

THE ROLE OF MICROBIAL PROCESSES IN THE OXIDATION AND REMOVAL OF ARSENIC FROM DRINKING WATER



IMPACT STATEMENT

The U.S. Environmental Protection Agency (EPA) recently reduced the drinking water standard for arsenic (As) in water from 0.05 to 0.01 milligrams (mg)/Liter (L) (10 micrograms (μg) /L). This reduction was prompted by new health effects research, which concluded that extended human exposure to this element can cause severe illnesses (including various types of cancers) at much lower levels than previously believed. The recent revision to the arsenic standard has required many new water treatment systems to apply treatment processes. Findings from this study will further enable EPA to provide subject matter expertise and guidance on best available technologies for the removal of arsenic from drinking water.

BACKGROUND:

The oxidation state of arsenic, As(III) or As(V), is very important in water treatment, the latter can be removed more easily. Source waters that contain As(III) generally require the use of a strong oxidant such as free chlorine or permanganate to oxidize the arsenic early in the treatment process. Oxygen is not an effective As(III) oxidant, but it is however, effective at oxidizing Fe(II). Aeration is commonly incorporated into iron removal processes particularly in the Midwest. For such systems that also contain As(III) in their source water, they may need to add a stronger oxidant before aeration to achieve the desired arsenic removal efficiency. The oxidation of As(III) by bacteria is well known, but never reported to be important in drinking water treatment systems. In water treatment, the application of microbial processes is not a widely accepted practice in the United States. The lack of acceptance is due largely to the negative perception of using bacteria to clean water when at the same time a goal of water treatment is to remove and kill bacteria. Secondly, the concern that pathogenic bacteria could be harbored in the filters and regularly shed to the finished water always exists.

One iron removal treatment plant (oxidation and filtration) in Ohio has observed effective iron (2.3 mg/L) and arsenic (46 $\mu\text{g}/\text{L}$) removal, and regularly meets the new arsenic standard. The majority of arsenic in the raw water is in the reduced As (III) form (37 $\mu\text{g}/\text{L}$). The interesting observation is that arsenic is removed without the addition of a strong chemical oxidant such as free chlorine to convert As (III) to the more easily removable As (V) form. Aeration is used to oxidize iron in the source water. Preliminary investigations suggested that oxidation of As (III) takes place within the filters by microorganisms which could explain the greater than expected arsenic removal. If microbiological oxidation of As (III) does occur within the filters, taking advantage of the natural microbiological population in the source water can avoid the need, costs, and possible complications associated with adding a strong oxidant to the water.

DESCRIPTION:

The objectives of this study were to 1) document the removal of arsenic in a full-scale water treatment plant, 2) conduct bench-scale studies to identify the mechanism(s) responsible for arsenic removal, 3) identify the role of bacteria, if any, on arsenic removal, and 4) conduct pilot-scale studies to identify the most effective and rapid method to regain microbial activity within the filters.

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:

Water utilities, states and engineers will better understand nitrification problems and approaches to reduce nitrification in distribution systems.

OUTPUTS:

Current and future outputs of the project will consist of published papers, peer-reviewed journal articles.

RESOURCES:

EPA Arsenic Research: <http://www.epa.gov/nrmrl/wswrd/dw/arsenic/>

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