

## **Fluoride in Drinking Water State of the Science, Regulatory Update, and Additional Resources**

Fluoride is a naturally occurring compound derived from fluorine, the 13th most abundant element on Earth. It is found in rocks, soil, and fresh and ocean water. Fluoride is present naturally in almost all foods and beverages including water, but levels can vary widely. It is added to drinking water to provide public protection from dental caries. The U.S. Environmental Protection Agency (EPA) has set a Maximum Contaminant Level (MCL) for fluoride of 4.0 mg/L for drinking water for public water systems. EPA has also set a secondary standard of 2.0 mg/L. The U.S. Public Health Service has established the "optimal level" for fluoride content in drinking water to be in the range of 0.7 mg/L to 1.2 mg/L. In January 2011, EPA announced their intention to review the drinking water regulations for fluoride. Also in January 2011, the U.S. Department of Health and Human Services (HHS) [proposed a recommendation](#) of 0.7 mg/L to replace the current recommended range of 0.7 to 1.2 mg/L. In response to the recent regulatory actions, the Water Research Foundation produced this document to summarize occurrence of fluoride in natural waters, regulations, and treatment. It also provides resources for additional reading and research.

### **OCCURRENCE IN NATURAL WATERS**

Fluoride occurs naturally in public water systems as a result of runoff from weathering of fluoride-containing rocks and soils and leaching from soil into groundwater. Atmospheric deposition of fluoride-containing emissions from coal-fired power plants and other industrial sources also contributes to amounts found in water, either by direct deposition or by deposition to soil and subsequent runoff into water. Unfortunately, there is no comprehensive occurrence data summarizing fluoride occurrence in U.S. natural waters. The best available information was created by the U.S. Geological Survey showing fluoride levels in some groundwater can average as much as 8 mg/L or more (Fleischer et al. 1974). CDC estimates that in 1992, approximately 10 million people were served by naturally fluoridated public supplies (CDC 1993). Of the 10 million people, 6.7 million had natural fluoride concentrations less than or equal to 1.2 mg/L, 1.4 million had concentrations between 1.3 and 1.9 mg/L, 1.4 million had concentrations between 2.0 and 3.9 mg/L, and 200,000 had concentrations equal to or exceeding 4.0 mg/L. Exceptionally high concentrations of fluoride in drinking water are found in areas of Arizona, Colorado, Idaho, Iowa, Montana, New Mexico, North Dakota, Oklahoma, and Texas.

USGS estimates that 15% of the U.S. population uses private wells ([USGS 2004](#)). Focazio et al. (2006) reviewed the existing water quality data collected from private wells. According to their findings, fluoride was detected in 76.7% of the wells, but only 0.81% exceeded the 4 mg/L MCL set by EPA.

## FLUORIDE IN FINISHED DRINKING WATERS

Fluoride has been added to many public drinking water supplies since 1945. The “optimal” concentration of fluoride in finished drinking water for the United States has been set at 0.7 to 1.2 mg/L, depending on the mean temperature of the locality. Exact level is determined by the annual average of maximum daily ambient air temperature (Table 1).

**Table 1. Recommended optimal fluoride levels for community public water supply systems (CDC 1995)**

Annual Average Of Maximum Daily Air Temperatures (°F)	Recommended Fluoride Concentrations (mg/L)
50.0–53.7	1.2
53.8–58.3	1.1
58.4–63.8	1.0
63.9–70.6	0.9
70.7–79.2	0.8
79.3–90.5	0.7

\*Based on temperature data obtained for a minimum of 5 years.

[According to CDC 2008 water supply statistics](#), 27.6% of the U.S. population served by Community Water Systems (CWS) received nonfluorinated water while 72.4% received optimally fluorinated water, representing approximately 195 million people. Recently, EPA has analyzed Information Collection Request data for fluoride ([EPA 2010](#)). According to their analysis, median fluoride concentrations in U.S. waters ranged from 0.83 to 0.86 mg/L in 1998 and from 0.75 to 0.86 mg/L in 2005. In 1995, 4.8% to 5.6% systems had more than 2 mg/L fluoride in finished water whereas these numbers in 2005 ranged from 6.9% to 8.3%.

## FLUORIDE REGULATION

Although community water fluoridation in the United States began in mid-1940s, the first interim primary drinking water regulation was proposed in 1975 after the passage of the Safe Drinking Water Act in 1974. The range proposed was between 1.2–2.4 mg/L. EPA’s interim guideline was selected to prevent the occurrence of objectionable enamel fluorosis. In 1986, based on its review of the available data and consideration of the recommendations of various advisory bodies, EPA set a Maximum Contaminate Level Goal (MCLG) of 4 mg/L on the basis of crippling skeletal fluorosis. For fluoride, the MCL equals the MCLG, because analytical methods or treatment technology do not pose any limitation. EPA also set a secondary standard (SMCL) for fluoride at 2 mg/L. 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. The level of the SMCL for fluoride was set based upon a balancing of the beneficial effects of protection from tooth decay and the undesirable effects of excessive exposures leading to discoloration. In the early 1990s, the National Research Council (NRC) was asked to independently review the health effects of ingested fluoride and EPA’s MCL. The NRC ([1993](#)) found EPA’s MCL of 4 mg/L to be an appropriate interim standard.

The Safe Drinking Water Act requires EPA to periodically review the national primary drinking water regulation for each contaminant and revise the regulation, if appropriate. In 2003 and as part of the first Six Year Review, EPA reviewed the drinking water standard for fluoride and found that new health and exposure data were available on orally ingested fluoride. EPA requested that the NRC conduct a review of this data and in 2006, the NRC published their evaluation in a report entitled, [Fluoride in Drinking Water: A Scientific Review of EPA's Standards](#). The NRC recommended that EPA update its fluoride risk assessment to include new data on health risks and better estimates of total exposure ([EPA, Frequently Asked Questions](#)).

In March 2010 and as part of the second Six Year Review, the EPA indicated that the Office of Water was in the process of developing its health and exposure assessments to address the NRC's recommendations. EPA finalized the risk and exposure assessments for fluoride in January 2011 and announced its intent to review the drinking water regulations for fluoride to determine whether revisions are appropriate. HHS [proposed a recommendation](#) of 0.7 mg/L to replace the current recommended range of 0.7 to 1.2 mg/L.

## **FLUORIDE REMOVAL**

Fluoride is only required to be removed from drinking water if the levels are higher than 4.0 mg/L MCL set by the EPA. Fluoride removal methods can be divided in two alternatives: membrane and adsorption techniques. Membrane techniques include reverse osmosis, nanofiltration, dialysis, and electrodialysis, while adsorption techniques include alumina/aluminium based materials, clays and soils, calcium based minerals, synthetic compounds, and carbon based materials. Each one of these approaches has advantages and disadvantages. A recent paper published by Mohapatra et al. (2009), Review of Fluoride Removal from Drinking Water, summarizes the current state of knowledge on this topic. EPA recommends distillation or reverse osmosis as effective approaches for removing fluoride to below 4.0 mg/L ([USEPA, Frequently Asked Questions](#)).

## **INTERNET RESOURCES**

[CDC's Website](#) has tons of very useful information. Information is organized using the following categories:

- [Benefits](#) – Provides information on the oral health benefits of fluoride to individuals and communities.
- [Safety](#) – Provides references and other information about fluoride safety.
- [Statistics](#) – Provides access to data sources such as the National Oral Health Surveillance System. It is a good resource showing current fluoridation statistics in the United States.
- [Engineering and Operations](#) – Provides information on water fluoridation technical assistance resources to state programs.
- [Other Fluoride Products](#) – Describes forms of fluoride delivery other than water fluoridation.
- [Guidelines and Recommendations](#) – Offers technical information on programs.
- [Fact Sheets](#) – Covers specific topics.
- [Journal Articles](#) – Summarizes recent scientific information.

- [Related Links](#) – Provides links to various agencies and organizations recognizing the benefits of community water fluoridation.

[EPA's Website](#) provides information about fluoride in drinking water. The site answers basic questions and provides links to many resources. The page also provides a link to EPA's most recent document on [environmental exposure of children and adults to fluoride and the relative source contribution \(RSC\) for water](#). The RSC is needed in order to derive the MCLG from the dose-response assessment.

[American Dental Association's Website](#) has general information about fluoride in drinking water and health effects. Information is organized using following sections:

- [Recent Fluoridation Issues](#) – Items in this section address emerging issues related to community water fluoridation
- [ADA Fluoridation Resources](#) – This section provides resources from ADA such as a media press kit
- [ADA Fluoridation Policy & Statements](#)
- [Internet Resources](#) – This section provides a list of non-ADA Websites that provide information on fluorides and fluoridation issues

[Fluoride in Drinking Water: A Scientific Review of EPA's Standards](#) – National Research Council review on Fluoride

[A Half-century of Community Water Fluoridation in the United States: Review and Commentary](#) – Excellent review of the 50-year history of community water fluoridation

[American Water Works Association](#) – Contains AWWA information about fluoride, including publications, references, and links.

[Health Canada](#) – Contains information on fluoride and human health. It also provides a link to Canadian drinking water guidelines for fluoride.

[UKWIR Database](#) – This database on chemical toxicity, environmental fate, and water treatment contains more than 500 substance information profiles, including fluoride. Information of fluoride is organized using the following categories: Synopsis, Occurrence & Use, Mammalian Toxicology, Emergencies & SNARLS, Standards, Removal During Treatment, and Analytical Chemistry. Water Research Foundation subscribers can access the database free of charge by visiting the Resources/Web Tools area of the [Website](#) (you will need to login in order to see the database).

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