Public Health

Water Fluoridation Basics: What Operators Need to Know

Fluoride can greatly reduce the incidence of tooth decay among children. However, to achieve fluoridation’s maximum benefits, the optimal fluoride concentration in the water supply must be continuously maintained.

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This year marks the 75th anniversary of the start of water fluoridation, and generations of people in the United States, Canada, and dozens of other countries on every continent benefit with improved oral health and reduced tooth decay. Water fluoridation entails adjusting the fluoride level in water to optimize oral health. According to the US Centers for Disease Control and Prevention (CDC), 72.8 percent of the US population served by public water systems (PWSs) had fluoridated water in 2016 (www.cdc.gov/oralhealth). The number of people benefitting from fluoridated water continues to increase each year as additional systems initiate water fluoridation.

FLUORIDE FACTS

Fluoride is safe, healthy, and effective for improving oral health and reducing tooth decay. There are thousands of fluoride studies that support its use as an essential health benefit. The 0.7 mg/L fluoride level recommended in drinking water by the US Public Health Service has no adverse health effects. AWWA joins the CDC, US Public Health Service, US Office of the Surgeon General, World Health Organization, and many other professional organizations in the medical community that recommend water systems should adjust fluoride in drinking water to the suggested level.

Fluoride benefits all ages of people and all socioeconomic levels. As the 13th-most abundant element in the Earth’s crust, fluorine, from which fluoride is derived, can be found in many rock ores and soils. As shown in Figure 1, fluoride leaches into natural surface waters, which commonly have a natural fluoride level of 0.1 to 0.2 mg/L, which is consistent with rainwater’s fluoride level. Groundwaters may have fluoride levels varying from 0.1 to more than 10 mg/L, depending on local geological rock ores. Sea water’s fluoride level is typically 1.2 mg/L but can vary between 0.8 and 1.5 mg/L, depending on proximity to fresh water sources and local evaporative effects.

ORAL HEALTH BENEFITS

Early in the 20th century, a dentist, Frederick McKay, practicing in Colorado Springs, Colo., observed that people using certain springs for their water supply had discoloring stains on their teeth, but they retained their teeth to old age. This was a surprise, as most people in that era rarely retained their teeth.

https://doi.org/10.1002/opfl.1382
Fluoride is an essential element for good oral health, as it helps to remineralize tooth enamel to create a more decay-resistant surface (inset).

Subsequent studies during the next several decades by the US Public Health Service identified it was fluoride in local water sources that caused the enamel staining and provided decay resistance.

By the 1940s, it was established that an “optimum” level of fluoride in water was around 1 mg/L. At that level, users could reduce tooth decay and avoid undesirable enamel staining. Naturally occurring fluoride at a beneficial level is rare, so obtaining fluoride’s benefits for reducing tooth decay requires exposure above insufficient natural levels. The first community to adjust the fluoride in its water supply was Grand Rapids, Mich., which first added fluoride in January 1945.

Early trials were conducted in several cities as part of joint research among AWWA, the American Dental Association (ADA), and the National Research Council of the National Academies of Sciences. After six years of data were analyzed and found to have compelling health benefits, the US Surgeon General, ADA, and AWWA all issued a policy recommendation that communities should adjust fluoride to the beneficial level for oral health. All three partners in fluoridation continue to issue policy statements supporting and promoting water fluoridation; the current AWWA statement can be found at https://news.awwa.org/fluoridation.

When community water fluoridation was first initiated, almost everyone had tooth decay and no one knew how to prevent it. About half of older Americans (age 65+) had lost all their natural teeth. Now fluoride is considered an essential element for good oral health, as it helps to remineralize tooth enamel to create a more decay-resistant surface. Teeth are part of the skeleton system, comprising calcium, carbonates, phosphate, hydroxide, and fluoride. Because teeth experience continual demineralization and remineralization, fluoride is essential to promote remineralization, as shown in the inset figure above. Fluoride and hydroxide have the same atomic diameter, so they can replace each other within the crystal matrix; as the proportion of fluoride increases, tooth enamel gains hardness and decay resistance.

**OPERATIONAL CONCERNS**

The benefits in reducing tooth decay increase as fluoride in water increases up to 2 mg/L, at which point the maximum decay benefit is achieved. However, most of the benefit is achieved at 0.7 mg/L; incremental benefit above that level is small. Thus, the recognized beneficial range for fluoride in water is 0.6 to 1.0 mg/L; levels below that are insufficient to provide decay resistance at the desired level.

For fluoride to be most effective, it’s important for the concentration to be as close to 0.7 mg/L as possible. The CDC evaluated the operational capabilities of 4,251 PWSs reporting to the CDC Water Fluoridation Reporting System, a national database for managing and monitoring water fluoridation. That evaluation showed that water systems can be expected to achieve an operational tolerance of plus or minus 0.2 mg/L, and they tend to trim the feed on the lower side of the operational range to minimize additive cost. The CDC is currently developing an operational range based on this tolerance to guide the best operational practices for
The CDC encourages water treatment plants to adjust fluoride levels to a beneficial level for oral health, but the US standard for fluoride in drinking water is 0.7 mg/L. This is to prevent tooth decay and promote healthy bones and teeth. The Environmental Protection Agency (USEPA) has set a maximum contaminant level (MCL) of 4 mg/L to ensure public health safety. Fluoride levels exceeding 4 mg/L can lead to skeletal fluorosis, a condition in which bones are permanently weakened.

In areas with naturally occurring fluoride levels below 0.6 mg/L, water treatment plants can add fluoride to meet the USEPA’s recommended level of 0.7 mg/L. However, in areas with fluoride levels above 2 mg/L, water treatment plants must remove fluoride to prevent skeletal fluorosis.

The CDC recommends monitoring water systems to ensure fluoride levels are within the safe range. Water suppliers should notify customers about the fluoride content in their drinking water, and water operators should work with public health officials to ensure that fluoride levels meet regulatory standards.

Figure 2: Enamel Fluorosis

- **Fluoride Less Than 0.6 mg/L**: Less than 0.3 percent of the US population
- **Fluoride Between 0.6 and 2 mg/L**: About 75 percent of the US population
- **Fluoride Greater Than 2 mg/L but Less Than 4 mg/L**: Less than 0.3 percent of the US population
- **Fluoride Greater Than 4 mg/L**: Less than 0.01 percent of the US population
- **Fluoride Greater Than 4 mg/L**: Exceeds the USEPA’s MCL and results in skeletal fluorosis.