

Project Summary

Evaluation of Concurrent Removal of Arsenic and Iron for Wisconsin Water Producers

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Background & Need

New regulations and a greater understanding of the health effects of arsenic exposure will lead many water suppliers to consider reducing arsenic concentrations in their drinking water. Concurrent iron and arsenic removal may provide an opportunity for many small water systems to simultaneously address a significant aesthetic water quality problem and provide risk reduction from arsenic exposure. Unfortunately, current information on arsenic removal does not provide a clear discussion of the limitations and advantages of concurrent arsenic and iron removal particularly for small groundwater systems using conventional, low-residence time, oxidation/filtration systems.

Objectives

The research described in this report examined combined iron and arsenic removal, and in particular, arsenic removal during the oxidation and precipitation of iron followed by pressure filtration in short residence time systems. This project had two primary objectives. The first was to evaluate the likely utility of iron removal as a means to reduce arsenic concentrations in Wisconsin public water supplies. The second was to provide a detailed laboratory and field demonstration of iron and arsenic removal that was directed towards identification of kinetic and speciation concerns for oxidation/direct filtration processes.

Methods

This project combined a field and laboratory investigation of arsenic removal. Existing information on water quality at Wisconsin public water suppliers was used to evaluate the likely feasibility of iron removal as an arsenic treatment technique. Then the removal of arsenic was measured at two water treatment systems in Wisconsin that currently have arsenic in their raw water and also use iron oxidation followed by filtration to treat their water. The laboratory investigation examined the kinetics of simultaneous iron oxidation and filtration with arsenic removal. A laboratory evaluation of iron and arsenic removal focused on the rate of simultaneous iron and arsenic removal in reactors that mimicked conditions typically encountered at small water systems. Removal of both arsenite (As(III)) and arsenate (As(V)) were evaluated. Although the work used data collected at Wisconsin water systems, the results were developed to be applicable to many regions of the Midwestern U.S.

Results and Discussion

The field investigation showed iron is usually present in public water supply wells that contain arsenic. It also showed arsenic removal occurring at the two field sites currently removing iron. Removal of approximately 70% of the arsenic was observed at facilities that were treating water with an iron concentration of more than 2 mg/l and arsenic concentrations less than 15 µg/l.

The laboratory investigation found that in a water typical of many Wisconsin public water supplies, neutral pH, and a hard, high alkalinity (~2.5 mM), the removal of arsenate can be estimated assuming a pseudo-equilibrium partition between arsenate and forming iron solid with a rate of removal dictated by the removal of iron. At a solution arsenic concentration of 5 µg/l, the apparent arsenic density on ferric iron solids was 30-40 µg As/mg Fe. That is considerably higher than reported for preformed iron solids and more than double that reported during ferric coagulant addition and suggests that the reactivity or surface area of the iron solids is increased during coincident iron oxidation. In contrast, arsenite removal was much lower in these rapid reaction systems. Little adsorption of arsenite was observed during the first 15-20 minutes of iron oxidation/ferric hydroxide formation. This suggests both low reactivity and slow in-situ oxidation of arsenite is expected in Wisconsin treatment systems.

Conclusions and Recommendations

The results of this research confirm the utility of coincident iron and arsenic removal for the treatment of groundwater containing arsenic. In groundwater systems treating water through relatively short residence times, the oxidation/precipitation/filtration treatment process can effectively remove As(V). The solids generated can have a relatively high arsenic density compared to preformed solids, suggesting that the high surface area accessible to arsenate during iron precipitation can enhance the removal of arsenic. The rate of arsenic association with precipitating iron did not appear to be a significant limitation with respect to As(V), but may be a consideration with respect to As(III), particularly for those systems with very short hydraulic residence times. Although the reduced form of arsenic was not removed significantly over the short time in these experiments, it can be oxidized with chlorine and subsequently should then be sorbed by the iron solids.

Related Publications

Technical Presentation: Iron and Arsenic: What's the Connection. Presented at the Wisconsin Water Association Annual Meeting, September, 2002, Wisconsin Dells, Wisconsin.

Poster Presentation: Wisconsin State Environmental Health Meeting: Arsenic Removal with Iron (w/ undergraduate student Jesse Baumann), September, 2003

Poster Presentation: Arsenic Removal During Iron Treatment (w/ undergraduate student Jesse Baumann) at the American Water Resources Association Wisconsin Section Meeting, Lac du Flambeau, February, 2003.

Key Words: Arsenic removal, water treatment, iron oxidation

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