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FLUORIDE FACT SHEET

Contaminant	In Water As	Maximum Contaminant Level
Fluoride (F^-)	Fluoride ion, F^-	**US EPA:** MCL* = 4.0 mg/L or ppm Secondary Standard** = 2.0 mg/L or ppm **WHO† Guideline** = 1.5mg/L
Sources of Contaminant	Natural deposits Municipally treated drinking water (> 2 mg/L, potentially as a result of poorly monitored or malfunctioning feeding equipment)	
Potential Health Effects	Skeletal fluorosis, from long-term consumption at > 4 mg/L (a serious bone disorder resembling osteopetrosis and characterized by extreme density and hardness and abnormal fragility of the bones)	
Potential Aesthetic Effects	Mottling (discoloration) of teeth in children under 9 years of age (from long-term consumption at > 2 mg/L) Disfiguration/pitting of teeth in children	
Treatment Methods **Point-of-Entry** **Point-of-Use**	Reverse Osmosis Strong base anion exchange (Cl^- form) Activated alumina adsorption media Distillation	

*Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

**National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

WHO† - World Health Organization

Fluorine is a natural trace element and exists in almost all soils. In elemental form fluorine is a flammable, irritating, and toxic halogen gas that is one of the most powerful oxidizing agents known. It therefore occurs naturally only in the reduced (fluoride, F^-) form in combination with other minerals. Fluoride is classified as any binary compound of fluorine with another element. Fluoride compounds make up approximately 0.08 percent of the earth's crust. Fluorspar, cryolite, and fluorapatite are the most common fluoride producing compounds known. Fluorspar contains the highest percentage of fluoride by weight, as calcium fluoride (CaF_2), of the minerals mentioned.

Perhaps the most widely known use of fluoride is its addition to public drinking water supplies at about one milligram per liter (mg/L) of a fluoride salt, measured as fluoride, for the purpose of reducing tooth decay. This is achieved at the municipal treatment plant by injecting or feeding a solution of hydrofluosilicic acid, sodium silicofluoride, or sodium fluoride into the treated water stream. It is the fluoride ion in mineral ionic form that occurs in water, bones, teeth, and public drinking water supplies. According to a 2011 EPA report about 196 million people drink fluoridated water at levels ranging from 0.7 to 1.2 mg/L. The US Department of Health and Human Services oversees the national water fluoridation program and recommends an optimal level of 0.7 mg/L to promote public health benefits of fluoride for preventing tooth decay while minimizing the chance for dental fluorosis. The Center for Disease Control and Prevention (CDC) provides recommendations about the optimal levels of fluoride in drinking water in order to prevent tooth decay (see reference below "My Water's Fluoride" and CDC Web site).

HEALTH EFFECTS

Some water systems with naturally occurring fluoride must treat their water supply to remove the excess fluoride to comply with the Safe Drinking Water Act limits. Children under nine years of age exposed to levels of fluoride greater than about two mg/L may develop a condition known as mottling or discoloration of the permanent teeth. In certain cases the teeth become chalky white in appearance. The U.S. Environmental Protection Agency has advised a secondary maximum contaminant level (SMCL) limit of two mg/L to protect against this aesthetic or cosmetic adversity from fluorides in drinking water.

Further, federal regulations require that fluoride not exceed a concentration of four mg/L in drinking water. This is an enforceable maximum contaminant level (MCL) standard; it has been established to protect public health. Exposure to drinking water levels above four mg/L for many years may result in cases of crippling skeletal fluorosis, which is a serious bone disorder resembling osteopetrosis and characterized by extreme density and hardness and abnormal fragility of the bones (sometimes called "marble bones.")

The USEPA has recently completed a new risk and exposure assessment for orally ingested fluoride and have concluded that fluoride exposure among the population has increased in the last 40-50 years. From the data in this assessment, EPA has proposed a reference dose (RfD – estimate of the daily exposure likely to be without harmful effect during a lifetime) of 0.08 mg/kg/day for protection against pitting of tooth enamel and also protective against fractures and skeletal effects in adults.

TREATMENT METHODS

Residential Point-of-Entry	Activated alumina (requires regeneration or tank exchange) Anion exchange (requires regeneration or tank exchange)
Residential Point-of-Use	Activated alumina Anion exchange Reverse osmosis Distillation
Municipal	Activated alumina
Visit WQA.org or NSF.org to search for products certified to WQAS-200, NSF/ANSI 53, 58, 62 for fluoride reduction.	

For large municipal treatment systems, the use of activated alumina is probably the most commonly used fluoride removal technology. Activated alumina requires a two-step, caustic (NaOH) regeneration followed by acid (H_2SO_4) neutralization, regeneration process. This technology is now being used in exchange tanks for POE (point-of-entry) and disposable filters for POU (point-of-use) applications. For activated alumina to operate most effectively the pH range should be held to 5.5 to 6.5. Activated alumina is generally specific for fluoride and is not affected significantly by the common other competing sulfate, nitrate, or chloride anions in the influent water.

POU reverse osmosis is an excellent choice for the reduction of fluoride. Using a cellulose acetate/cellulose triacetate (CA/CTA) membrane, rejection rates of 80-90 percent are achievable when the pH is in the 4-8.5 range. Thin Film Composite membranes (TFC) will yield a higher rejection rate (up to 95 percent) in the 3-11 pH range. Both the CA/CTA and TFC membranes should be operated at a minimum membrane pressure differential of at least 30 psi.

The use of bone charcoal or bone char (carbonized animal bone) is reported to be an effective means for the reduction of fluoride. Bone charcoal contains a carbon structure while supporting a porous hydroxyapatite matrix (a calcium phosphate hydroxide in crystalline form which is rich in surface ions which can be readily replaced by fluoride ion). Adsorption and ion exchange are thought to be the mechanism for fluoride reduction by bone char. Regeneration of this material can be accomplished by a two percent sodium hydroxide rinse and a backwashing cycle. Reduction of fluoride using bone charcoal is somewhat pH dependent, the challenge water should be below 6.5 pH to suppress any ion competition. Electro dialysis, deionization, and distillation would also be effective treatment processes.

The treatment methods listed herein are generally recognized as techniques that can effectively reduce the listed contaminants sufficiently to meet or exceed the relevant MCL. However, this list does not reflect the fact that point-of-use and point-of-entry (POU/POE) devices and systems currently on the market may differ widely in their effectiveness in treating specific contaminants, and performance may vary from application to application. Therefore, selection of a particular device or system for health contaminant reduction should be made only after careful investigation of it's performance capabilities based on results from competent equipment validation testing for the specific contaminant to be reduced.

Visit WQA.org to find water professionals in your area. Note that Certified Water Specialists have passed the water treatment education program with the Water Quality Association and continue their education with recertification every 3 years.

REGULATIONS

In the United States the EPA, under the authority of the Safe Drinking Water Act (SDWA), has set the Maximum Contaminant Level (MCL) and the MCL Goal (MCLG) for fluoride at 4.0 mg/L. This means that utilities must ensure that water from the customer's tap does not exceed this level in at least 90 percent of the homes sampled. The utility must take certain steps to correct the problem if the tap water exceeds the limit and they must notify citizens of all violations of the standard. In the State of California the MCL is 2.0 mg/L of fluoride in drinking water.

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