## HUMAN PHYSIOLOGICAL QUESTIONS

Updated June 2013

### Q: **What is the position of the regulatory agencies on the use of chloramine for drinking water disinfection?**

A: The California Conference of Local Health Officers (CCLHO) joined the California Department of Public Health and the US Environmental Protection Agency (USEPA) in endorsing the use of chloramine as a safe alternative to chlorine in the residual disinfection of public drinking water supplies. In February of 2004, the San Francisco Public Utilities Commission (SFPUC) changed the drinking water residual disinfectant from chlorine to chloramine. Using chloramine in SFPUC drinking water results in lower levels of potentially harmful disinfection by-products than were present with the use of chlorine.

Chloramine is a more effective distribution system disinfectant than chlorine. It has been used extensively in California, the U.S., and around the world for decades. SFPUC was the last major water agency in the Bay Area to switch to chloramine in February 2004. Using chloramine as a distribution system disinfectant allows SFPUC to comply with the USEPA regulations regarding allowed levels of disinfection by-products in drinking water. The decision to change to chloramine was made in conjunction with 29 wholesale water agencies represented by the Bay Area Water Supply and Conservation Agency (BAWSCA) after careful analysis of current scientific information about the risks and benefits of chlorine and chloramine.

### Q: **What happens when chloramine is ingested?**

A: When people ingest chloramine, the chloramine is broken down quickly in the digestive system to chloride and ammonia. The chloride is eliminated through the urine, and the ammonia is transformed to urea in the urea cycle. Whether it comes from the breakdown of chloramine or the breakdown of proteins in foods like hamburger or tofu, ammonia is transformed to urea in the urea cycle. Ammonia does not bioaccumulate.

### Q: **Is there an impact of chloramine on human metabolism?**

A: There is evidence that chloramine in the concentrations that are present in drinking water has no effect on human metabolism. A study conducted in 1993 and published in the peer-reviewed journal Environmental Health Perspectives showed no effects of chloramine ingestion at levels of 2 mg/L. Healthy men were randomized to consume 1.5 liter per day of either distilled water, water containing 2 mg/L chloramine, or water containing 15 mg/L chloramine for four weeks. At the end of the study, the men who were drinking 2 mg/L chloramine, showed no difference in total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, apolipoproteins A1, A2, or B, compared to the men drinking distilled water. The 2 mg/L study group had no difference in thyroid metabolism compared to the distilled water group. The men who drank 15 mg/L chloramine had no differences except that their plasma apolipoprotein B levels, (a protein associated with LDL cholesterol) had risen by about 10%, whereas the men drinking distilled water and the men drinking water with 2 mg/L chloramine had their plasma apoliporotein B levels drop slightly. The authors suggested that this finding may be due to chance (Wones et al., 1993). EPA's standard for monochloramine is set at a level where no digestive problems are expected to occur. An important characteristic of monochloramine is that any amount ingested quickly leaves the body. (USEPA, 2009)

Another study found that 10 healthy male volunteers experienced no biochemical or physiochemical response after drinking water treated with chloramine at concentrations up to 24 mg/L and compared to a control group (Lubbers et al., 1981). Typical levels of chloramine in drinking water in SFPUC system are between 1 and 2.5 mg/L $Cl_2$.

Q: **What happens when chloramine is inhaled?**

**A: Monochloramine is preferentially created in the SFPUC disinfection process, and this compound is soluble and stable in the water. Monochloramine does not volatilize to any significant extent in a shower or bathing environment.**

Vikesland et al (2001) showed that at 35 degree C and pH 7.5, monochloramine has a half-life of 75 hours. With this long half-life, the concern about inhalation exposures is unwarranted. The half-life of chloramine can be even longer (several weeks) in high quality waters at lower temperatures and slightly alkaline pH values typical for drinking water distribution systems (Wilczak et al., 2003b).

The Occupational Safety and Health Administration (OSHA) documents for concentrated chemicals and studies investigating exposure to chlorine and trichloramine at swimming pools in Europe are not relevant to drinking water. Monochloramine is highly soluble in water and loss to evaporation is minimal. Dichloramine is a little more volatile but it is not present in SFPUC drinking water-- based on the presence of free ammonia, the pH range, and the extent of loss of disinfectant due to aeration. It is impossible for highly volatile trichloramine to exist in a chloraminated drinking water system without free chlorine (White, 1999). There is no record of inhalation concerns in the water industry.

SFPUC performed bench top tests to estimate how much chlorine or chloramine may be lost to volatilization or reactions with the air or other constituents in a bath or shower, finding that chloramine loss in the shower or bath was minimal as compared with chlorine, which was more volatile at all tested temperatures. At shower temperature of 100 degree F (38 degree C), which is typical for bathing, less than 8% of chloramine was lost from the water in the bath or shower, which is consistent with the literature. In chlorinated water, 12 to 94% of the chlorine was lost in the shower at 100 degree F, depending on pH. In cold water at 67 degree F (20 degree C), the loss of chloramine in the shower or bath was within the measurement error (i.e., insignificant). Relatively less chloramine was lost in the shower compared with chlorine.

Q: **Can chloramine be absorbed through skin during bathing?**

A: There have been no published studies on the absorption of chloramine through the skin, in either animals or humans (USEPA 1994). This is likely because there is no evidence that chloramine would come out of solution in the water to enter through the skin.

Q: **What is the damage to blood cells by chloramine?**

A: If chloramine enters the blood stream directly, it combines with hemoglobin (red blood cells) so it can no longer carry oxygen. This can occur if chloramine is not removed from water used in dialysis machines but cannot happen by drinking chloraminated water. Both chlorine and chloramine need to be removed from kidney dialysis water.

Q: **Can one safely wash an open wound with chloraminated water?**

A: Yes. It is safe to use chloraminated water in cleaning an open wound because virtually no water can enter the bloodstream that way (Kirmeyer et al., 2004). In dialysis patients, blood may come into direct contact (via a semi-permeable membrane) with between 90 and 190 liters of water in a single session. Even if a person soaked a bleeding wound in one liter of water at the typical concentration of 2 mg/L for several hours the wound would be exposed only to the 2 milligrams of chloramine in the liter. Not all of that would be absorbed into the bloodstream via the wound, and even if it were, it would still not be enough to make any difference in the usual level of hemoglobin that is available to carry oxygen in the bloodstream.

Q: **Can chloramine and ammonia bioaccumulate in the body?**

A: Chloramine and ammonia do not bioaccumulate in the body. Chloramine is broken down quickly in the digestive system and eliminated through the urine. The breakdown product ammonia is converted to urea in the urea cycle. All proteins that people ingest are broken down into ammonia and converted to urea in the same way. These products do not bioaccumulate. Chloramine is not a persistent chemical and is neutralized rapidly by common drinks (e.g., tea, coffee, juices) or foods (e.g., chicken stock).

Q: **Is ammonia toxic and/or digestible?**

A: Ammonia, in the concentrations used for drinking water disinfection, is not toxic. Ammonia is not of direct importance for health in the concentrations to be expected in drinking-water. (WHO, 2003) Whether it comes from the breakdown of chloramine or the breakdown of proteins in foods like hamburger or tofu, ammonia is transformed to urea in the urea cycle. Ammonia does not bioaccumulate. About 99% of metabolically produced ammonia is absorbed from the gastrointestinal tract and transported to the liver, where it is incorporated into urea as part of the urea cycle. Urea formed in the liver is absorbed by the blood, transferred to the kidney, and excreted in urine (WHO, 2003)

Many foods contain ammonia, and the exposure via drinking water is a small fraction of that in other foods. Water typically contains about 2 mg/L chloramine and less than 1 mg/L ammonia, typically 0.5 mg/L $NH_3$-N, so ingesting 1 liter of water results in ingestion of less than 1 mg $NH_3$. By comparison, a one-ounce serving of cheddar cheese contains about 31 mg $NH_3$ (derived from Rudman et al., 1973). The estimated daily ammonia intake through food and drinking-water is 18 mg, by inhalation less than 1 mg, and through cigarette smoking (20 cigarettes per day) also less than 1 mg. In contrast, 4000 mg of ammonia per day are produced endogenously in the human intestine. Ammonia is a key metabolite in mammals. It has an essential role in acid–base regulation and the biosynthesis of purines, pyrimidines, and amino acids. It is formed in the body by the deamination of amino acids in the liver, as a metabolite in nerve excitation and muscular activity, and in the gastrointestinal tract by the enzymatic breakdown of food components with the assistance of bacterial flora (WHO, 2003).