

THE EFFECT OF WATER CHEMISTRY ON THE REMOVAL OF ARSENIC FROM DRINKING WATER DURING IRON REMOVAL TREATMENT

IMPACT STATEMENT

New health effects research prompted the U.S. Environmental Protection Agency (EPA) to reduce the drinking water standard for arsenic from 0.05 to 0.010 milligrams (mg) l⁻¹ (10 micrograms (µg) l⁻¹), and as a result many drinking water systems, particularly smaller ones, throughout the country will no longer be in compliance. A number of technologies are currently available to remove arsenic from water. In waters that contain natural iron, arsenic removal can be achieved during iron removal, but the effectiveness of iron to remove arsenic depends on many variables. The objective of this study was to identify the operational and water quality factors that impact arsenic removal during iron removal. The findings of this study will help EPA provide guidance and solutions that may lead to best available technologies for the co-removal



of iron and arsenic, particularly for small systems facing unique compliance challenges.

BACKGROUND:

The new arsenic standard for drinking water will require thousands of drinking water systems to install arsenic removal technology. Arsenic, which is found at varying levels in many groundwaters and some surface waters, can have both natural and anthropogenic sources. In natural environments, high levels of arsenic are generally caused by the leaching of arsenic from certain arsenic-containing minerals, such as arsenopyrite and other various arsenic sulfides and sulfosalts. In addition to arsenic-bearing host minerals, discharge from various industries (including mining, petroleum refining, and glass and ceramics manufacturing) can cause arsenic pollution. Pesticides, herbicides and fertilizers are also known sources of arsenic release. Treatment methods for the removal of arsenic from water include coprecipitation processes using iron and aluminium salts, iron removal, anion exchange, lime softening, reverse osmosis, electrodialysis reversal (EDR), nanofiltration and adsorption media. Many arsenic removal processes are iron-based treatment technologies, such as chemical coagulation with iron salts, natural iron removal from source waters by oxidation and filtration, and iron-based adsorptive media. These processes are particularly effective at removing arsenic from aqueous systems because iron surfaces have a strong affinity to adsorb arsenic. As a result, the adsorption and coprecipitation of arsenate and arsenite on iron oxide surfaces have been investigated extensively. Due to geochemistry, many arsenic-containing groundwaters also contain significant levels of iron (Fe), which is typically in the reduced (i.e. dissolved) Fe(II) state. In these cases, conventional Fe removal processes can be used to reduce arsenic by taking advantage of the surface adsorptive capacity of natural iron particles that are produced following the oxidation of Fe(II). The capacity to remove arsenic during iron removal depends largely on the amount of arsenic and natural Fe present in the source water.

DESCRIPTION:

This research investigates the effects of water chemistry, oxidant type and concentration on the removal of iron and arsenic from drinking water. The research will be conducted using one of the National Risk Management Research Laboratory's Water Supply and Water Resources Division's current drinking water treatment pilot plants. Suspension color, turbidity, pH, and iron and arsenic levels will be regularly monitored during pilot plan runs. The impact of water quality including calcium, chlorine, orthophosphate and sulfate on iron and arsenic removal will be determined. The effect of water chemistry and oxidant on pilot plant operational parameters, such as filter headloss, will also be considered.

The results of this research thus far showed that (1) arsenic removal improves with increasing iron concentration and particle surface area; (2) freshly precipitated Fe particles had a much greater capacity to remove arsenic than preformed particles that were formed by oxidation of ferrous Fe with either oxygen or chlorine; (3) chlorination, or application of a stronger oxidant, may be necessary to improve arsenic removal at many drinking water treatment plants; (4) the point of strong oxidant addition in the treatment train is important; and (5) the pH and other competing water quality variables such as phosphate play significant roles in the amount of arsenic removed.

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 provide sound methods for improving and optimizing arsenic removal during iron removal to water utilities, states, engineers, and consultants.

OUTPUTS:

Current outputs consist of several presentations and peer-reviewed journal articles.

- JOURNAL ARTICLE: Lytle, D.A., Sorg, T.J., and Snoeyink, V.L. *Optimizing Arsenic Removal During Iron Removal: Theoretical and Practical Considerations*. Journal of Water Supply: Research and Technology - AQUA 54(8):545-560, (2005). International Water Supply Association (London, England). IWA Publishing, London, Uk.

RESOURCES:

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

Optimizing Arsenic Removal during Iron Removal: Theoretical and Practical Considerations:
<http://www.iwaponline.com/jws/054/jws0540545.htm>

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>

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



Drinking Water