United States Environmental Protection Agency

RESEARCH PROJECT

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

RELATIONSHIP BETWEEN REDOX POTENTIAL, DISINFECTANT, AND PH IN DRINKING WATER

IMPACT STATEMENT

Oxidation-reduction (redox) reactions control many chemical and biochemical processes in both nature and engineered systems, such as water treatment processes. Measuring oxidation-reduction potential (ORP) in water is a well-established method used to indicate the redox reactions of water. ORP readings can provide water utility operators with beneficial water quality information such as the effectiveness of disinfectant and microorganism kill rates. Despite the availability of this technology, ORP measurements are not widely made by drinking water utilities for numerous reasons, including electrode reliability issues and, most importantly, the lack of understanding of what these measurements actually represent in a natural water system. Very little research has been conducted to understand the effect of pH, oxidant type, and oxidant concentration on ORP. This study will further contribute to on-going investigations by the U.S. Environmental Protection Agency (EPA) to develop predictive and preventative tools for monitoring drinking water processes. In doing so, this study will position EPA to continue providing subject-matter expertise and guidance to drinking water utilities, engineers, the general public and other stakeholders.

BACKGROUND:

Because redox reactions describe chemical and biological systems, they are especially important to drinking water treatment. In water, examples of naturally occurring reductants include iron^{2+} and Manganese^{2+}. Common oxidants used in drinking water treatment for microbial disinfection and oxidation of inorganic and organic contaminants include free chlorine (HOCl and OCl-1), oxygen, monochloramine, and ozone. Furthermore, the type and amount of reductants and oxidants present in a water system directly impact the ORP, and can greatly change the water quality of an aqueous system. Eh-pH diagrams can predict how redox conditions and pH impact the chemistry of aqueous species. These diagrams are derived from fundamental chemistry relationships and experimentally developed parameters, and they are well accepted and frequently used by engineers and scientists. ORP values listed in Eh-pH diagrams correspond to the theoretical Eh.

Despite the amount of research dedicated to ORP measurement accuracy and usable monitoring devices, established ORP ranges for common oxidants still remain unknown. Determining expected ranges and then comparing them to real field measurements may be advantageous to prove ORP measurements are viable, and could be used to identify problems with drinking water treatment.

DESCRIPTION:

This work will examine the effects of pH and oxidant type (chlorine [Cl_2], oxygen [O_2], hydrogen peroxide [H_2O_2], monochloramine [MCA], and potassium permanganate [$KMnO_4$]) and concentration (mg/L) on the redox potential of buffered test water. Also, the effects of incrementing iron with each oxidant will be investigated. The consistency and uncertainty of redox potential electrodes will also be explored. Using these associations, this research aims to achieve concrete relationships between redox potential, pH, and dose for each oxidant.

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:

After determining the actual relationships between redox potential, pH, and dose for each of the subject oxidants, the findings can be transferred to utility, engineering, consulting and other clients and stakeholders to optimize system performance with specific oxidant types.

OUTPUTS:

An output of the project will consist of a journal article.

RESOURCES:

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

CONTACTS:

Darren Lytle, *Principal Investigator* - (513) 569-7432 or lytle.darren@epa.gov
Steven Doub, *Media Relations* - (513) 569-7503 or doub.steven@epa.gov
Michelle Latham, *Communications* - (513) 569-7601 or latham.michelle@epa.gov

National Risk Management Research Laboratory
Water Supply and Water Resources Division

www.epa.gov/nrmrl

EPA/600/F-10/006
February 2010