QUESTIONS REGARDING SPECIFIC HEALTH CONDITIONS

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Q: **What types of evidence are taken into account when evaluating the toxicity of drinking water disinfectants?**

A: Three different kinds of evidence are available with regard to the potential adverse effects of disinfectants in drinking water: (1) information from animal testing; (2) information from feeding studies in humans; and (3) information from epidemiologic studies. The Integrated Risk Information System (IRIS) provides a summary of the USEPA's risk assessment of chloramine. The summary includes information on oral toxicity, chronic exposure and carcinogenicity of chloramine, based on human and animal studies. IRIS was updated with a comprehensive literature review in 2005, which determined that no new information is available to reconsider the conclusions made regarding reference doses or possible carcinogenicity (USEPA, 1992).

Q: **What is the evidence that drinking or bathing in chloraminated water does not cause health problems? Why haven't there been long-term studies of the health effects of chloraminated water?**

A: The Integrated Risk Information System (IRIS) provides a summary of the USEPA's risk assessment of chloramine. The summary includes information on oral toxicity, chronic exposure and carcinogenicity of chloramine, based on human and animal studies. The oral reference dose for chloramine of 0.1 mg/kg/day is based principally on the National Toxicology Program studies in rats and mice that were published in 1992. (US DHHS, 1992) The rat studies found "no clinical changes attributable to consumption of chloraminated water" and "no non-neoplastic lesions after the 2-year treatment with chloraminated water." The mouse studies had similar results (USEPA, 1992). One study in humans found no acute effects on lipid and thyroid metabolism associated with ingestion of chloraminated water at 2 mg/L concentration (Wones et al., 1993). EPA evaluated monochloramine primarily through an analysis of human health and animal data. EPA's monochloramine standard is set at a level where no human health effects are expected to occur. (USEPA, 2009)

Both chlorination and chloramination result in the formation of disinfection byproducts, although fewer halogenated by-products are formed with chloramine. Some studies have looked at the relationships between different health outcomes and the use of chloraminated water compared to water that is not chloraminated. One study (Zierler et al., 1988) showed that people who consumed water disinfected with chloramine had lower risk of bladder cancer compared to people who consumed chlorinated water. This result is likely due to the fact that chloraminated water has fewer disinfection byproducts than chlorinated water. In 1993, McGeehin and colleagues published a study finding that the longer people were exposed to chloraminated surface water, the lower their risk of bladder cancer. The study also found that the risk of bladder cancer among those exposed to chloraminated water was equivalent to the risk among those who consumed untreated groundwater (McGeehin et al., 1993), More recently a large study did not find an association between disinfection byproduct exposure and pregnancy loss in three study sites, two of which used chloramination (Savitz et al,, 2005).

Another study by Zierler et al (1986) found a slightly increased mortality due to pneumonia and influenza in cities that use chloramine versus those that use chlorine. In the 20 years since this study was published, these results have never been replicated, pointing to the likelihood of alternative explanations for these findings, which are well discussed in the manuscript (e.g. that differences in reporting or recording deaths could have led to these results, or that other differences such as smoking, occupational exposures, or other environmental differences could have explained the finding). A recent study of *Legionella* showed that chloramine has a beneficial effect in that it virtually eliminated the presence of *Legionella* species in San Francisco (Flannery et al 2006). Harms and Owen (2004) received a number of inquiries on the following topics prior to chloramine conversion at a large water utility in Florida: contact lenses, immune deficiencies, allergies, dermal absorption of chlorine and chloramine, ulcers and digestive disorders. A review of literature and inquiries to national experts found no indication that chloramine was related to or had any impacts on these topics. Harms and Owen (2004) conducted a survey of chloramination practice among 63 utilities nationwide (out of 111 utilities contacted): 17 respondents listed medical issues as a potential concern but identified none as a problem in practice, disinfection efficiency was identified by 15 respondents as a potential concern but none in practice, and increase in microorganisms was listed by 10 as a potential concern but none in practice.

A survey conducted by the New York City Department of Environmental Protection asked 13 major U.S. water utilities to report their history of chloramine use including public health impacts, advantages and disadvantages (Hoek et al., 2010). With the exception of the District of Columbia Water and Sewer Authority's (DCWASA) lead release that took place after switching to chloramination, the surveyed utilities did not indicate significant public health concerns, including those for special users, as a result of chloramination. DCWASA has since re-optimized corrosion control with the use of orthophosphate.

Q: **Can drinking or bathing in chloraminated water cause chronic or acute health conditions, including buildup of fluid in lungs, pulmonary edema, death, blood in stool, pain, heart failure, blue-baby syndrome, weight loss, weight gain, hair loss, depression or oral lesions?**

A: Presently, there is no evidence in the medical literature that links chloraminated drinking or bathing water to any of these health conditions. Lack of evidence does not necessarily imply that chloramine is not related to any of these conditions, however the likelihood of a relationship to these health conditions is minimal, principally because there is also no evidence that exposure to chloramine from drinking or bathing water is occurring in a way that people are not able to deal with physiologically.

For example, when drinking water is ingested, chloramine gets broken down. The chloride is eliminated through the urine, and the ammonia is transformed to urea in the urea cycle. There is also no evidence that chloramine would be absorbed to the bloodstream through the skin, as such, there have been no published studies on the absorption of chloramine through the skin, in either animals or humans (USEPA, 1994). There is no evidence that chloramine volatilizes in the shower. There is always the possibility that individuals have specific hypersensitivities to chemicals in their environment, however there is no evidence that any of these alleged health effects occur on the population level. People with individual health problems may wish to discuss treatment alternatives with their doctors. Chloramination is not a new technology. Chloramine has been used as a drinking water disinfectant for over 90 years (chlorine for 100 years). SFPUC staff is committed to tracking research and publications regarding chlorine, chloramine and other disinfectants and their potential health effects.

The concerns of chloramine being a respiratory irritant may be based on a concern that one can be exposed to dichloramine and trichloramine in their shower or bath, however these chloramine species do not form in the shower, bath or drinking water (see opinion of chloramine chemistry expert, Dr. Richard Valentine).

The conditions to form dichloramine are: pH range of 4 to 6 (at 5:1 – 7.6:1 chlorine to ammonia weight ratios) or pH range 7 to 8 (at a 10:1 weight ratio) (Kirmeyer et al, 2004). The conditions to form tri-chloramine are at pH < 4.4 at weight ratios greater than 7.6:1 (Kirmeyer et al, 2004). The conditions to form either dichloramine or trichloramine do not exist in the SFPUC distribution system. SFPUC maintains slightly alkaline water pH in the distribution system for corrosion control (the target is 8.6 to 9.4 depending on the water source), and a minimum of 8.2 is required by the California Department of Public Health (CDPH). The pH is stable in the system and does not drift appreciably in spite of low alkalinity and low mineral content of SFPUC waters. SFPUC provides rigorous quality control to maintain a target chlorine to ammonia-nitrogen weight ratio of 4.5 - 4.9:1 at the point of chloramine (monochloramine) formation. This ratio may decrease slightly in the distribution system as chloramine demand is exerted during water transmission and storage.

Both dichloramine and trichloramine are short lived and even if trace amounts were formed, any of these chloramine species would not persist to impact customers. Dichloramine and trichloramine will not form as long as proper pH of the water is maintained above the range of their formation, and as long as minimum free ammonia is present to maintain chlorine to ammonia weight ratio less than 5:1.

Some water systems monitored for mono-, di-, and tri-chloramine; however, these monitoring programs were discontinued because di- and tri-chloramine were never found. Water quality labs at water utilities typically do not speciate chloramine but measure total chlorine.

Studies describing the fate of chloramine in ambient air do not exist. In the air phase, it would be expected that chloramine would dissipate due to advection and dilution and would be subject to reaction, although no information has been located characterizing reactions for chloramine in a gaseous state. Various studies indicate that chloramines are thermodynamically unstable and susceptible to photolysis. Monochloramine and dichloramine are very water soluble and are thus susceptible to removal from the atmosphere by rain (Environment Canada, 2001). Inorganic chloramine fate is governed largely by water-phase processes (Environment Canada, 2001).

Q: **Does chloramine cause asthma?**

A: There is no evidence that chloraminated drinking water causes or exacerbates asthma symptoms. Monochloramine does not enter the air easily and therefore would be difficult to inhale. Breathing problems associated with trichloramine and indoor swimming pools have been reported. (USEPA, 2009) While some studies have found links between nitrogen trichloride (trichloramine) and asthma symptoms, no studies have demonstrated an association between exposure to chloramine in public drinking water supplies and asthma symptoms. This is because trichloramine cannot exist in SFPUC chloraminated drinking water in the absence of free chlorine.

Many different environmental conditions are responsible for asthma and its incidence is increasing worldwide, particularly in developing countries (where chloramine is not typically used). Factors including second hand tobacco smoke, air pollutants, occupational exposures, microbes, dietary factors, and allergens such as dust mites, cockroaches, and cat dander may contribute to worsening existing asthma conditions (Eder *et al*., 2006).

Q: **Does chloramine cause dry skin, skin rashes?**

A: The San Francisco Department of Public Health (SFDPH) literature review in 2004 indicated that skin rashes have not been associated with exposure to chloramine. An updated review in 2007 confirmed that no additional evidence of any association between chloramine and skin complaints has been published in the peer-reviewed medical literature. Approximately 10% to 12% of the population experiences dermatitis on a given day. Dermatitis may be caused by any number of inherited and environmental factors, including: soap, detergents and any prolonged wet work, strong chemical cleaning products including concentrated oxidants and disinfectants (e.g., chlorine bleach), paints, solvents, glues and resins, citrus fruits and vegetable juices, including tomato, onion and garlic, acids and alkalis, abrasive dust from stones, bricks, cement, sand or soil, nickel which may be found in jewelry, cutlery and coins, perfume and fragrances in toiletries and skin care products, plants, particularly chrysanthemums, primula and grass, rubber (latex), which can be found in some protective gloves, the adhesive used in sticking plasters, metal primers and leather, molds, and pharmaceutical products.

A review of the San Francisco Public Utilities (SFPUC) water quality customer complaints database for the time period 2002 - 2007 has not revealed any increased trends in customer complaints regarding water quality or general health due to chloramine. The SFPUC Water Quality Division (WQD) typically receives and responds (with on-site inspector follow-up) to approximately one customer complaint per day on average from the San Francisco Water System; this call volume did not change in the time period 2002 – 2006 in any water quality category. One exception was dirty water complaints, which decreased after chloramine conversion due to improved water quality maintenance practices implemented for chloramine conversion.

The customer complaints/inquiries at other utilities that converted to chloramine in recent years were that "skin feels dry or scalp itches more". These utilities felt that customers had made an association between a known change and an unrelated condition. Calls with similar complaints lasted for a couple of months. The response to known changes in water treatment procedures has been studied and documented (Lamberg et al., 1997; Lyons et al., 1999).

Skin complaints associated with municipal drinking water are not uncommon; however there is no evidence of a link between any specific water quality parameter and such complaints (du Peloux Menage & Greaves, 1995; Bircher, 1990). An investigation by the San Francisco Department of Public Health of 17 people in the SFPUC service area, mostly from suburban areas served by agencies purchasing water from SFPUC, who had skin irritations and symptoms of dermatitis found that it was unlikely that the symptoms were due to any common cause, including exposure to the chloraminated drinking water (Weintraub et al, 2006). EPA believes that water disinfected with monochloramine that meets regulatory standards has no known or anticipated adverse health effects, including skin problems. (USEPA, 2009)

Q: **If chloramine is not a cause of skin irritation symptoms reported by people, what other reasons might explain why some people experience fewer symptoms when they shower or bathe with water that has not been chloraminated?**

A: When people reduce the frequency or change the location that they bathe, or when they bathe using bottled water, they are not just changing the quality of the water they are using. They are also changing many other things that may have been responsible for symptoms that they may believe were related only to the water. For example, the temperature of the water may be different, the types of cleaning products that are used in each location may differ, the types of soaps and lotions that the person is using may have changed, the length of time spent in the shower or bath may have been reduced, or other environmental allergens that were present in one location may not be present in the other. The American Academy of Dermatology recommends reducing the duration, temperature and frequency of baths and showers to help people who experience dry skin, itchiness, and other problems with their skin (American Academy of Dermatology, 2006).

Q: **Is chloramine a carcinogen?**

A: The USEPA has not classified chloramine as to its carcinogenicity because there is inadequate human data and equivocal evidence of carcinogenicity from animal bioassays (USEPA, 1992).

USEPA imposes maximum residual disinfectant levels for chlorine and chloramine at 4 mg/L and for chlorine dioxide at 0.8 mg/L based on 12-month averages. None of the disinfectants are carcinogenic. The toxicological effects of disinfectants (e.g., chlorine and chloramine) are nonspecific and occur at concentrations well above the suggested use levels. More specific effects appear to be associated with hypochlorite solutions, chlorine dioxide, and iodine with respect to effects on thyroid function. Only in the case of iodine does this seem to limit its long-term use in the disinfection of municipal drinking water (Bull et al., 2001). EPA believes that water disinfected with monochloramine that meets regulatory standards poses no known or anticipated adverse health effects, including cancer. (USEPA, 2009)

Q: **Is there evidence of a link between chloramine in drinking water and the occurrence of Acanthamoeba Keratitis?**

A: Acanthamoeba Keratitis is a waterborne ameba commonly found in the environment that may cause eye infection. Most people will be exposed to Acanthamoeba during their lifetime and will not get sick. Although an early investigation of increased acanthamoeba keratitis rates in Illinois hypothesized that there may be a link to the type of disinfectant used in municipal drinking water, no data supporting this hypothesis have been presented in the initial or subsequent publications. The CDC addressed this more completely in a comprehensive case-control study, which concluded that water disinfection type was not an important risk factor in this outbreak (Verani et al, 2009).

Q: **Is there any association between chloramine and heart failure?**

A: Chloramine is not associated with heart failure. Chloramine has a different molecular structure from, for example, phenylpropanolamine, which has been linked to heart problems.

Q: **What are the impacts on dialysis patients and can chloramine contribute to kidney failure?**

A: Chloramine ingestion does not contribute to kidney failure. Both chlorine and chloramine can harm kidney dialysis patients during the dialysis process if they are not removed from the water prior to dialysis treatment. This is because between 90 and 190 liters of water is used in the kidney dialysis treatment process, and this water comes into direct contact (via a semi-permeable membrane) with the patient's bloodstream. To protect patients during the dialysis process, chloramine, like chlorine, is removed from tap water at treatment facilities before dialysis treatment takes place (Amato 2005). Prior to the SFPUC conversion to chloramine in 2004, the California Department of Public Health inspected and certified all hospitals and dialysis patient care facilities in the SFPUC service area to insure that all facilities had made the necessary changes to their water treatment systems. Home dialysis patients receive care and direction through a certified hemodialysis care facility. There are very few home dialysis patients throughout the SFPUC service area and all of those were contacted through their care facility. Kidney dialysis patients can safely drink chlorinated and chloraminated water (USEPA, 2009) as residual disinfectants are broken down in the digestive process. For the standard methods used in kidney dialysis systems, see http://www.aami.org/publications/standards/dialysis.html. The Transpacific Renal Network can be found at: ESRD Network #17 Home Page

Q: **Can chloramine cause gastric lesions?**

A: There is no evidence that chloramine ingested in drinking water causes gastric lesions. This concern is likely due to a misunderstanding of scientific articles that investigate the role of monochloramine produced by cells in cancer associated with *Helicobacter pylori* infection (see, for example, Iishi et al., 1997). The relevance of this research to drinking water or other exogenous exposures is not known.

Q: **What is the interaction between chloramine and acid reflux?**

A: Chloraminated water will not affect acid reflux. According to the Society of Thoracic Surgeons, gastro esophageal reflux disease, commonly referred to as acid reflux, can be aggravated by certain foods and drinks. This disease is thought to be caused by a deficiency in the stomach valve allowing the contents of the stomach to be released into the esophagus, where irritation occurs (Ferguson, 2000).

Q: **Is chloraminated tap water safe for people with disease such as AIDS, cancer, kidney dialysis, diabetes, hepatitis, or lupus?**

A: Chloraminated water is safe for people with suppressed immune systems or other diseases. A comprehensive search of the medical literature does not reveal any studies showing that people with chronic diseases, including those with compromised immune systems and those who are taking medications, have any special problems metabolizing chloramine.

Q: **Why does the CDC recommend that people with compromised immune systems boil their drinking water?**

A: Neither chlorine, nor chloramine can destroy certain protozoans like *Cryptosporidium*. Therefore some people who have compromised immune systems may wish to use bottled water or to boil their water to make sure that they are not exposed to pathogens that might be present in the water despite the use of these disinfectants. In 2006, the USEPA promulgated a new Federal regulation, the Long Term 2 Enhanced Surface Water Treatment Rule, to specifically regulate the removal or disinfection of *Cryptosporidium* (USEPA, 2006b). In 2011, the SFPUC completed the construction of an ultraviolet light (UV) disinfection facility to comply with this USEPA rule.

Q: **Are there any known interactions between chloramine and medications?**

A: When drugs are tested in clinical trials most investigators do not specify that water other than tap water be used. Enough cities already use chloramine that it is quite likely that the efficacy of some drugs is already based on how they act in persons drinking chloraminated water. Chloramine interaction with pharmaceuticals has not been specifically studied.

Q: **What is the general sensitivity to ammonia? Is there any damage from ammonia and upsets to the pH balance of the body?**

A: The ammonia is predominantly bound in chloramine with a slight excess of so called “free ammonia” and will not produce adverse effects from exposure by washing. Ammonia is released during the digestion of chloramine in the digestive system.

Q: **Are people with urea cycle disorder able to drink chloraminated water?**

A: People with urea cycle disorder are not able to metabolize ammonia, therefore it is certainly possible that people with this condition could benefit by drinking non-chloraminated water if they are reducing their ammonia intake in other ways as well. Since ammonia-containing foods are common, people with these disorders would probably achieve greater reductions by avoiding foods with higher ammonia contributions first. Ingesting 1 liter of water results in ingestion of less than 1 mg NH_3 (typically less than 0.5 mg/L NH_3). By comparison, a one-ounce serving of cheddar cheese contains about 31 mg NH_3 (derived from Rudman et al, 1973). We have been unable to identify any medical literature that suggests drinking chloraminated water is an important exposure pathway for people with urea cycle disorder. Boiling water for 20 minutes will remove chloramine and ammonia.

Q: **Is it safe for babies to drink chloraminated water?**

A: Yes.