The impact of increased chloramine use in water treatment on the foodservice industry.

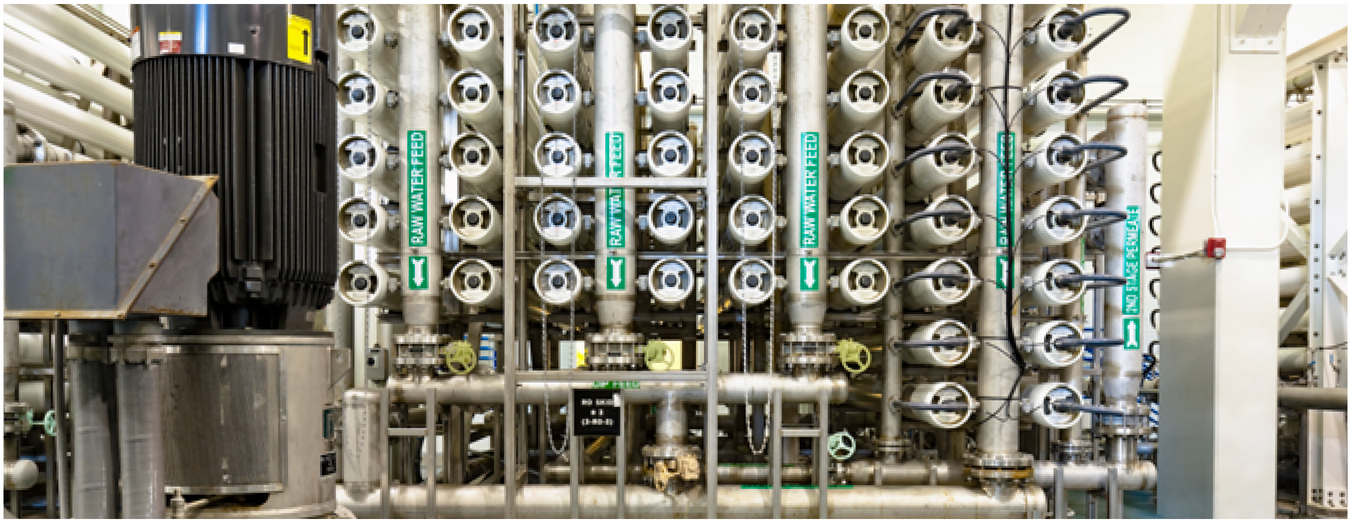
Chloramine is increasingly used in public water supply for disinfection of drinking water. In many instances, chloramine is completely displacing chlorine as a disinfectant or used in conjunction with chlorine. Based on a 2014 3M survey of several United States large water utilities, it was estimated that more than 55% of the population was being served drinking water treated with chloramines.

While chloramines play a significant role in reducing the health risks related to waterborne illnesses, it has several drawbacks or side effects that may make operating a restaurant or a foodservice establishment challenging. Presence of chloramines in municipal water affects the taste and flavour of drinking water, cold beverages and hot beverages like coffee and tea. These beverages are some of the most profitable items being served and negative perceptions of flavour may affect the sales and profitability of restaurants. In addition to the effect on menu item aesthetics, chloramines may also corrode and reduce the life of foodservice equipment, such as steamers and espresso machines. Because chloramines are very stable oxidizing agents, they are corrosive.

The vast majority of foodservice water filtration solutions use standard activated carbon and are not certified per NSF 42 for chloramine reduction. This leaves restaurant operators vulnerable to the negative effects of chloramines in water. Some filtration systems use catalytic carbons to achieve NSF 42 certification for chloramine reduction, but these lower capacity filters may be highly inadequate for large, quick service restaurants or coffee shops that have high water demands.

Today, single system solutions that reduce both chlorine and chloramine—like 3M™ High Flow CLX Series Water Filters—can help foodservice operators serve great tasting beverages and protect their equipment from costly chloramine-related equipment issues.

Introduction: Disinfection in public water supply.



Drinking water can come from various water sources, such as lakes, rivers, reservoirs and ground water aquifers.[1] Due to the ubiquitous nature of microorganisms (such as viruses, bacteria, and cysts like Giardia, or Cryptosporidium) many are often found in source water. Untreated drinking water can cause ill health effects such as gastrointestinal discomfort, diarrhea, vomiting, cramps and other potential severe health risks.

Public water utilities throughout the world have relied on the use of disinfectants to inactivate or kill these microbial pathogens. Oxidation techniques include disinfection using chlorine, chloramine, ozone, or chlorine-dioxide. Sometimes radiation techniques, like UV-light disinfection or mechanical filtration techniques like membrane-separation, may also be used.

Historically, chlorine has been the water disinfectant of choice for municipalities and water utilities across North America. Several decades of use have shown that chlorine is highly effective at making water safer by killing potentially harmful organisms such as bacteria and viruses. Several studies have also shown the significant reduction in risks related to diseases from waterborne microorganisms.

While chlorine continues to play a very important role in public water disinfection, there are some known concerns with its use. One of the issues is that chlorine can prematurely dissipate in water distribution pipes and may not provide disinfection at the far ends of the distribution line. When that occurs, the concentration of chlorine may be too low to provide adequate residual disinfection and microorganisms may start finding their way back into the water system. Another potential concern with its use is chlorine's reaction with the naturally occurring organics in water, creating some carcinogenic byproducts such as trihalomethanes (THMs), haloacetic acids (HAA), chlorite, and bromate.[2]

In an effort to counter the risks related to formation of THMs in water, the Environmental Protection Agency (EPA) implemented two significant "disinfection byproducts rules" (DBPRs). These rules specify limits in terms of how much of these regulated disinfection byproducts can be allowed to be present in the drinking water and thereby, limit exposure to these disinfectant byproducts. To comply with these rules and reduce disinfection byproducts, many water utilities changed their secondary disinfectant from chlorine to monochloramine. This decision was made because water treated with monochloramine contains reduced levels of regulated disinfection byproducts compared to water treated with chlorine and chloramine, and it is less reactive than chlorine with natural organic matter. Water utilities switching from chlorine to monochloramine report fewer consumer concerns related to disinfection byproducts.[3]

Chloramine and its prevalence.

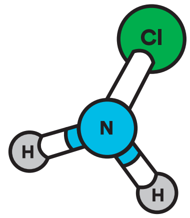
Chloramines are formed by adding chlorine and ammonia to drinking water. The different types of chloramines that could form are monochloramine, dichloramine, trichloramine, and organic chloramines. Monochloramine is the predominant species formed when disinfecting drinking water since dichloramine, trichloramine, and organic chloramines are produced at much lower levels than monochloramine and controlling water chemistry allows the water utility to maximize the formation of monochloramine.

Typical chloramine concentrations of 0.5–2 ppm (parts per million) are found in drinking water supplies where chloramine is used as a primary disinfectant or to provide a chlorine residual in the distribution system. Chloramine residuals in the U.S. range from 0.6–5.0 ppm and 75% of utilities have finished water with chloramine residual levels between 1.0 and 3.0 ppm entering the distribution system.

Over the past 15 years, various studies have been conducted to determine the prevalence of chloramines in public drinking water. Earlier reports from the EPA indicated that more than 1 in 5 Americans were provided water disinfected with chloramines. The use of chloramines has increased in North America since then.

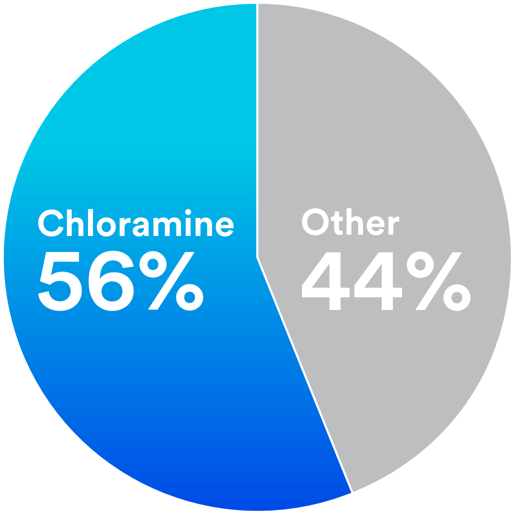
Chloramine is also used for disinfection in several countries or regions outside of North America. Areas of London and Scotland in the United Kingdom, areas of Sydney and Western Australia, areas of Shanghai, Beijing and Guangzhou in China and areas in Finland, Israel and Spain have all been found to use chloramines for disinfection.

For areas where the local water quality data is not available, free and total chlorine test methods can be used to confirm if the water has chloramine. A total chlorine test method provides a total reading of free chlorine and chloramine (i.e. combined chlorine) in the water. So, conducting a measurement of both total chlorine and free chlorine and then taking the difference of the two measurements will provide the concentration of chloramines.



Provinces in Canada using chloramine
Health Canada reported that most Canadian drinking water supplies maintain a chloramine residual below 4 mg/L in the distribution system showing use of chloramines in provinces including Ontario, British Columbia, Quebec, Saskatchewan and Nova Scotia[4].

Water treated with chloramines in the U.S.
In a 2014 3M survey of several large water utilities (each serving >100,000 people), it was estimated that more than 55% of population in the U.S. was being served with drinking water treated with chloramines.



Water Disinfection Treatment
3M 2014 US study

Chloramine's impact on drinking water in foodservice industries.

The adverse effects of chloramine fall under two major categories:

- **Aesthetics:** Causes off-taste and odour in drinking water and both hot and cold beverages
- **Corrosion:** Being an oxidizing agent, chloramine can corrode a lot of plumbing materials or foodservice equipment. Chloramine can damage O-rings, seals and gaskets in foodservice equipment which can cause premature equipment failure and/or the need for unscheduled service

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Metal corrosion

For metallic plumbing materials or foodservice equipment that are passivated and likely to have developed lead oxide scale, changes in disinfectant (conversion to chloramines) are likely to cause a notable increase of lead leaching when conversion to chloramines is implemented.

In a study conducted by the researchers of the Water Research Foundation,[5] seven different metals (copper, brass, bronze, three types of solders, and mild steel) were exposed to different levels of pH (6–8), chlorine (0.5 and 5.0 ppm), chloramines (0.5 and 5.0 ppm) and ammonia (<10 ppm). They measured corrosivity using weight methods, electrochemical analysis, and galvanic current on coupons or pipe segments exposed to disinfectants and made the following conclusions:

- Both chlorine and chloramines accelerate the corrosion of copper and its alloys at pH of 6 but cause minimal corrosion at pH of 8
- An increase in disinfectant concentration can increase corrosion of copper and its alloys at pH of 6
- Corrosion of copper and copper alloys by free or combined chlorine was greatest for brass, followed by copper, and then bronze
- The presence of free or combined chlorine did not lead to pitting type corrosion on copper or copper alloy surfaces under the conditions tested in this project
- The presence of ammonium ions produced no discernible increase in corrosion on copper or copper alloy surfaces
- Neither leaded nor lead-free solders are substantially influenced by the presence of free or combined chlorine at pH levels common to distribution systems
- In equal concentrations, free chlorine is slightly more corrosive than chloramines on copper and its alloys. However, residual concentrations are higher in systems that are disinfected with combined chlorine, compared to free chlorine. As a result, systems that convert to chloramine disinfection may experience higher rates of corrosion depending on pH levels.

Negative effects on elastomers

A study by the American Waterworks Associations Research Foundation shows that chloramine attacks the elastomeric materials, leading to significant degradation of the physical properties.[6] The rate of decay increased as the temperature increased.

This is also observed in various real-world foodservice applications. The elastomers are widely used in water plumbing and foodservice equipment for making O-rings, gasket, flow controls, pressure switches and solenoid valves. The severity of the effect of chloramine exposure varies depending on the material formulation used, chloramine level present, and operating temperature. But the reported examples of negative effects of chloramines on elastomers include leaky plumbing or equipment from flaking of O-ring material, scaled or clogged drains from swollen orifice flow control or faulty solenoid valves from pilot-hole damage.

Effects on drinking water taste

A study by Krasner and Barret using a trained panel of moderate-to-highly-sensitive individuals derived taste and odour thresholds for monochloramine, dichloramine and trichloramine.[7]

	Taste threshold	Odour threshold
Monochloramine	0.48 ppm	0.65 ppm
Dichloramine	0.13 ppm	0.15 ppm
Trichloramine	0.02 ppm	0.02 ppm

Other studies found variability in individual perception of chloramine taste. Compared to monochloramine, the presence of dichloramine and trichloramine was detected at much lower concentrations. However, Krasner and Barrett felt that 0.5 ppm was a better cut-off since objectionable taste and odour were noted at 0.9–1.3 ppm, and at a lesser level at 0.7 ppm.

Taste and odour thresholds
Compared to monochloramine, the presence of dichloramine and trichloramine was detected at much lower concentrations.

NSF/ANSI Standard 42 and CSA B483.1 adopted the level of 0.5 ppm as the maximum allowable level of chloramine in product for certification of water filters for chloramine reduction.

Cold beverage taste

It is expected that the negative effects of the taste and odour of chloramines in drinking water also translate to the cold beverages made with chloraminated water. Many companies have set a specification of the water quality required to make a quality beverage.

As an example, for its cold beverage products, Coca-Cola North America requires a water treatment system as base filtration to improve the water quality from municipal water sources due to inconsistent production or contamination from distribution systems. This is particularly to reduce off-taste and off-odour and reduce total chlorine (free chlorine and/or chloramine) to less than 0.5 ppm demonstrated by NSF 42 chloramine reduction certification and reduce visible particles (> 30 micron).[8]

Hot beverage effects

Monochloramine does not dissipate quickly when water is heated like chlorine does. In one study, the stability of chloramines was determined by measuring the half-life of chloramine or the time to reduce the concentration in half by boiling 37.85 litres (10 gallons) of water. The study found that chlorine dissipated to half its starting concentration in 1.8 hours while chloramine dissipated in 26.6 hours.[9]

Chlorine dissipation:
1.8 hrs

Chloramine dissipation:
26.6 hrs

This finding about the high stability of chloramine in high-temperature or near-boiling water is particularly significant for hot beverages because this means that chloramines will likely be present in hot beverages like tea or coffee. The Statistics & Standards Committee of the Specialty Coffee Association of America has determined the water used to brew specialty coffee should have no chlorine or chloramines (among other specifications), for a superior quality extraction of coffee solids.

Effects on steam equipment

Steamers like combi ovens are increasingly used for cooking in restaurants. These are expensive pieces of equipment—as an example, a 10kW combi-oven has a list price in excess of $10,000 USD. Protecting such expensive equipment is important for the overall profitability of restaurants.

A combi-oven showing corrosion.

The operational aspects of a steamer make this equipment particularly prone to corrosion from a variety of water factors—including pH, chlorides, chlorine and yes, chloramines. Steamers operate at a very high temperature where the corrosive effect of chloramine is prominent. Since water evaporates in steamers, scale or mineral residual may be left behind and a variety of methods may be used to clean out this scale using abrasives or acids. Some of these techniques may damage the passivated layer of the metals used in the steamer, exposing the underlying iron and leaving it prone to forming corrosion.

Current filtration options for reducing chloramines

Activated carbon is the filtration technology used extensively in the foodservice industry to reduce chlorine taste and odour. But standard activated carbons have a significantly limited capacity for reducing chloramines. In many instances, the capacity of a filter with standard activated carbon for chloramine reduction is one to two orders of magnitude less than the capacity for chlorine reduction when evaluated per NSF/ANSI Standard 42. The vast majority of water filtration solutions in the foodservice market that use standard activated carbon are not certified per NSF 42 for chloramine reduction and, thus, leave restaurant operators vulnerable to the negative effects of chloramines.

Catalytic activated carbon with nitrogen groups have been found to be capable of reducing some chloramines from water. This catalytic carbon is made using the pyrolysis process to remove acidic oxides (unreactive carboxylic acid sites) from the surface of the carbon, which creates more active carbon sites (C*) leading to greater catalytic activity and greater capacity for removing chloramine. During the pyrolysis process, carbon is treated with ammonia-water solution, leading to higher catalytic nitrogen sites (N*). The higher the N* sites, the greater the chloramine reduction capacity. Many filtration systems that carry NSF/ANSI 42 certification for chloramine reduction use this type of catalytic carbon. But even these filters may be inadequate for a large quick service restaurant or coffee shop with high water demand because such catalytic carbons still have much lower capacity compared to the needs of a large restaurant. As an example, a leading chloramine product features four replacement filters used in a single system with a combined capacity of only 136,274.82 litres (36,000 gallons) per year. This is heavily undersized for a restaurant that serves cold beverages, ice, coffee and water requiring closer to 378,541.18 litres (100,000 gallons) of water per year.

Innovation in chloramine reduction filtration

Recently, 3M utilized material-science to develop a solution—a catalytic carbon water filtration system with superior chloramine reduction capacity to meet the rigours of the foodservice industry. The 3M™ High Flow CLX Filter Series offers a water filtration system with the industry's highest capacity of 851,717.65 litres (225,000 gallons) of chlorine reduction for 56.78 lpm (15 gpm) and chloramine reduction for 17.034 lpm (4.5 gpm).

The 3M™ High Flow Filters CLX Series offers a wide selection of water filtration systems that are designed with built-in filtering for both chlorine and chloramine disinfection types, so restaurant operators do not have to try to figure out if the local water is treated with chlorine or chloramine. This is particularly useful in cases when the local water utility switches the method of disinfection from one to the other. The 3M high flow filters CLX Series is certified per NSF/ANSI standard and CSA B483.1 for the reduction of chlorine taste and odour and chloramine, which may be a requirement for major beverage-syrup suppliers, equipment manufacturers and local inspectors or regulators. The 3M high flow filters CLX Series offers a selection of single filter cartridges for different needs of filtration performance, size, capacity, and flow rates—and these can be used as single cartridge systems or multiple cartridge systems for even higher flexibility.

HF90-CLX (left) and HF60-CLX (right).

From a sustainability standpoint, the 3M high flow filters CLX Series filters are also certified by Water Quality Association to WQA/ASPE/ANSI Standard S-803 for Sustainability Attributes. The 3M high flow filters CLX Series offers high chloramine reduction capacity in a compact size. As an example, a single HF98-CLX replacement filter is rated for reduction of both chlorine and chloramines for 283,905.88 litres (75,000 gallons) of water, which is more than three times the equivalent filter from a leading competitor's precoat filter. This results in fewer filters consumed and fewer filter change outs, which can help restaurants do more with less.

This innovation is founded on a novel material-science technology of modifying clean coconut-shell activated carbon and catalyzing it to increase the functional active sites on the carbon. Higher active sites lead to not only significantly higher chloramine reduction capacity, but even higher chlorine reduction capacity. Utilizing fine mesh carbon for higher kinetics allows this unique carbon to function at high flow rates. The fine mesh carbon is built into a porous cylindrical block format. In select CLX models, the carbon block is preceded by a pleated 0.2-micron microporous membrane which helps with high sediment life and reduction of cysts per NSF 53 standards. The microporous membrane also reduces waterborne bacteria from incoming water as demonstrated with 99.99% reduction of surrogate organism *E. coli* (ATCC 11229) and *P. fluorescens* (ATCC 49642) in lab tests performed by 3M.

[1] Certified to NSF/ANSI 53 for Cyst Reduction. Based on testing using Cryptosporidium parvum oocysts

[2] As demonstrated with 99.99% reduction of surrogate organism *E. coli* (ATCC 11229) and *P. fluorescens* (ATCC 49642) in manufacturer's lab test.

[3] As tested and verified by manufacturer's laboratory.

Summary

Current trends indicate that chloramines are here to stay as a disinfectant whether restaurant owners like it or not. If left unaddressed, chloramine and chlorine used in water treatment systems can have a negative impact on these businesses. Coffee, soft drinks and ice made from water containing chloramine and chlorine can have an off-taste and odour—giving customers a poor experience. Standard filtration solutions can help reduce one or the other and, even if it reduces chloramine, the capacity may not be enough to match the restaurant's water demand. Dealing with chloramines in water proactively may help improve the customer experience, boost a restaurant's sales and improve the bottom line by reducing costs from chloramines-related equipment issues.

About the Author

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