EPA United States Environmental Protection Agency

RESEARCH PROJECT

National Risk Management Research Laboratory
Water Supply and Water Resources Division
Treatment Technology Evaluation Branch

THE EFFECT OF OXIDANT AND REDOX POTENTIAL ON METAL CORROSION IN DRINKING WATER

IMPACT STATEMENT

Future drinking water regulatory action may require some water utilities to consider additional and/or alternative oxidation and disinfection practices. There is little known about the effect of oxidant changes on the corrosion of drinking water distribution system materials and the release of metals from corrosion by-products. This redox study implements an experimental loop apparatus system to evaluate the corrosion of metals in drinking water. Leads, copper, iron (Fe), and red brass coupons are placed in a controlled reaction cell. The results of this science will further allow the U.S. Environmental Protection Agency to provide guidance on corrosion control in our aging distribution systems as well as treatment approaches for reducing metal levels at the consumer's tap.

BACKGROUND:

Future drinking water regulatory action may require some water utilities to consider additional and/or alternative oxidation and disinfection practices. For example, the addition of ozonation to a treatment train will increase a utility's ability to inactivate *Cryptosporidium parvum*, improve total organic carbon (TOC) removal and reduce disinfection by-product (DBP) production. However, changing from chlorine disinfection to chloramine disinfection has been reported by some to reduce biofilm activity in the distribution system. There is little known about the effect of oxidant changes on the corrosion of drinking water distribution system materials and the release of metals from corrosion by-products. Metal corrosion by-products and their solubility are controlled by redox conditions as well as general water chemistry. Iron, for example, can be present as both the Fe^{2+} and Fe^{3+} oxidation states in drinking water. At low redox conditions, such as in distribution system dead ends and beneath thick corrosion scale and deposits, soluble Fe^{2+} will be the dominant oxidation state. The build-up of Fe^{2+} can result in releases of discolored water and also heavy tuberculation in drinking water distribution systems. Redox potential is directly related to many drinking water processes, including disinfection, iron and manganese removal, and corrosion of distribution system materials. The effects of redox potential, and primary oxidant type and concentration on metal release, corrosion rate and corrosion scale properties of distribution system pipe material (lead, copper and iron) are poorly understood. Research on this topic could reduce distribution system corrosion problems and metal levels at the consumers' tap.

DESCRIPTION:

An experimental loop system was used to (1) examine the effect of oxidant type and concentration on metal release from distribution materials (lead, copper, red brass, and iron), and (2) examine whether the effect of redox potential on metal release is independent from oxidant type and oxidant concentration. So far, this study has shown oxidant concentration impacts the amount of lead and copper leached from metal coupons. The intermediate chlorine concentration produced the highest metal levels, while little difference existed between the low and high doses of oxidant. Based on redox potential, copper was more reactive with chlorine than lead. The change in redox potential over a stagnation period decreased with age of the metal, as protective scales developed. Mineralogy and the appearance of copper and lead corrosion scales differ with oxidant concentration. The coupons come into contact with prepared water with various redox, pH, oxidants and aqueous water chemistry conditions. Metal release is measured throughout the study after water has been in contact with the coupons for 24 or 72 hours of stagnation. Redox potential and pH are measured continuously with on-line measurement devices. The system is operated for approximately three months under the same operating and water chemistry conditions. At the end of the run, the corrosion scales are analyzed. The system is cleaned, new coupons are installed, and a new run with a different water quality (oxidant or oxidant concentration) is started.

EPA GOAL: Goal #2 - *Clean & Safe Water*; Objective 2.1.1- *Water Safe to Drink*
ORD MULTI YEAR PLAN: Drinking Water (DW), Long Term Goal - DW-2 *Control, Manage, and Mitigate Health Risks*

EXPECTED OUTCOMES AND IMPACTS:

The project will help water utility, engineering, consulting, and other clients and stakeholders understand how redox conditions of water will impact the release of lead, copper, and iron into drinking water.

OUTPUTS:

Current outputs consist of a M.S. Thesis, two presentations, and a peer-reviewed journal article.

RESOURCES:

NRMRL Corrosion Research: http://www.epa.gov/nrmrl/wswrd/cr/index.html
NRMRL Drinking Water Research: http://www.epa.gov/ORD/NRMRL/wswrd/dw/index.html
NRMRL Treatment Technology Evaluation Branch: http://www.epa.gov/ORD/NRMRL/wswrd/tteb.htm

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Drinking Water

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