Managing Manganese

Background

Manganese (Mn) is an element that occurs naturally in water, soil, air, and food, and can be found in ground and surface water supplies. Manganese is one of the most abundant metals in the earth’s crust, usually co-occurring with iron. It is a component of over 250 minerals but is not found naturally in its pure (elemental) form. It is an essential nutrient for animals and plants. In humans and other animals, it is important in both growth and nervous system functioning. For humans, the typical daily intake for Mn is about 10 mg, the majority of which comes from natural occurrence in food sources.

Drinking water professionals have an interest in understanding Mn for a number of reasons. At relatively low concentrations (0.02 mg/L or greater), Mn can cause discolored water (usually black or dark red/brown), staining of laundry and plumbing fixtures, and increased turbidity. At higher levels, Mn can create a metallic taste in water (0.1 mg/L or greater). These are concerns for both water customers and water utilities. Recent research has documented the role of Mn in pipe scale formation and the impacts of later release of this store of Mn (referred to as legacy Mn) on water quality. Manganese can accelerate biological growth in distribution systems, with periodic sloughing of material that leads to black water problems.

Current Regulatory Framework

Manganese is not currently regulated by the U.S. Environmental Protection Agency (EPA) as a primary drinking water standard. In 2004, the EPA evaluated whether a primary drinking water standard for Mn was necessary, and concluded that, based on available data, regulation of Mn did not present a meaningful opportunity for health risk reduction. Yet emerging research suggests that Mn exposure from drinking water may contribute to adverse health effects such as hyperactivity (Bouchard et al. 2007), impaired intellect (Bouchard et al. 2011), and poorer memory and motor function (Oulhote et al. 2014). As a result, EPA included Mn on its Draft Contaminant Candidate List 4 (CCL4) in 2015. EPA will use the final CCL4 to guide data collection efforts for unregulated contaminants to support regulatory determinations.

There is also a renewed concern about the health risks associated with the mere presence of legacy Mn in distribution systems. Recent research demonstrates the ability of hydrous legacy Mn oxide solids to adsorb regulated trace inorganics like lead, barium, radium, etc., thus contributing to the accumulation (and potential release) of these toxic contaminants (Friedman et al. 2010, Schock et al. 2008) during Mn release episodes.

While Mn is not regulated, EPA has established a National Secondary Drinking Water Regulation for Mn that sets a non-mandatory water quality standard of 0.05 mg/L. This secondary maximum contaminant level (SMCL) is a guideline to assist public water systems in managing drinking water for aesthetic considerations, such as taste, color, and odor. The EPA’s Mn Health
Advisory, on which the SMCL was based, includes a Lifetime Health Advisory Value (HAV) of 0.3 mg/L to protect against potential neurological concerns. This HAV is estimated to be an intake for the general population that is not associated with adverse health effects and represents the portion of an individual’s total exposure attributed to drinking water.

Connecticut and California have set health-based limits of 0.5 mg/L Mn, 10 times the SMCL. World Health Organization (WHO) Guidelines for Drinking Water Quality set the health-based level for Mn at 0.4 mg/L, with the notation that concentrations at or below this level may affect the appearance, taste, or odor of the water, leading to consumer complaints. WHO has also set an aesthetic guideline of 0.05 mg/L.

**Treating Manganese**

Manganese chemistry and removal is very complex. Manganese can be removed or controlled using a variety of treatment techniques. Each has advantages and disadvantages depending on the level of manganese present, chemical form, other water quality parameters, competing treatment objectives, and treatment’s role in the utility’s overall manganese control strategy. Chemical oxidation and particle removal, filter media oxidation, biological treatment, ion exchange, and sequestration are common manganese control techniques. Even if utilities remove most of the manganese from their source water, substantial manganese accumulation can still occur in the distribution system. Stabilizing water chemistry and flushing pipes may help prevent and remove pipe scales.

**Research on Manganese**

The Water Research Foundation (WRF) has conducted numerous studies that utilities can draw upon to address manganese control and removal. The most pertinent projects and resources are listed below:

**Overview Projects**

- Guidance for the Treatment of Manganese - 4373
- Legacy of Manganese Accumulation in Water Systems - 4314
- Occurrence of Manganese in Drinking Water and Manganese Control - 2863
- Metals Accumulation and Release within the Distribution System: Evaluation of Mechanisms and Mitigation - 4509

**Treatment-Specific Projects**

- Optimizing Filter Conditions for Improved Manganese Control During Conversion to Biofiltration - 4448
- Occurrence, Impacts, and Removal of Manganese in Biofiltration Processes - 4021
- Characterization and Performance of Filter Media for Manganese Control - 2951
- Advanced Processes for Simultaneous Arsenic and Manganese Removal - 2748
- Use of Various Oxidants for the Control of Iron and Manganese - 306
- Sequestering Methods of Iron and Manganese Treatment - 229
- Manganese Treatment by the Addition of Sodium Silicate and Sodium Hypochlorite – 60

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Other Related Documents and Resources

- WRF Webcast on Legacy of Manganese Accumulation in Water Systems
- WRF Webcast on Guidance for the Treatment of Manganese
- Connecticut Department of Public Health Fact Sheet on Manganese in Drinking Water
- EPA Guidance on the Secondary Drinking Water Regulations
- World Health Organization Document on Manganese in Drinking Water

References


