyl amine (NDMA) or possibly iodinated DBPs. Both chlorination and chloramination can form these and other disinfection byproducts. In general, exposure to these other disinfection byproducts is much lower than to TTHM and HAA5.

EPA expects to collect national occurrence data for NDMA and other nitrosamines under the Unregulated Contaminant Monitoring Rule 2, which requires public water systems to gather occurrence data in the finished water and the distribution system (72 FR 367, January 4, 2007). The data are to support EPA in regulatory assessment and decisions.

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How does EPA regulate DBPs?

EPA has worked collaboratively with stakeholders over the last 15 years in developing regulations for DBPs. EPA believes that these regulations will decrease risks from DBPs in drinking water nationwide. EPA's current standards for DBPs provide the safest balance between the need to disinfect drinking water for protection against pathogens while safeguarding citizens from potentially harmful contaminants.

The Agency first regulated total trihalomethanes (TTHM) in 1979 at 100 parts per billion (ppb) [100 micrograms/liter ($\mu\text{g/L}$)] for systems serving at least 10,000 people. The Agency revised this rule when it issued the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR) in December of 1998. The Stage 1 DBPR was the first phase in a rulemaking strategy required by Congress as part of the 1996 Amendments to the Safe Drinking Water Act. The Stage 1 DBPR set the maximum contaminant level for TTHM at 80 ppb and for the first time set a maximum contaminant level for five haloacetic acids (HAA5) at 60 ppb. These standards had to be met by the end of 2002 for surface water systems serving 10,000 or more people and by the end of 2004 for all other systems.

The Stage 2 DBPR was proposed in August 2003 and finalized on December 15, 2005. This rule builds on the other DBP rules. EPA believes that this regulation will further reduce exposure to DBPs and decrease potential cancer, reproductive, and developmental risks.

For more information:

- visit [Microbials and Disinfection Byproducts Web site](#), or
- contact the [Safe Drinking Water Hotline](#).

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Chloramine Health Information

What are the health effects of chloramine exposure?

Drinking water chloramine levels that meet the EPA standard are associated with minimal to no risk and should be considered safe. Some people who use water containing chloramine well in excess of the Maximum Residual Disinfectant Level (MRDL) could experience irritating effects to their eyes and nose. Some people who drink water containing chloramine well in excess of the MRDL could experience stomach discomfort or anemia.

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Did EPA examine inhalation and dermal studies in developing the drinking water health goal for chloramine?

Yes. In 1994, EPA examined inhalation and dermal studies on chloramine when determining the health goal (the Maximum Residual Disinfectant Level Goal or MRDLG), but there was not much information available. These studies covered both human clinical cases and animal studies and are summarized in the criteria document for chloramine. EPA is in the process of conducting a new literature search, and if additional information is found, the Agency would expect to update the criteria document.

EPA based its health goal on the lowest effect dose seen (or the lowest intake of chloramine to show any adverse effects) among all studies examined and made further adjustments from the low dose to allow for an adequate margin of safety. In the case of chloramine, this was a drinking water study in rats. See the Stage 1 Rule for further information.

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I am experiencing respiratory, skin, or digestive problems. Could it be chloramine in the water?

The available studies do not link these conditions to chloramine or chlorine at the level the public is exposed to in drinking water. EPA has set what it believes is a safe limit to exposure to chloramine in the drinking water, and this limit is closely monitored by your water system. There are many different causes of irritations, and the source is difficult to identify and varies with each person. If concerned, consult your physician.

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Are there home devices that can be used to remove chloramine?

Boiling the water or letting it sit out at in an open container at room temperature will not effectively get rid of the residual chloramine. Point of entry and point of use (POE/POU) devices can be used to eliminate the chloramine in household water. POE/POU devices that remove chloramine are filtration systems with granular activated carbon or charcoal.

The National Sanitation Foundation (NSF) independently tests and certifies water treatment systems for chloramine removal. In order for a product to earn "certification" for reduction of chloramine, it must be able to reduce chloramine from 3 mg/L (ppm) to 0.5 mg/L (ppm).

- Information on NSF Certified Drinking Water Treatment Units can be obtained either:
 - [on NSF's Web site](#), or
 - by phone 1-877-867-3435.

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Resources

How do I learn more about my drinking water?

EPA strongly encourages people to learn more about their drinking water. Your water bill or telephone book's government listings are a good starting point for local information. Water systems have several different choices when it comes to disinfection. To find out if chloramine is used in your community, contact your local water system.

EPA requires all community water systems to prepare an annual consumer confidence report (CCR) (sometimes called a water quality report) for their customers. The CCR lists the level of contaminants that have been detected in treated water and shows how these compare with EPA's drinking water regulations. Some water suppliers have posted their annual reports on EPA's Web site. Otherwise, if you have not received this annual report, you may request it by calling your water system.

- [Consumer Confidence Reports Web site](#)
- [Find out if your water systems has their CCR listed online](#)

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Where can I get more information on chloramine?

More information about health effects and drinking water disinfection from EPA is available in the following locations:

- [EPA's Integrated Risk Information System \(IRIS\) Web site](#).
IRIS includes updated information up to 2005 for the oral and carcinogenicity assessments for chloramine (assessment found under heading monochloramine).
- [Drinking Water Health Criteria Document for Chloramines](#), (155pp, 2M, [About PDF](#))
Health and Ecological Criteria Division, Office of Science and Technology, Office of Water, EPA, 1994

- [Stage 1 Rule page](#) has further information on exposure and occurrence and summarizes of health information used to set the current chloramine standard.
- [Stage 2 Rule Web site](#) has further information on disinfection practices and explains risk-risk tradeoffs associated with disinfection byproducts and pathogen control.

To reach EPA for more information:

- Write
[EPA's Water Resource Center \(RC-4100T\)](#)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Please specify document(s) requested, or
- contact the [Safe Drinking Water Hotline](#).

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Last updated on Friday, June 29th, 2007.

<http://www.epa.gov/safewater/disinfection/chloramine/index.html>

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