



Chloramines Q &A's

Chloramines are disinfectants used to treat drinking water. Chloramines are most commonly formed when ammonia is added to chlorine to treat drinking water. The typical purpose of chloramines is to provide longer-lasting water treatment as the water moves through pipes to consumers. This type of disinfection is known as secondary disinfection. Chloramines have been used by water utilities for almost 90 years, and their use is closely regulated. More than one in five Americans uses drinking water treated with chloramines. Water that contains chloramines and meets EPA regulatory standards is safe to use for drinking, cooking, bathing and other household uses.

Many utilities use chlorine as their secondary disinfectant; however, in recent years, some of them changed their secondary disinfectant to chloramines to meet [disinfection byproduct regulations](#). In order to address questions that have been raised by consumers about this switch, EPA scientists and experts have answered 29 of the most frequently asked questions about chloramines. We have also worked with a risk communication expert to help us organize complex information and make it easier for us to express current knowledge.

The question and answer format takes a step-wise approach to communicate complex information to a wide variety of consumers who may have different educational backgrounds or interest in this topic. Each question is answered by three key responses, which are written at an approximately sixth grade reading level. In turn, each key response is supported by three more detailed pieces of information, which are written at an approximately 12th grade reading level. More complex information is provided in the *Additional Supporting Information* section, which includes links to documents and resources that provide additional technical information.

EPA continues to research drinking water disinfectants and expects to periodically evaluate and possibly update the questions and answers about chloramines when new information becomes available.

EPA Chloramines Q & A's
BASIC INFORMATION ABOUT CHLORAMINES

1) What are chloramines?

Chloramines are *disinfectants* used to treat drinking water.

- Chloramines are most commonly formed when ammonia is added to chlorine to treat drinking water.
- The most typical purpose of chloramines is to protect water quality as it moves through pipes.
- Chloramines provide long-lasting protection as they do not break down quickly in water pipes.

The different types of chloramines are monochloramine, dichloramine, trichloramine, and organic chloramines.

- When chloramines are used to disinfect drinking water, monochloramine is the most common form.
- Dichloramine, trichloramine, and organic chloramines^{1,2} are produced when treating drinking water but at much lower levels than monochloramine.
- Trichloramines¹ are typically associated with disinfected water used in swimming pools.

The Environmental Protection Agency regulates the safe use of chloramines in drinking water.³

- EPA requires water utilities to meet strict health standards when using chloramines to treat water.
- EPA chloramines regulations are based on the average concentration of chloramines found in a water system over time.
- EPA regulates certain chemicals formed when chloramines react with natural organic matter⁴ in water.

Additional Supporting Information:

1. Dichloramine is formed when the chlorine to ammonia-nitrogen weight ratio is greater than 5:1, however, this reaction is very slow. Organic chloramines are formed when chlorine reacts with organic nitrogen compounds. Source: *Optimizing Chloramine Treatment*, 2nd Edition, AwwaRF, 2004
2. Trichloramine formation does not usually occur under normal drinking water treatment conditions. However, if the pH is lowered below 4.4 or the chlorine to ammonia-nitrogen weight ratio becomes greater than 7.6:1, then trichloramine can form. Trichloramine formation can occur at a pH between 7 and 8 if the chlorine to ammonia-nitrogen weight ratio is increased to 15:1. Source: *Optimizing Chloramine Treatment*, 2nd Edition, AwwaRF, 2004
3. The drinking water standard for chloramines is 4 parts per million (ppm) measured as an annual average. More information on water utility use of chloramines is available at <http://www.epa.gov/safewater/disinfection/index.html> and in the 1997-1998 Information Collection Rule, a national survey of large drinking water utilities for the Stage 2 Disinfection Byproducts Rule (DBPR). Information on the Stage 2 DBPR is available at <http://www.epa.gov/safewater/disinfection/stage2/>. More information on EPA's standard setting process may be found at: <http://www.epa.gov/OGWDW/standard/setting.html>.
4. *Natural Organic Matter*. Complex organic compounds that are formed from decomposing plant, animal and microbial material in soil and water. They can react with disinfectants to form disinfection by products. Total organic carbon (TOC) is often measured as an indicator of natural organic matter.

2) How long has **monochloramine been used as a drinking water disinfectant? How is monochloramine typically used? How many people/water utilities use monochloramine?**

Monochloramine has been used as a drinking water disinfectant for more than 90 years.¹

- Monochloramine has been shown to be an effective disinfectant based on decades of use in the U.S., Canada, and Great Britain.
- Monochloramine is typically used along with chlorine as part of the drinking water treatment process.
- Monochloramine helps protect people from waterborne diseases.²

Monochloramine is most often used to maintain water quality in the pipes.³

- Monochloramine provides long-lasting protection of water quality.
- Monochloramine is effective as a disinfectant because it does not dissipate quickly
- Monochloramine helps lower levels of potentially harmful regulated disinfection byproducts compared to chlorine.

More than one in five Americans use drinking water treated with monochloramine.

- Monochloramine use has increased in recent years due in part to new drinking water regulations developed to limit certain disinfection byproducts.
- New drinking water regulations limit the concentration of potentially harmful disinfection byproducts that may occur in drinking water.⁴
- Several large cities such as Denver and Philadelphia have been using monochloramine as part of their treatment process for decades.

Additional Supporting Information:

1. For more information on the history of drinking water disinfection visit: <http://www.epa.gov/safewater/consumer/pdf/hist.pdf>.
2. For more information on waterborne disease visit: http://www.cdc.gov/ncidod/diseases/list_waterborne.htm.
3. Drinking water is typically treated before it is passed through the pipes, however, water is not sterile and can contain low levels of microorganisms that survive through treatment and distribution. Microbes can grow on pipe surfaces forming a thin biofilm layer. These microbes, while typically not harmful, can contribute to various problems, including (1) the release of coliform bacteria into the water, (2) increased disinfectant demand, (3) aesthetic water quality problems (e.g., unpleasant taste or odor), and (4) pipe corrosion or nitrification reactions and the resulting release of contaminants such as nitrite, nitrate, and lead into the water. See question 27 for more information on contaminant release, biofilms, and nitrification. In some cases, biofilms have been known to harbor pathogens that cause disease, especially in severely immunocompromised persons. See *Drinking Water Distribution Systems – Assessing and Reducing Risks*—chapters 6 and 7, http://www.nap.edu/catalog.php?record_id=11728#toc. Also see EPA's Biofilm White Paper: http://epa.gov/SAFEWATER/disinfection/tcr/pdfs/whitepaper_tcr_biofilms.pdf.
4. See the Stage 1 and Stage 2 Disinfection Byproduct Rules for more information on new drinking water regulations (<http://www.epa.gov/safewater/disinfection/index.html>).

BASIC INFORMATION ABOUT DRINKING WATER DISINFECTION

3) Why is drinking water disinfected? What is the difference between primary and secondary disinfection? How is monochloramine used in a treatment plant?

Drinking water is disinfected to protect public health.¹

- Prior to the widespread use of [disinfectants](#), many people became ill or died because of contaminated water.²
- Disinfection reduces or eliminates illnesses acquired through drinking water.
- EPA and CDC believe the benefits of drinking water disinfection outweigh the potential risks from [disinfection byproducts](#).

Primary disinfection kills or inactivates bacteria, viruses, and other potentially harmful organisms in drinking water.³

- Disinfection prevents infectious diseases such as typhoid fever, hepatitis, and cholera.⁴
- Some disinfectants are more effective than others at inactivating certain potentially harmful organisms.³
- Disinfection processes vary from water utility to water utility based on their needs and to meet EPA treatment requirements.⁵

Secondary disinfection provides longer-lasting water treatment as the water moves through pipes to consumers.

- Secondary disinfection maintains water quality by killing potentially harmful organisms that may get in water as it moves through pipes.⁵
- Monochloramine is commonly used as a secondary disinfectant.
- Monochloramine may be more useful than chlorine in killing certain potentially harmful organisms in pipes such as those that cause Legionnaire's disease.⁶

Additional Supporting Information:

1. Not all federally-regulated ground water utilities are required to disinfect their water. Regulatory authorities work with utilities to decide if treatment is necessary.
2. See question 2 for additional history on drinking water disinfection.
3. Potentially harmful organisms include disease-causing bacteria, viruses, and protozoa. Chlorination and chloramination are not effective at inactivating *Cryptosporidium*. EPA requires that utilities that use surface water test and treat for *Cryptosporidium* where necessary. For information on alternative disinfectants and other oxidants visit: <http://www.epa.gov/safewater/mbdp/mbdptg.html#disinfect>.
4. For more information on these infectious diseases visit the following websites:
http://www.cdc.gov/ncidod/dbmd/diseaseinfo/typhoidfever_g.htm (for typhoid fever);
<http://www.cdc.gov/hepatitis/index.htm> (for hepatitis);
http://www.cdc.gov/nczved/dfbmd/disease_listing/cholera_gi.html (for cholera).
5. All utilities that use surface water are required to treat or remove 99.99% of viruses and also to filter their water. However, some surface water systems may obtain waivers for filtration if the water comes from a protected source. Surface water systems must also have a detectable disinfectant residual in their distribution system. Ground water systems are only required to disinfect as necessary and are not required to have a detectable disinfectant residual. Ground water systems that are found to be influenced by surface water (for example, wells located next to rivers) are required to follow the treatment requirements for surface water. In addition, States may have more stringent treatment requirements and may, for example, require all of their ground water systems to disinfect. For more information on EPA surface water treatment requirements visit:
<http://www.epa.gov/safewater/mbdp/mbdptg.html> and for information on requirements for ground water systems visit: <http://www.epa.gov/safewater/disinfection/gwr/basicinformation.html>.
6. For more information on Legionnaire's disease visit <http://www.cdc.gov/legionella/>.

4) What **disinfectants** are available for drinking water?

Most water utilities use chlorine as a *primary disinfectant* because of its effectiveness in killing potentially harmful organisms.²

- Chlorine is effective in killing bacteria, viruses, and other potentially harmful organisms in water.
- One disadvantage of chlorine is it can react with natural organic matter³ present in water to form potentially harmful disinfection byproducts.
- Water utilities sometimes use chlorine several times during treatment because the initial dose loses its effectiveness over time.

Monochloramine is commonly used as a *secondary disinfectant* to protect the water as it travels from the treatment plant to consumers.

- Monochloramine is effective in killing bacteria, viruses, and other potentially harmful organisms but takes much longer to act than chlorine.
- One disadvantage of monochloramine is it can react with natural organic matter present in water to form potentially harmful disinfection byproducts.
- Monochloramine is more chemically stable than chlorine, which makes it longer lasting and an effective secondary disinfectant.

Water utilities may use *ozone, UV light, or chlorine dioxide* as *primary disinfectants* in the treatment plant.

- **Ozone**, UV light, and chlorine dioxide are effective in killing bacteria, viruses, and other potentially harmful organisms in water at the treatment plant.
- One disadvantage of ozone, UV light, and chlorine dioxide is they do not provide protection as water travels through pipes.
- Either chlorine or monochloramine should still be used in addition to any primary treatment process to protect the quality of treated water as it travels from the treatment plant to the customer.

Additional Supporting Information:

1. See question 3 for a discussion of primary and secondary disinfectants. See questions 5 and 6 for a specific discussion of chlorine and monochloramine as a primary and secondary disinfectant.
2. Potentially harmful organisms include disease-causing bacteria, viruses, and protozoa. Chlorination and chloramination are not effective at inactivating *Cryptosporidium*. EPA requires that utilities that use surface water test and treat for *Cryptosporidium* where necessary.
3. *Natural Organic Matter*: Complex organic compounds that are formed from decomposing plant, animal and microbial material in soil and water. They can react with disinfectants to form disinfection by products. Total organic carbon (TOC) is often measured as an indicator of natural organic matter.

5) How effective is **monochloramine** vs. chlorine as a **primary disinfectant**?

Monochloramine can be an effective primary disinfectant in limited situations.

- Monochloramine takes much longer than chlorine to kill most potentially harmful organisms.²
- Monochloramine can be used as a primary disinfectant but the amount of time needed for treatment makes it impractical for most utilities.
- But because it is longer lasting than chlorine, monochloramine is often used as a secondary disinfectant.

Chlorine is a very effective primary disinfectant.

- Chlorine is very effective at killing most potentially harmful organisms.²
- Chlorine kills most potentially harmful organisms quickly.
- Chlorine is the most frequently used primary disinfectant of drinking water.

A combination of disinfectants is often used for primary disinfection.

- Primary disinfection usually consists of multiple disinfection steps that may start as the water enters the treatment plant.
- When used as a primary disinfectant, monochloramine effectiveness is increased by combining it with other disinfectants.
- The choice of which combination of disinfectants to use varies from water utility to water utility based on their needs and to meet EPA treatment requirements.³

Additional Supporting Information:

1. See question 3 for a discussion of primary and secondary disinfectants. See questions 17 and 18 for advantages and disadvantages of monochloramine use.
2. Potentially harmful organisms include disease-causing bacteria, viruses, and protozoa. Chlorination and chloramination are not effective at inactivating *Cryptosporidium*. EPA requires that utilities that use surface water test and treat for cryptosporidium where necessary.
3. All utilities that use surface water are required to treat or remove 99.99% of viruses and also to filter their water. However, some surface water systems may obtain waivers for filtration if the water comes from a protected source. Surface water systems must also have a detectable disinfectant residual in their distribution system. Ground water systems are only required to disinfect as necessary and are not required to have a detectable disinfectant residual. Ground water systems that are found to be influenced by surface water (for example, wells located next to rivers) are required to follow the treatment requirements for surface water. In addition, States may have more stringent treatment requirements and may, for example, require all of their ground water systems to disinfect. For more information on surface water treatment requirements visit <http://www.epa.gov/safewater/mdbp/implement.html> and <http://www.epa.gov/safewater/disinfection/lt2/basicinformation.html> ; for information on requirements for ground water systems visit: <http://www.epa.gov/safewater/disinfection/gwr/basicinformation.html>.

6) How effective is **monochloramine** vs. **chlorine** as a **secondary disinfectant**¹?

Both chlorine and monochloramine are effective secondary disinfectants.¹

- Both chlorine and monochloramine protect the quality of treated water as water travels through pipes.
- Both chlorine and monochloramine produce disinfection byproducts, some of which are harmful to human health.
- EPA and CDC believe the benefits of drinking water disinfection outweigh the potential risks from disinfection byproducts.

Monochloramine has several advantages over chlorine as a secondary disinfectant.

- Monochloramine is more chemically stable than chlorine.
- Monochloramine produces fewer potentially harmful *regulated* disinfection byproducts than chlorine.³
- Monochloramine is longer lasting than chlorine, making it useful for killing certain harmful organisms found in pipes such as those that cause Legionnaires' disease.⁴

The choice of which secondary disinfectant to use varies from water utility to water utility based on their needs.

- States and water utilities work together in selecting primary and secondary disinfectants.¹
- States and water utilities balance a wide range of factors in deciding which disinfectant to use.⁵
- Either chlorine or monochloramine is used as a secondary disinfectant by water utilities.

Additional Supporting Information:

1. See question 3 for a discussion of primary and secondary disinfectants. See questions 17 and 18 for advantages and disadvantages of monochloramine use.
2. See question 2 for a more information about protecting the quality of water as it travels through pipes.
3. EPA has adopted enforceable regulations to limit occurrence of disinfection byproducts in drinking water for a group of four total trihalomethanes (TTHMs): (chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM), and bromoform);, a group of five haloacetic acids (HAA5): (monochloroacetic acid (MCA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid (MBA), and dibromoacetic acid (DBA)); , and the individual disinfection byproducts chlorite and bromate. The maximum contaminant levels for these disinfection byproducts are: TTHMs (0.080 mg/L), HAA5 (0.060 mg/L), chlorite (1.0 mg/L), bromate (0.010 mg/L). See Stage 2 Disinfection Byproducts Rule (71 FR 388, January 4, 2006) for more information on disinfection byproducts and discussion of uncertainties, at <http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-04/w03.pdf>.
4. For more information on Legionnaire's disease visit <http://www.cdc.gov/legionella/>.
5. Factors include the type and condition of source water, how much water needs to be treated, complexity of operation, etc. Guidance manuals are available at: <http://www.epa.gov/safewater/disinfection/stage2/compliance.html>. Hard copies are available by ordering publications through EPA's Water Resource Center (phone: 202-566-1729).

WATER SYSTEMS, DISINFECTION BYPRODUCTS, AND THE USE OF MONOCHLORAMINE

7) Why are disinfection byproducts a public health concern?

Drinking water research indicates that certain byproducts of water disinfection have the potential to be harmful.¹

- Some research indicates that certain byproducts of water disinfection are linked to increases in cancer incidence, including bladder cancer.
- Some research indicates that certain byproducts of water disinfection can be linked to liver, kidney, central nervous system problems, and reproductive effects.
- Some research indicates that certain byproducts of water disinfection can be linked to anemia.²

Assessments of the risks of water disinfection can be highly uncertain.

- Scientists from many organizations have conducted research on the effects of disinfection byproducts.
- In some cases research results are contradictory; some studies show links to adverse health effects and others do not.
- Regulatory documents describe the uncertainties in risk assessments of disinfection byproducts.¹

The Environmental Protection Agency considers risk and uncertainty in establishing regulations for water disinfection.

- Regulators weigh the public health benefits of disinfection against the risks of the potentially harmful disinfection byproducts.³
- EPA sets limits for certain disinfection byproducts which are linked to health effects such as bladder cancer.¹
- EPA and other organizations continue to conduct research on disinfection byproducts.

Additional Supporting Information:

1. EPA has adopted enforceable regulations to limit occurrence of disinfection byproducts in drinking water for a group of four total trihalomethanes (TTHMs) (chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM), and bromoform), a group of five haloacetic acids (HAA5) (monochloroacetic acid (MCA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid (MBA), and dibromoacetic acid (DBA)), and the individual byproducts chlorite and bromate. The maximum contaminant levels for these disinfection byproducts are: TTHMs (0.080 mg/L), HAA5 (0.060 mg/L), chlorite (1.0 mg/L), bromate (0.010 mg/L). See Stage 2 Disinfection Byproducts Rule (71 FR 388, January 4, 2006) for more information on disinfection byproducts and discussion of uncertainties, <http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-04/w03.pdf>.
2. For more information on anemia and disinfection byproducts visit <http://www.epa.gov/ogwdw/hfacts.html>.
3. See question 8 for additional information on how EPA regulates disinfection byproducts.

8) How does EPA regulate **disinfection byproducts (DBPs)**?

EPA uses the presence of regulated **disinfection byproducts** as indicators of the presence of other disinfection byproducts.¹

- EPA sets limits for two individual and two groups of disinfection byproducts (DBPs)² that are linked to health problems.
- Disinfectants react with natural organic matter³ to produce disinfection byproducts, some of which are of health concern.
- Recent EPA drinking water regulations require water utilities to not exceed certain concentration limits for particular disinfection byproducts.¹

Water utilities must test water regularly to make sure regulated disinfection byproducts are within EPA limits.

- EPA recently strengthened disinfection byproduct regulation.²
- Regardless of the disinfectant used, the types and concentrations of disinfection byproducts will vary from day to day and among utilities.
- The concentration and type of disinfectant byproducts depend on many factors, including source water type, water temperature, the levels of natural organic matter in the water, as well as the amount and type of disinfectant used.

EPA conducts research to better understand disinfection byproducts in drinking water.

- EPA scientists coordinate their research on disinfection byproducts with scientists from many organizations.
- Scientific studies are focused on identifying disinfection byproducts that may have an adverse effect on public health.⁴
- EPA scientists and decision makers review regulations of disinfection byproducts every six years to determine if they need to be revised.⁵

Additional Supporting Information:

1. EPA has adopted enforceable regulations to limit the occurrence of disinfection byproducts in drinking water for a group of four total trihalomethane (TTHMs) (chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM), and bromoform), a group of five haloacetic acids (HAA5) (monochloroacetic acid (MCA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid (MBA), and dibromoacetic acid (DBA)), and the individual byproducts chlorite and bromate. The maximum contaminant levels for these disinfection byproducts are: TTHMs (0.080 mg/L), HAA5 (0.060 mg/L), chlorite (1.0 mg/L), bromate (0.010 mg/L). See Stage 2 Disinfection Byproducts Rule (71 FR 388, January 4, 2006) for more information on disinfection byproducts and discussion of epidemiological data on chlorinated water exposure and cancer, <http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-04/w03.pdf>. TTHMs and HAAs typically occur at higher levels than other known and known but unidentified disinfectant byproducts. The presence of TTHMs and HAA5 is representative of the occurrence of many other chlorinated disinfectant byproducts; thus, a reduction in TTHMs and HAA5 generally indicates a reduction of other types of disinfectant byproducts.

2. The two groups are total trihalomethanes and haloacetic acids. The two individual DBPs are chlorite and bromate.

3. *Natural Organic Matter*. Complex organic compounds that are formed from decomposing plant, animal and microbial material in soil and water. They can react with disinfectants to form disinfection byproducts. Total organic carbon (TOC) is often measured as an indicator of natural organic matter.

4. See the Contaminant Candidate List online at <http://www.epa.gov/OGWDW/ccl/ccl3.html> for contaminants EPA proposes to review.

5. EPA scientists consider new disinfection byproducts research as part of the six year review process. For information on the six year review process visit: <http://epa.gov/safewater/review.html>.

9) How do the kinds and concentrations of *disinfection byproducts* formed by *monochloramine* compare to those formed by chlorine?

Water treated with chlorine and *monochloramine* contains different types and concentrations of *disinfection byproducts*.

- Compared to chlorine, water treated with monochloramine contains fewer regulated disinfection byproducts that have been linked to human health problems.
- The formation of disinfection byproducts is influenced by source water type and the type of disinfectant used.
- Formation can vary daily with the amount of natural organic matter in the water, temperature, rainfall, and distance from the treatment plant or other factors influencing water chemistry.¹

Compared to chlorine, water treated with monochloramine contains lower concentrations of regulated disinfection byproducts.²

- Compared to water treated with chlorine, water treated with monochloramine contains lower concentrations of the two major types of *regulated* disinfection byproducts.²
- Compared to water treated with chlorine, water treated with monochloramine contains lower concentrations of *regulated* disinfection byproducts linked to bladder cancer.
- Regardless of the disinfectant used, the types and concentrations of disinfection byproducts vary from each utility and also from day to day.

Compared to water treated with chlorine, water treated with monochloramine may contain higher concentrations of unregulated disinfection byproducts.³

- EPA scientists are currently studying the *unregulated* disinfection byproducts³ that form in water treated with monochloramine.
- Compared to water treated with chlorine, water treated with monochloramine may contain different *unregulated* disinfection byproducts than chlorinated water.
- EPA and other organizations continue to conduct research on *unregulated* disinfection byproducts.³

Additional Supporting Information:

1. Water chemistry describes the chemical properties of water such as pH, hardness, and alkalinity. Changes in water chemistry can cause subsequent changes to the physical (e.g., taste and odor) and biological (e.g., biofilm formation and nitrification) properties of water.
2. TTHM and HAA5 are the regulated disinfection byproduct groups that form at lower concentrations with monochloramine. See question 7 for more information about TTHM and HAA5.
3. Examples of these unregulated disinfection byproducts include nitrosamines (including nitrosodimethylamine, NDMA), iodo-trihalomethanes, and iodo-acids. See question 7 for additional detail on disinfection byproducts. Specific information on NDMA can be found at <http://www.epa.gov/tio/download/contaminantfocus/epa542f07006.pdf>. See question 19 for additional information on disinfection byproduct research.

10) Why are water utilities switching to **monochloramine**?

New EPA regulations require water utilities to control levels of regulated disinfection byproducts.¹

- Water utilities are required to comply with EPA's revised regulations.
- Water utilities are assessing if they need to make changes to comply with revised EPA regulations.²
- To meet the new regulations, a subset of utilities has decided to change their secondary disinfectant from chlorine to monochloramine.

Water treated with monochloramine contains reduced levels of regulated disinfection byproducts compared to water treated with chlorine.¹

- Monochloramine produces lower concentrations of regulated disinfection byproducts because it is less reactive than chlorine with natural organic matter.³
- The formation of disinfection byproducts is influenced by source water type and the type of disinfection used.
- Formation can vary daily with the amount of natural organic material in the water, temperature, rainfall, and distance from the treatment plant or other factors influencing water chemistry.⁴

Water utilities switching from chlorine to monochloramine report fewer consumer concerns about their water.

- Water utilities switching from chlorine to monochloramine report fewer consumer concerns about the taste of water.⁵
- Water utilities switching from chlorine to monochloramine report fewer consumer concerns about odor.⁵
- Consumers may still notice a chlorine smell when utilities use monochloramine.⁵

Additional Supporting Information:

1. See Stage 2 Disinfection Byproducts Rule (71 FR 388, January 4, 2006) for more information on disinfection byproducts and discussion of epidemiological data on chlorinated water exposure and cancer, <http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-04/w03.pdf>.
2. See question 11 for additional ways utilities could comply with EPA's revised regulations.
3. *Natural Organic Matter*. Complex organic compounds that are formed from decomposing plant, animal and microbial material in soil and water. They can react with disinfectants to form disinfection by products. Total organic carbon (TOC) is often measured as an indicator of natural organic matter.
4. Water chemistry describes the chemical properties of water such as pH, hardness, and alkalinity. Changes in water chemistry can cause subsequent changes to the physical (e.g., taste and odor) and biological (e.g., biofilm formation and nitrification) properties of water.
5. Certain home drinking water treatment systems and filters can reduce or eliminate chlorine taste and odor. See question 29 for more specific information about these devices.

11) Other than chlorine and monochloramine, what options could water utilities consider to control the levels of disinfection byproducts?

Water utilities have several options for reducing disinfection byproducts other than chlorine and monochloramine.¹

- One option for reducing disinfection byproducts is to reduce the amount of time water spends in pipes.²
- Another option for reducing disinfection byproducts is to use ozone or ultraviolet (UV) light.³
- A third option for reducing disinfection byproducts is improving filtration to reduce natural organic matter in water that react with disinfectants to form byproducts.⁴

The options for reducing disinfection byproducts have disadvantages.

- Better system management to reduce the amount of time water spends in pipes or improved filtration methods may still not be enough to reduce regulated byproduct levels.
- Ozone, UV and some improved filtration processes require a high level of sophistication, expertise, and management skills to operate successfully.
- One disadvantage of ozone and ultraviolet (UV) light is they often require the installation of new and expensive technology, making it impractical for many utilities.

Utilities use chlorine or monochloramine to protect drinking water from harmful organisms in pipes.

- The major disinfection alternatives to chlorine and monochloramine can reduce the formation of some disinfection byproducts but can increase the production of others.
- The major treatment alternatives for reducing disinfection byproducts do not by themselves provide adequate protection for drinking water as it moves through water pipes.
- EPA encourages water utilities to consider a full-range of alternative technologies and operational practices² for reducing disinfection byproducts.

Additional Supporting Information:

1. Guidance manuals are available at:

<http://www.epa.gov/safewater/disinfection/stage2/compliance.html>. Hard copies are available by ordering publications through EPA's Water Resource Center (phone: 202-566-1729).

2. Certain regulated disinfection byproducts may increase over time as water continues to react with natural organic matter. *Natural Organic Matter*: Complex organic compounds that are formed from decomposing plant, animal and microbial material in soil and water. They can react with disinfectants to form disinfection by products. Total organic carbon (TOC) is often measured as an indicator of natural organic matter. Operational practices for reducing water age include flushing programs and eliminating dead-end locations in pipes.

3. UV is effective at inactivating disease-causing protozoa such as *Cryptosporidium*.

4. In some cases, natural organic matter (precursors to DBP formation) can be removed. Removal technologies include nanofiltration, enhanced coagulation, granular activated carbon, enhanced coagulation, or ozone followed by biologically active filtration.

12) Does EPA require water utilities to use [monochloramine](#)? Who approves the decision for a water utility to use monochloramine?

EPA does not require water utilities to use [monochloramine](#) or any specific treatment process.

- EPA does require that water utilities comply with EPA drinking water regulations.
- EPA's Regional Offices provide technical assistance² to water utilities for complying with EPA drinking water regulations.
- EPA works with States¹ to ensure compliance with EPA drinking water regulations.

Each water utility chooses the most effective approach for disinfecting water and meeting regulations.

- Water utilities often work with States¹ to decide the best way to meet EPA regulations.
- Water utilities decide the best way to reduce disinfection byproducts including whether to use monochloramine.²
- States¹ assure that water utilities are capable of complying with EPA regulations.

Water utilities receive approval from a state agency¹ or other authority for changes in disinfection processes.

- Water utilities work with States¹ to weigh the advantages and disadvantages of using monochloramine or other disinfectants.
- Water utilities typically notify customers of plans to use monochloramine.
- Contact your water utility for information about disinfection practices used to treat your water.

Additional Supporting Information:

1. A State drinking water regulatory agency is also known as primacy agency. A primacy agency has the primary responsibility for administering and enforcing federal drinking water regulations. Under the Safe Drinking Water Act; states, U.S. territories, and Indian tribes that meet certain requirements (such as setting regulations that are at least as stringent as EPA's) may also apply for, and receive, primary enforcement authority.

2. Guidance manuals are available at:

<http://www.epa.gov/safewater/disinfection/stage2/compliance.html>. Hard copies are available by ordering publications through EPA's Water Resource Center (phone: 202-566-1729).

13) What assistance does EPA provide to water utilities that are considering a switch from chlorine to **monochloramine?**

EPA provides regulatory guidance to water authorities that are considering a switch to **monochloramine**.

- EPA provides regulatory guidance primarily through state regulatory agencies,¹ which in turn provide guidance to water utilities.
- Water utilities look primarily to states for guidance since it is the state agencies that approve changes in water treatment processes.
- Water utilities provide information about drinking water quality to interested parties on request.

EPA provides training for state and local water authorities that are considering changes in disinfection processes.

- EPA develops guidance documents to help state and local water authorities better understand drinking water regulations.
- EPA works with state and local water authorities when they request additional guidance regarding EPA drinking water regulations.
- EPA manuals on water treatment and disinfection processes are available as printed documents or through the Internet.²

EPA representatives attend professional meetings to explain chlorine, monochloramine, and **disinfection byproduct** regulations

- EPA provides specialized training on the new disinfection byproduct regulation.
- EPA's Regional Offices provide technical assistance to water authorities seeking specific guidance on the new disinfection byproduct regulations.
- EPA has established a Drinking Water Academy for EPA staff, state regulators, tribes, and others on implementing new drinking water regulations.³

Additional Supporting Information:

1. A State drinking water regulatory agency is also known as primacy agency. A primacy agency has the primary responsibility for administering and enforcing federal drinking water regulations. Under the Safe Drinking Water Act; states, U.S. territories, and Indian tribes that meet certain requirements (such as setting regulations that are at least as stringent as EPA's) may also apply for, and receive, primary enforcement authority

2. Guidance manuals are available at:

<http://www.epa.gov/safewater/disinfection/stage2/compliance.html>. Hard copies are available by ordering publications through EPA's Water Resource Center (phone: 202-566-1729).

Information on changing disinfectants and controlling contaminant release (including lead) into drinking water, as well as biofilm activity and nitrification, including the resulting nitrite and nitrate formation can be found at:

http://www.epa.gov/OGWDW/disinfection/stage2/pdfs/guide_st2_pws_simultaneous-compliance.pdf. See question 27 for additional information.

3. Information on the Drinking Water Academy is available at:

<http://www.epa.gov/ogwdw/dwa.html>.

CHLORAMINES-RELATED RESEARCH

14) How did EPA evaluate the safety of **monochloramine** for use as a drinking water **disinfectant**?

EPA evaluated *monochloramine* primarily through an analysis of human health and animal data.

- Research reviewed in EPA's safety analysis is contained in EPA's *Drinking Water Criteria Document for Chloramines*.¹
- The criteria document for monochloramine provides a complete summary of health and other data considered in establishing a monochloramine standard.
- EPA periodically updates the monochloramine "criteria document."

EPA's monochloramine standard² is set at a level where no human health effects are expected to occur.

- Data from animal and human studies provide information on the health effects of monochloramine.
- EPA reviews and considers new research results as they become available.³
- EPA's standard for monochloramine takes data gaps and uncertainty into account by building safety factors⁴ into the regulatory standard.

EPA reviewed historical data in its evaluation of monochloramine.

- Monochloramine has been in use as a drinking water disinfectant since the 1930's.⁵
- Decades of use in the US, Canada, and Great Britain shows that monochloramine is an effective secondary drinking water disinfectant.
- Denver, Philadelphia, and other large cities have used monochloramine as part of their water treatment process for years.

Additional Supporting Information:

1. The *Drinking Water Criteria Document for Chloramines* can be found at <http://www.epa.gov/ncea/pdfs/water/chloramine/dwchloramine.pdf>, Publication No.: ECAO-CIN-D002, March, 1994.
2. The Maximum Residual Disinfectant Level (MRDL) for chloramines is 4 parts per million (ppm).
3. See the Contaminant Candidate List online at <http://www.epa.gov/OGWDW/ccl/ccl3.html> for contaminants that EPA proposes to review. EPA scientists review regulations of disinfectants and disinfection byproducts every six years. For information on EPA's six-year review visit: <http://epa.gov/safewater/review.html>
4. For additional information regarding how uncertainty factors (also known as safety factors) are applied to risk assessments to provide a wide margin of safety see: <http://epa.gov/risk/dose-response.htm>.
5. Cleveland, OH, Springfield, IL, and Lansing, MI were among the first cities to use monochloramine in 1929 (see Chapter 1 of *The Quest for Pure Water Vol II*, AWWA, 1981).

15) Why does EPA believe that sufficient research has been conducted to approve the use of **monochloramine as a drinking water **disinfectant**?**

EPA uses **risk assessment methods to evaluate the safety of drinking water disinfectants.**

- EPA's *Drinking Water Criteria Document for Chloramines*¹ provides the detailed risk assessment process followed in setting the standard for monochloramine.²
- EPA's risk assessment process included a review of available research and historical data.
- EPA's risk assessment process focused on health outcomes that scientists considered most critical.

EPA's regulations account for uncertainties in the **risk assessment by applying **uncertainty factors**.**³

- Risk assessments of monochloramine contain substantial uncertainties regarding potentially harmful disinfection byproducts.
- Federal laws require EPA to act to protect human health even when there is incomplete information⁴.
- Regulators must weigh the public health benefits of disinfection against the risks of the harmful disinfection byproducts⁵.

Research and experience indicate that **monochloramine is safe at levels that are typically used to treat drinking water.**

- Research indicates that monochloramine produces lower levels of regulated disinfection byproducts that may be harmful.
- Monochloramine use may reduce the potential cancer risk from chlorinated byproducts.
- EPA continues to encourage research⁶ on the safety of monochloramine as a drinking water disinfectant.

Additional Supporting Information:

1. The *Drinking Water Criteria Document for Chloramines* can be found at <http://www.epa.gov/ncea/pdfs/water/chloramine/dwchloramine.pdf>, ECAO-CIN-D002, March, 1994.
2. The chloramine limit was set in the Stage 1 DBP Rule. This rule is available at <http://www.epa.gov/safewater/disinfection/index.html>. In addition, EPA has enforceable regulations to limit occurrence of disinfection byproducts in drinking water for a group of four total trihalomethanes (TTHMs) (chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM), and bromoform), a group of five haloacetic acids (HAA5) (monochloroacetic acid (MCA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid (MBA), and dibromoacetic acid (DBA)), and the individual byproducts chlorite and bromate. The maximum contaminant levels for these disinfection byproducts are: TTHMs (0.080 mg/L), HAA5 (0.060 mg/L), chlorite (1.0 mg/L), bromate (0.010 mg/L). See Stage 2 Disinfection Byproducts Rule (71 FR 388, January 4, 2006) for more information on disinfection byproducts and discussion of uncertainties, <http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-04/w03.pdf>.
3. For additional information regarding how uncertainty factors (also known as safety factors) are applied to risk assessments to provide a wide margin of safety see: <http://epa.gov/risk/dose-response.htm>.
4. For example, See the Safe Drinking Water Act section 1412(b).
5. See the Safe Drinking Water Act section 1412(b)(6) for more information.
6. See question 19 for more information on research.

16) Why does EPA believe **monochloramine** is safe and appropriate to use?

Research and experience indicate that **monochloramine use at regulated levels is a safe means for disinfecting drinking water.**

- Research indicates that monochloramine produces lower levels of regulated disinfection byproducts compared to chlorine.
- Decades of use in the U.S., Canada, and Great Britain shows monochloramine is a safe and effective secondary drinking water disinfectant.
- EPA continues researching the safety of monochloramine and other drinking water disinfectants.

EPA used accepted **risk assessment methods to evaluate the safety of monochloramine.**

- EPA's risk assessment process included a review of available research and historical data.
- EPA's *Drinking Water Criteria Document for Chloramines*¹ provides the detailed risk assessment process that the Agency followed in setting the standard for monochloramine.²
- EPA's risk assessment process focused on health outcomes that scientists considered most critical.

EPA's regulatory standard for chloramines provides a wide margin of safety³ to offset uncertainties in **risk assessments.**

- Risk assessments of monochloramine contain uncertainties, including information regarding potentially harmful disinfection byproducts.
- Federal laws require EPA to take action to protect human health even when there is incomplete information⁴.
- EPA regulatory officials must weigh the public health benefits of disinfection against the uncertain risks of the harmful disinfection byproducts⁵.

Additional Supporting Information:

1. The *Drinking Water Criteria Document for Chloramines* can be found at <http://www.epa.gov/ncea/pdfs/water/chloramine/dwchloramine.pdf>, ECAO-CIN-D002, March, 1994.
2. The chloramine limit was set in the Stage 1 DBP Rule. This rule is available at <http://www.epa.gov/safewater/disinfection/index.html>. In addition, EPA has enforceable regulations to limit occurrence of disinfection byproducts in drinking water for a group of four total trihalomethanes (TTHMs) (chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM), and bromoform), a group of five haloacetic acids (HAA5) (monochloroacetic acid (MCA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid (MBA), and dibromoacetic acid (DBA)), and the individual byproducts chlorite and bromate. The maximum contaminant levels for these disinfection byproducts are: TTHMs (0.080 mg/L), HAA5 (0.060 mg/L), chlorite (1.0 mg/L), bromate (0.010 mg/L). See Stage 2 Disinfection Byproducts Rule (71 FR 388, January 4, 2006) for more information on disinfection byproducts and discussion of uncertainties, <http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-04/w03.pdf>.
3. For additional information regarding how uncertainty factors are applied to risk assessments to provide a wide margin of safety see: <http://epa.gov/risk/dose-response.htm>.
4. For example, See the Safe Drinking Water Act section 1412(b).
5. See the Safe Drinking Water Act section 1412(b)(6) for more information.

17) What does EPA see as the advantages of using **monochloramine**?

Switching to *monochloramine* is one approach that utilities can use to meet new EPA drinking water regulations.¹

- Water utilities are required to comply with EPA's new drinking water regulations to control disinfection byproducts.
- Water utilities are assessing whether to switch to monochloramine use as a way to meet new EPA drinking water regulations.
- To meet the new EPA regulations, a subset of utilities has decided to use monochloramine as a secondary disinfectant.²

Water treated with *monochloramine* contains reduced levels of regulated disinfection byproducts compared to water treated with chlorine.³

- Monochloramine produces lower concentrations of *regulated* disinfection byproducts because it is less reactive than chlorine with natural organic matter.⁴
- The formation of disinfection byproducts is influenced by source water type and the type of disinfection used.
- The formation of disinfection byproducts can vary daily with the amount of natural organic matter in the water, temperature, rainfall, distance from the treatment plant, and other factors.

Monochloramine is a practical and effective *secondary disinfectant*.

- The use of monochloramine is often more affordable and requires less new equipment than other alternatives², especially if a water utility is already using chlorine.
- Monochloramine helps protect drinking water quality as it moves through pipes.
- Several large cities such as Denver and Philadelphia have used monochloramine successfully as part of their water treatment process for decades.

Additional Supporting Information:

1. See question 18 for additional information on factors that utilities should consider when deciding whether to switch to monochloramine.
2. See question 11 for additional ways utilities could comply.
3. See Stage 2 Disinfection Byproducts Rule (71 FR 388, January 4, 2006) for more information on disinfection byproducts and discussion of epidemiological data on chlorinated water exposure and cancer, <http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-04/w03.pdf>.
4. *Natural Organic Matter*: Complex organic compounds that are formed from decomposing plant, animal and microbial material in soil and water. They can react with disinfectants to form disinfection by products. Total organic carbon (TOC) is often measured as an indicator of natural organic matter.

18) What does EPA see as the disadvantages of using **monochloramine?**

Water utilities work with local and state regulatory agencies to determine if **monochloramine** is appropriate for their utility.

- The appropriateness of monochloramine use varies with water types and among water utilities.¹
- The appropriateness of monochloramine use varies with the amount of organic matter in the source water, temperature, rainfall, distance from the treatment plant, and other factors.
- EPA guidance is available to help states and water utilities make informed decisions as to whether monochloramine use is appropriate.²

Gaps in research on how monochloramine affects water should be filled.

- There are few studies on how monochloramine affects human health.
- There are few studies on the disinfection byproducts that form when monochloramine reacts with natural organic matter in water.
- Compared to chlorine, water treated with monochloramine may contain higher concentrations of some unregulated disinfection byproducts.¹

Utilities using monochloramine should monitor water quality for problems³ that may arise related to monochloramine use.

- Utilities using monochloramine should monitor for lead and other regulated contaminants from metal corrosion that may be caused by monochloramine use.²
- Water utilities that add substances to control for metal corrosion must comply with all relevant regulations related to these substances.
- Water utilities using monochloramine should monitor and control for biofilm activity as well as nitrite and nitrate formation.³

Additional Supporting Information:

1. Use of monochloramine with source waters with high bromide, high iodide or high total organic matter may lead to bromo-, iodo-, and nitrosamine disinfection byproduct formation, which are unregulated disinfection byproducts. EPA scientists are currently studying the unregulated disinfection byproducts that form in water treated with monochloramine. See Question 7 for additional information about disinfection byproducts.
2. The addition of monochloramine can make water more corrosive, which may lead to pipe corrosion and increased levels of lead or other contaminants in the water. However, utilities can test water for corrosiveness and make changes to the water treatment process to address this problem. EPA requires that systems monitor lead and copper levels in the distribution system under the Lead and Copper Rule. Monitoring for other water quality issues are discussed in guidance manuals. Guidance manuals are available at: <http://www.epa.gov/safewater/disinfection/stage2/compliance.html>. Hard copies are available by ordering publications through EPA's Water Resource Center (phone: 202-566-1729). EPA's simultaneous compliance manual can be found at: http://www.epa.gov/OGWDW/disinfection/stage2/pdfs/guide_st2_pws_simultaneous-compliance.pdf.
3. See questions 2 and 27 for more information on contaminant release, biofilms, and nitrification. High levels of nitrates/nitrites can be especially harmful to infants; additional health effect information can be found at: http://www.epa.gov/ogwdw/contaminants/dw_contamfs/nitrates.html.

19) What is EPA's current focus regarding chloramines research¹? What other ongoing research is EPA aware of?

The current focus of EPA chloramines research is on determining disinfectant effectiveness, the effects of disinfection, and [disinfection byproduct formation](#).¹

- Evaluating the effectiveness of disinfectants, including monochloramine, is a focus for EPA's chloramines research.²
- Research is targeted at understanding the various effects that may be caused by disinfectant use, such as byproduct formation.³
- EPA supports research on evaluating potential treatment technologies that can reduce effects sometimes caused by disinfectant use.

Results from past and ongoing research indicate [monochloramine use at regulated levels can be a safe means for disinfecting drinking water](#).

- Several large cities such as Denver and Philadelphia have used monochloramine successfully as part of their water treatment process for decades.
- Research shows that monochloramine produces fewer potentially harmful *regulated* disinfection byproducts than chlorine.⁴
- EPA reviews and considers new research results as they become available.⁵

Many organizations support research on the safety of monochloramine use.

- Academic institutions and water industry groups conduct research on monochloramine use.⁶
- CDC has investigated community concerns related to monochloramine use.⁷
- EPA continues to work with other organizations on research related to the safe use of monochloramine.

Additional Supporting Information:

1. More information on the EPA Drinking Water Research Program can be found at

<http://www.epa.gov/ord/hpd/dwresearch-intro.htm>.

2. Research includes studying the effectiveness of chloramines at controlling potentially harmful organisms under different source water and treatment options. See question 3 for more information on potentially harmful organisms.

3. Efforts include improving the understanding of the various effects that may be caused by the use of disinfectant(s) or mixed disinfectants on water properties, such as the formation of disinfection byproducts, the release of contaminants, including lead into water, and biofilm activity, including nitrification. See question 27 for additional information on contaminant release, biofilms, and nitrification.

4. Compared to chlorine, water treated with monochloramine may contain different *unregulated* disinfection byproducts than chlorinated water. There are few studies on health effects of unregulated disinfection byproducts. For example, TTHMs and HAAs (see question 6 for more information) typically occur at higher levels than other known and known but unidentified disinfection byproducts. The presence of TTHMs and HAA5 is representative of the occurrence of many other chlorinated disinfection byproducts; thus, a reduction in TTHMs and HAA5 generally indicates a reduction of other types of disinfectant byproducts. Information on one unregulated byproduct associated with chloramination, NDMA, can be found at <http://www.epa.gov/tio/download/contaminantfocus/epa542f07006.pdf>. Also, see question 9 and 23.

5. See the Contaminant Candidate List online at <http://www.epa.gov/OGWDW/ccl/ccl3.html> for contaminants EPA proposes to review. EPA scientists review regulations of disinfection byproducts every six years.

(<http://epa.gov/safewater/review.html>). EPA is currently monitoring for several unregulated disinfectant byproducts (NDEA, NDMA, NDPA, NPYR). More information can be found at <http://www.epa.gov/safewater/ucmr/index.html>.

6. The Water Research Foundation (WRF) is an example of a group that conducts water industry research.

7. A federal partner of EPA is the Center for Disease Control and Prevention (CDC). The CDC Chloramines Vermont Trip Report can be found at http://healthvermont.gov/enviro/water/documents/CDC_Chloramines_report_011608.pdf.

COMMON HEALTH QUESTIONS RELATED TO MONOCHLORAMINE

20) Is it safe to drink and cook with chloraminated water?

Chloraminated water that meets EPA regulatory standards is safe to use for drinking and cooking.

- The proposed Stage 1 Disinfectant and Disinfection Byproduct Rule (DBPR) provides the detailed risk assessment process followed in setting the standard for [monochloramine](#).¹
- Health authorities recognize that some people may have chemical sensitivities and some people may have a chemical sensitivity to [monochloramine](#).²
- People who have health concerns about monochloramine use should consult their physicians.

EPA regulations limit chloramines³ to levels where no adverse health effects are anticipated.¹

- The proposed Stage 1 Disinfectant and Disinfection Byproduct Rule (DBPR) provides the detailed risk assessment process followed in setting the standard for monochloramine.¹
- EPA's risk assessment process included a review of available research and historical data.
- EPA's risk assessment process focused on health outcomes that scientists considered to be most critical.

Special populations, such as people with weak immune systems, should check with their physicians before consuming any type of drinking water.

- Special populations with potentially weak immune systems include transplant patients and people with AIDS.
- People with weak immune systems can be more susceptible than others to harmful organisms in water.⁴
- People who have weakened immune systems should consult with their physicians regarding any type of drinking water they consume, including bottled water.⁵

Additional Supporting Information:

1. The final stage 1 DBPR was published in the federal register on December 16 1998 (Volume 63, number 241, pages 69389-69476) it is available on the epa website at: <http://www.epa.gov/ogwdw/mdbp/dbpfr.html>. The proposed stage 1 DBPR provides the detailed risk assessment and analysis process followed in developing the standard for monochloramine. No changes regarding the MRDL or MRDLG for monochloramine were made from the proposed to the final regulation. The proposed regulation was published on July 29, 1994 (Volume 59, number 145) It is available online at the federal register: <http://frwebgate6.access.gpo.gov/cgi-bin/TEXTgate.cgi?WAISdocID=882277236942+7+1+0&WAIAction=retrieve>.
2. EPA is not aware of any studies regarding monochloramine chemical sensitivity. CDC investigated reports of monochloramine and health effects in Vermont but they were unable to draw any conclusions from the investigation. The CDC Chloramines Vermont Trip Report can be found at http://healthvermont.gov/enviro/water/documents/CDC_Chloramines_report_011608.pdf
3. The chloramines limit was set in the Stage 1 DBP Rule. This rule is available at <http://www.epa.gov/safewater/disinfection/index.html>. In addition, EPA has enforceable regulations to limit occurrence of disinfection byproducts in drinking water for a group of four total trihalomethanes (TTHMs) (chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM), and bromoform), a group of five haloacetic acids (HAA5) (monochloroacetic acid (MCA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid (MBA), and dibromoacetic acid (DBA)), and the individual byproducts chlorite and bromate. The maximum contaminant levels for these disinfection byproducts are: TTHMs (0.080 mg/L), HAA5 (0.060 mg/L), chlorite (1.0 mg/L), bromate (0.010 mg/L). See Stage 2 Disinfection Byproducts Rule (71 FR 388, January 4, 2006) for more information on disinfection byproducts and discussion of uncertainties, <http://www.epa.gov/fedrgstr/EPA-WATER/2006/January/Day-04/w03.pdf>.
4. Potentially harmful organisms include disease-causing bacteria, viruses, and protozoa. Chlorination and chloramination are not effective at inactivating *Cryptosporidium*. EPA requires that utilities that use surface water test and treat for cryptosporidium where necessary.
5. More information regarding drinking water for those with weak immune systems is available at: <http://www.epa.gov/ogwdw/crypto.html>.

21) Can I shower in or use a humidifier with chloraminated water?

Chloraminated water that meets EPA standards is safe to use for showering.

- Showering with chloraminated water poses little risk because [monochloramine](#) does not easily enter the air.
- Trichloramine¹, a chemical related to monochloramine and often found in swimming pools, enters the air more easily and has been linked to breathing problems.
- Trichloramine may form more easily in swimming pools because of higher levels of chlorine as well as ammonia from bodily fluids that are often found in swimming pools.²

Chloraminated water that meets EPA standards is safe for use in humidifiers.

- The use of chloraminated water in humidifiers poses little risk because monochloramine does not easily enter the air.
- EPA is not aware of any studies that investigate the use of disinfected water in humidifiers.
- It is important to follow the manufacturer's instructions regarding proper maintenance and operation of your humidifier.

EPA considered a wide range of household uses in establishing regulatory limits for chloramines in water.

- EPA considered all available research in establishing regulatory limits for chloramines in water.³
- EPA considered historical data in establishing regulatory limits for chloramines in water.³
- EPA's regulatory standard for chloramines provides a wide margin of safety⁴ to offset any uncertainties in risk assessments.

Additional Supporting Information:

1. Trichloramine formation does not usually occur under normal drinking water treatment conditions. However, if the pH is lowered below 4.4 or the chlorine to ammonia-nitrogen ratio becomes greater than 7.6:1, then trichloramine can form. Trichloramine formation can occur at a pH between 7 and 8 if the chloramine to ammonia-nitrogen ratio is increased to 15:1. Source: *Optimizing Chloramine Treatment*, 2nd Edition, AwwaRF, 2004.

2. Problems with trichloramine have been most-often associated with indoor swimming pools and are known to cause a strong chlorine-type odor. Trichloramine can be controlled in indoor swimming pools with proper pool maintenance and ventilation. For more information see: <http://www.cdc.gov/healthyswimming/irritants.htm>.

3. More information on EPA's standard setting process may be found at: <http://www.epa.gov/OGWDW/standard/setting.html>.

4. For additional information regarding how uncertainty factors (also known as safety factors) are applied to risk assessments to provide a wide margin of safety see: <http://epa.gov/risk/dose-response.htm>.

22) Can chloraminated or chlorinated water be used for dialysis or in an aquarium?

Chloraminated or chlorinated water may need additional treatment if used for specialized purposes.

- Water utilities typically provide health care agencies and organizations with information about their disinfection processes.
- Water utilities typically provide consumers with information about disinfection processes.
- Water utilities consult with regulatory authorities about major changes in their water treatment processes.

Chlorine and **monochloramine** must be removed prior to use in kidney dialysis machines.¹

- Chlorine and chloramines or must be removed from water used in dialysis machines because this water comes into direct contact with blood.
- Dialysis patients should consult with their physicians if they have concerns about using chlorinated or chloraminated water.
- Dialysis patients can safely drink chlorinated or chloraminated water.²

Chlorine and **monochloramine** must be neutralized or removed if used in aquariums.

- Chlorine and monochloramine can be harmful to fish because they directly enter their bloodstream through the gills.
- Chlorine and monochloramine can also prevent the growth of beneficial bacteria that are necessary for healthy fish tanks.
- Chlorinated and chloraminated water can be safely used in aquariums by using products readily available from aquarium supply stores.

Additional Supporting Information:

1. A 1988 FDA Safety Alert on chloramines and dialysis is available at:

<http://www.fda.gov/cdrh/safety/021988-chloramine.pdf>.

2. Dialysis patients with severely compromised immune systems should consult with their physician before consuming any type of water.

23) Does **monochloramine** cause cancer?

EPA believes that water disinfected with **monochloramine that meets regulatory standards poses no known or anticipated adverse health effects, including cancer.**

- Most of the research on the cancer risk of monochloramine comes from animal studies using mice and rats.¹
- EPA believes that available data support the use of monochloramine to protect public health.
- EPA's regulatory standard for chloramines provides a wide margin of safety² to offset any uncertainties in risk assessments.

Monochloramine use may reduce bladder cancer risk compared to chlorine use.

- Several studies have shown lower rates of bladder cancer in communities served by systems that use monochloramine as a secondary disinfectant compared to systems that use chlorine.¹
- Compared to chlorine, water treated with monochloramine may contain higher concentrations of *unregulated* disinfection byproducts but the cancer risk is unknown.³
- EPA continues to support research³ on the safety of monochloramine use.

Monochloramine use produces lower levels of regulated **disinfection byproducts that are linked to cancer.**

- *Regulated* disinfection byproducts are produced in lower amounts when monochloramine is used.
- *Regulated* disinfection byproducts serve as indicators⁴ of other types of byproducts that may also be reduced as a result of using monochloramine.
- Compared to chlorine, water treated with monochloramine may contain higher concentrations of *unregulated* disinfection byproducts.³

Additional Supporting Information:

1. More information on these studies can be found at EPA IRIS (Integrated Risk Information System) <http://www.epa.gov/ncea/iris/subst/0644.htm>, in the Stage 2 DBPR (71 FR 388, January 4, 2006), or the Criteria Document for Chloramines, (<http://www.epa.gov/ncea/pdfs/water/chloramine/dwchloramine.pdf>).

2. For additional information regarding how uncertainty factors (also known as safety factors) are applied to risk assessments to provide a wide margin of safety see: <http://epa.gov/risk/dose-response.htm>

3. EPA is currently researching *unregulated* disinfectant byproducts that can form from monochloramine use. Compared to chlorine, water treated with monochloramine may contain different *unregulated* disinfection byproducts than chlorinated water. There are few studies on health effects of unregulated disinfection byproducts. However, additional information on NDMA, an unregulated byproduct, can be found at: <http://www.epa.gov/tio/download/contaminantfocus/epa542f07006.pdf> Also see question 9 and 19.

4. TTHMs and HAAs (see question 6 for more information) typically occur at higher levels than other known and unknown disinfectant byproducts. The presence of TTHMs and HAA5 is representative of the occurrence of many other chlorinated disinfectant byproducts; thus, a reduction in TTHMs and HAA5 generally indicates a reduction of other types of disinfectant byproducts.

24) Does **monochloramine** cause skin problems?

EPA believes that water disinfected with **monochloramine** that meets regulatory standards has no known or anticipated adverse health effects, including skin problems.

- Isolated cases of skin problems due to exposure to chloramines have been reported.¹
- Monochloramine has not been shown to be a cause or contributor to reported skin problems.
- CDC's investigation² of reports of monochloramine-related skin problems associated with drinking water use was unable to draw any conclusions about monochloramine and health effects.

Trichloramine, a chemical related to monochloramine that often forms in swimming pools, has been linked to skin problems.

- Trichloramine forms in swimming pools when chlorine reacts with ammonia from bodily fluids.
- Skin problems traceable to disinfected water are typically related to swimming pool use.³
- EPA continues to study and review research on disinfectants used in swimming pools.

People who believe that their skin problems are related to monochloramine should consult with their doctors.

- Skin problems are a common health issue, and it is often difficult to trace their causes.
- People who have skin problems should inform their doctors if they have been in a swimming pool recently.
- CDC's investigation² of reports of monochloramine-related skin problems associated with drinking water use was unable to draw any conclusions about monochloramine and health effects.

Additional Supporting Information:

1. Reported skin problems, such as eczema, due to chloramines are primarily associated with dermal antiseptic contact in occupational/hospital settings. The "Drinking Water Criteria Document for Chloramines" can be found at <http://www.epa.gov/ncea/pdfs/water/chloramine/dwchloramine.pdf>, ECAO-CIN-D002, March, 1994 and it includes more information on isolated health effects incidents. See question 1 for a discussion of the different types of chloramines.

2. CDC and EPA conducted a preliminary investigation of reports of monochloramine-related skin problems associated with drinking water. The investigation consisted of a questionnaire filled out by the people who had complained of health problems. The information collected can be used to help design future epidemiologic studies.

CDC's trip report can be found at:

http://healthvermont.gov/enviro/water/documents/CDC_Chloramines_report_011608.pdf

3. Improper pool maintenance can often lead to trichloramine formation. Some examples include: www.cdc.gov/niosh/hhe/reports/pdfs/2007-0163-3062.pdf and <http://www.cdc.gov/mmwr/PDF/wk/mm5636.pdf>.

25) Do chloramines cause breathing problems?

EPA believes that water disinfected with [monochloramine](#) that meets regulatory standards has no known or anticipated adverse health effects, including breathing problems.

- Monochloramine does not enter the air easily and therefore would be difficult to inhale.
- CDC's investigation¹ of reports of monochloramine-related breathing problems associated with drinking water use was unable to draw any conclusions about monochloramine use and health effects.
- Breathing problems associated with trichloramine and indoor swimming pools have been reported.²

Trichloramine³, a chemical related to monochloramine and often found in swimming pools, has been linked to breathing problems.

- Trichloramine forms in swimming pools when chlorine reacts with ammonia from bodily fluids.
- Breathing problems traceable to disinfected water are typically related to swimming pool use.⁴
- EPA continues to review research related to the use of disinfectants used in swimming pools.

People who believe their breathing problems are related to [monochloramine](#) should consult with their doctors.

- The causes of breathing problems are often difficult to determine.
- People who have breathing problems should inform their doctors if they have spent time in or around a swimming pool recently.
- CDC's investigation¹ of reports of monochloramine-related breathing problems associated with drinking water use was unable to draw any conclusions about monochloramine and health effects.

Additional Supporting Information:

1. CDC and EPA conducted a preliminary investigation of reports of monochloramine-related respiratory problems associated with drinking water. The investigation consisted of a questionnaire filled out by complainants. The information collected could be used to help design future epidemiologic studies.

CDC's trip report can be found at:

http://healthvermont.gov/enviro/water/documents/CDC_Chloramines_report_011608.pdf.

2. Reported breathing problems due to chloramines are primarily related to inhalation of household chemicals (mixing ammonia and bleach cleaning products), indoor swimming pool air, or industrial exposure. See question 1 for further information about different types of chloramines.

3. Trichloramine formation does not usually occur under normal drinking water treatment conditions. However, if the pH is lowered below 4.4 or the chlorine to ammonia-nitrogen ratio becomes greater than 7.6:1, then trichloramine can form. Trichloramine formation can occur at a pH between 7 and 8 if the chloramine to ammonia-nitrogen ratio is increased to 15:1. Source: *Optimizing Chloramine Treatment*, 2nd Edition, AwwaRF, 2004.

4. Improper pool maintenance can often lead to trichloramine formation: Some examples include: www.cdc.gov/niosh/hhe/reports/pdfs/2007-0163-3062.pdf and www.cdc.gov/mmwr/PDF/wk/mm5636.pdf.

26) Does **monochloramine** cause digestive problems?

EPA believes that water disinfected with **monochloramine** that meets regulatory standards has no known or anticipated adverse health effects, including digestive problems.

- EPA's regulatory standard for monochloramine is based primarily on risk assessments focused on drinking water.
- EPA's standard for monochloramine is set at a level where no digestive problems are expected to occur.
- EPA's regulatory standard for monochloramine provides a wide margin of safety to offset uncertainties in risk assessments.

An important characteristic of monochloramine is that any amount ingested quickly leaves the body.

- Monochloramine is broken down by saliva.
- Monochloramine is neutralized by stomach acid.
- Monochloramine leaves the body through human waste.

People who believe that their digestive problems are related to monochloramine should consult with their doctors.

- The causes of digestive problems are often difficult to determine.
- People who have digestive problems should inform their doctors about what they have drunk or eaten and about any unusual exposures to chemicals.
- CDC's investigation¹ of reports of monochloramine-related digestive problems associated with drinking water use was unable to draw any conclusions about monochloramine and health effects.

Additional Supporting Information:

1. CDC and EPA conducted a preliminary investigation of reports of monochloramine-related digestive problems associated with drinking water. The investigation consisted of a questionnaire filled out by complainants. The information collected can be used to help design future epidemiologic studies. CDC's trip report can be found at:
http://healthvermont.gov/enviro/water/documents/CDC_Chloramines_report_011608.pdf.

27) Does [monochloramine](#) use change water chemistry? Does monochloramine use contribute to the release of lead or other contaminants into drinking water?

Water chemistry¹ can be changed by many factors, including the use of [monochloramine](#).

- Water chemistry can be changed by many factors including temperature, rainfall, the presence of natural organic matter², and monochloramine use.
- Changes in water chemistry from monochloramine use may impact lead or other contaminant levels.³
- Changes in water chemistry from monochloramine use can also impact biofilm activity as well as nitrite and nitrate formation.⁴

Water utilities typically monitor for problems caused by changes in water chemistry from monochloramine use.

- Water utilities should monitor for changes in water chemistry at water treatment facilities.
- Utilities should monitor for lead and other regulated contaminants from metal corrosion that may be caused by monochloramine use.³
- Water utilities using monochloramine should monitor and control for biofilm activity as well as nitrite and nitrate formation.⁴

Water utilities may need to adjust their treatment processes for problems caused by changes in water chemistry from monochloramine use.

- Water utilities may need to adjust their treatment processes to reduce levels of lead or other regulated contaminants to meet EPA regulations.
- Water utilities may need to adjust their treatment processes to reduce biofilm activity, including nitrite and nitrate formation.⁴
- EPA provides guidance for water utilities on problems that can arise from changes in water chemistry from monochloramine use.⁵

Additional Supporting Information:

1. Water chemistry describes the chemical properties of water such as pH, hardness, and alkalinity. Changes in water chemistry can cause subsequent changes to the physical (e.g., taste and odor) and biological (e.g., biofilm formation and nitrification) properties of water.
2. *Natural Organic Matter*: Complex organic compounds that are formed from decomposing plant, animal and microbial material in soil and water. They can react with disinfectants to form disinfection by products. Total organic carbon (TOC) is often measured as an indicator of natural organic matter.
3. Changes in water chemistry can make water more corrosive, which may lead to pipe corrosion (in the distribution system and home plumbing) and an increase in the release of lead or other contaminants into the water. However, utilities can test water for corrosiveness and make changes to the water treatment process to address this problem. See monitoring guidance at http://www.epa.gov/OGWDW/lcrrm/pdfs/guidance_lcrrm_pws_monitoring.pdf. (Also see question 18 and footnote 5 below).
4. The addition of ammonia that is added to the water to make monochloramine, or which naturally occurs in some waters, impacts water chemistry. Ammonia can be converted by naturally occurring bacteria through a process called nitrification to form nitrites and nitrates. EPA regulates these contaminants at the treatment plant. For more information about nitrification see: http://www.epa.gov/safewater/disinfection/tcr/pdfs/whitepaper_tcr_nitrification.pdf For more information about biofilms see question 2 or: http://www.epa.gov/safewater/disinfection/tcr/pdfs/whitepaper_tcr_biofilms.pdf. Nitrate/nitrite, biofilm and lead/corrosion control are discussed in EPA's simultaneous compliance manual at: http://www.epa.gov/OGWDW/disinfection/stage2/pdfs/guide_st2_pws_simultaneous-compliance.pdf. High levels of nitrates/nitrites can be especially harmful to infants; additional health effect information can be found at: http://www.epa.gov/ogwdw/contaminants/dw_contamfs/nitrates.html.
5. EPA guidance to utilities on addressing corrosion issues is available at: http://www.epa.gov/safewater/lcrrm/pdfs/guidance_lcrrm_control_stratageis_revised.pdf.

28) Can my doctor tell if my health problems are caused by **monochloramine or any other disinfectant in drinking water?**

A doctor would have difficulty making a direct link between a health problem and **monochloramine** or any other **disinfectant** in drinking water.

- People are exposed to many chemicals and other irritants in their daily lives and their sensitivity to these agents varies.
- EPA's drinking water regulations limit the use of chloramines to levels where no adverse health effects are anticipated.
- EPA's regulatory standard for chloramines in drinking water provides a wide margin of safety¹ to offset any uncertainties in risk assessments.

EPA believes that drinking water disinfected with monochloramine that meets regulatory standards poses no known or anticipated adverse health problems.

- Isolated cases of health problems thought to be related to drinking water have been reported and were investigated by CDC.²
- Trichloramine, a chemical that may be formed in swimming pools³, has been linked to skin irritation and breathing problems.
- CDC's investigation² of reports of monochloramine-related breathing problems related to drinking water was unable to draw any conclusions about monochloramine and health effects.

Contact your doctor if you think you have a health problem related to drinking water use.

- It is important for your doctor to know where and how you believe you were exposed to chloramines (e.g., via drinking water or a swimming pool).⁴
- Health problems are typically highly diverse in origin, making it difficult for doctors to specify exact causes.
- Your doctor should discuss health problems that he/she believes may be related to chloramines in drinking water with the local health department.

Additional Supporting Information:

1. For additional information regarding how uncertainty factors (also known as safety factors) are applied to risk assessments to provide a wide margin of safety see: <http://epa.gov/risk/dose-response.htm>.

2. CDC and EPA conducted a preliminary investigation of reports of monochloramine-related health problems associated with drinking water. The investigation consisted of a questionnaire filled out by complainants. The information collected can be used to help design future epidemiologic studies.

CDC's trip report can be found at:

http://healthvermont.gov/enviro/water/documents/CDC_Chloramines_report_011608.pdf.

3. Improper pool maintenance can often lead to trichloramine formation: Some examples include: www.cdc.gov/niosh/hhe/reports/pdfs/2007-0163-3062.pdf and www.cdc.gov/mmwr/PDF/wk/mm5636.pdf.

4.. See question 1 for a discussion of the different types of chloramines.

29) How can I remove **monochloramine** from my drinking water?

EPA believes that drinking water disinfected with **monochloramine** that meets regulatory standards is safe to use and it does not need to be removed.¹

- EPA drinking water regulations limit monochloramine use to levels where no adverse health effects are anticipated.
- Water utilities must test drinking water regularly to make sure it is within EPA regulatory limits.
- EPA's regulatory standard for monochloramine in drinking water provides a wide margin of safety² to offset any uncertainties in risk assessments.

Monochloramine can be more difficult to remove from drinking water than chlorine.

- Boiling water does not remove monochloramine from drinking water.
- Allowing water to sit at room temperature does not remove monochloramine from drinking water.
- Reverse osmosis filters³ do not remove monochloramine from drinking water.

Commercial products are available that indicate that they remove monochloramine from drinking water.

- Commercial products that remove monochloramine from drinking water often contain certifications describing their effectiveness.³
- Some home treatment systems and water filters³ may remove monochloramine.⁴
- EPA does not test or certify home treatment systems or filters³ that may remove monochloramine from drinking water.

Additional Supporting Information:

1. See question 14 for information on how EPA evaluated safety of monochloramine use as a drinking water disinfectant.
2. For additional information regarding how uncertainty factors (also known as safety factors) are applied to risk assessments to provide a wide margin of safety see: <http://epa.gov/risk/dose-response.htm>.
3. To search for household water treatment units certified to remove chlorine and/ or chloramine use the following link and search by Product standard NSF/ANSI 42: Drinking Water Treatment Units, aesthetic Effects. <http://www.wqa.org/sitelogic.cfm?id=1165§ion=3>. Also, use the following link and select "chloramines reduction" and then click on search: <http://www.nsf.org/certified/dwtu/>. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.
4. See question 22 for information regarding removing monochloramine for aquarium use.