SAFE AND SUSTAINABLE WATER RESOURCES RESEARCH PROGRAM

EPA United States Environmental Protection Agency

FY16 Product
Water Systems

Removal of Strontium from Drinking Water by Conventional Treatment and Lime Softening in Bench-Scale Studies

Darren Lytle, Ph.D.

Introduction & Significance

- Strontium in drinking water increases susceptibility of infants, children and adolescents to abnormal skeletal developments (USEPA 1990).
- This is exacerbated by inadequate calcium levels because strontium substitutes for calcium during bone calcification or displaces calcium from the existing calcified matrix (El Solh and Rousselet 1981).
- Strontium is distributed across the US in groundwater and some surface waters, making it a possible issue.
- Research is needed to see how effectively potential treatments can remove strontium from drinking water.

Approach

Coagulation:

- Coagulants tested: ferric chloride and alum.
- Examined impact of coagulant dose and pH on strontium removal.
- Source waters: Ohio River and local lake in Cincinnati.

Lime softening:

- Examined impact of pH, calcium, DIC (dissolved inorganic carbon), and lime dose, as well as strontium concentration
- Source waters: private homeowner's well, two cities in Ohio identified as site 1 and site 2, Strontium-spiked untreated water collected from Greater Cincinnati Water Works, Bolton Treatment Plant.

Controlled batch tests:

- Evaluated strontium removal during lime-soda ash softening and identifying patterns and removal mechanisms
- Source waters: made in lab
- Added step of pH stabilization

Results

Analyses:

- Water samples analyzed with ICP-AES analyses preserved with analytical grade ultrapure nitric acid.
- After filtration, precipitates were analyzed with scanning electron microscopy (SEM) and x-ray diffraction (XRD) to determine composition, particle size/morphology, and mineral identification.

Lime softening as source of removal:

- The most significant finding was that strontium removal paralleled calcium removal. Therefore, if a lime softening water treatment plant successfully removes calcium, it is likely also removing strontium in a similar manner. Strontium removal as great as 78% was achieved.

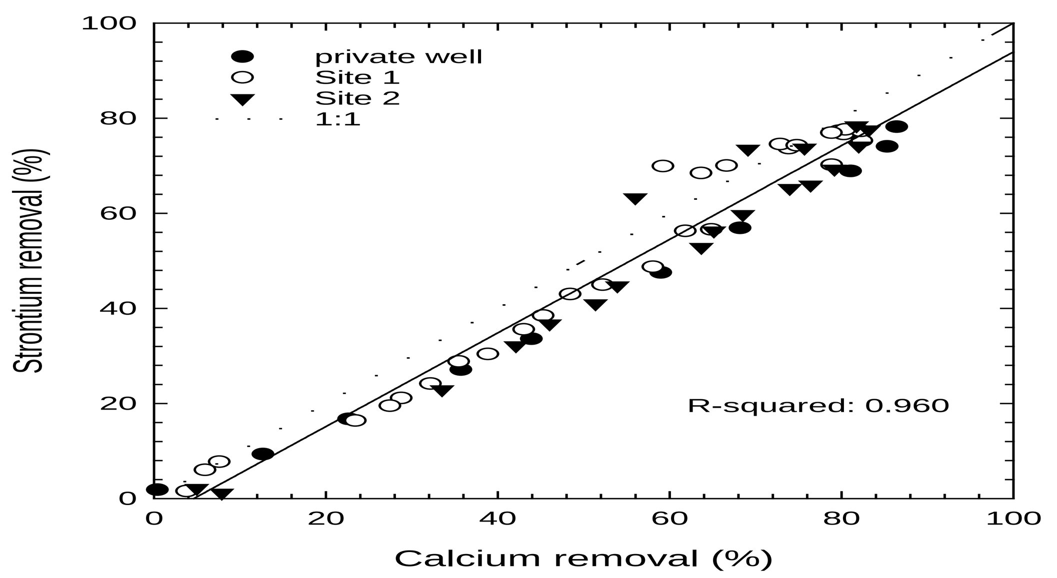

Figure 1. The relationship between Calcium removal (%) and Strontium Removal(%) as observed in private wells, Site 1, and Site 2.

Coagulation as source of removal:

- Not effective at removing strontium, independent of factors including pH and initial strontium concentration, and only slightly dependent on initial turbidity. Strontium removal using alum and ferric chloride achieved 12% and 5.9%, respectively.

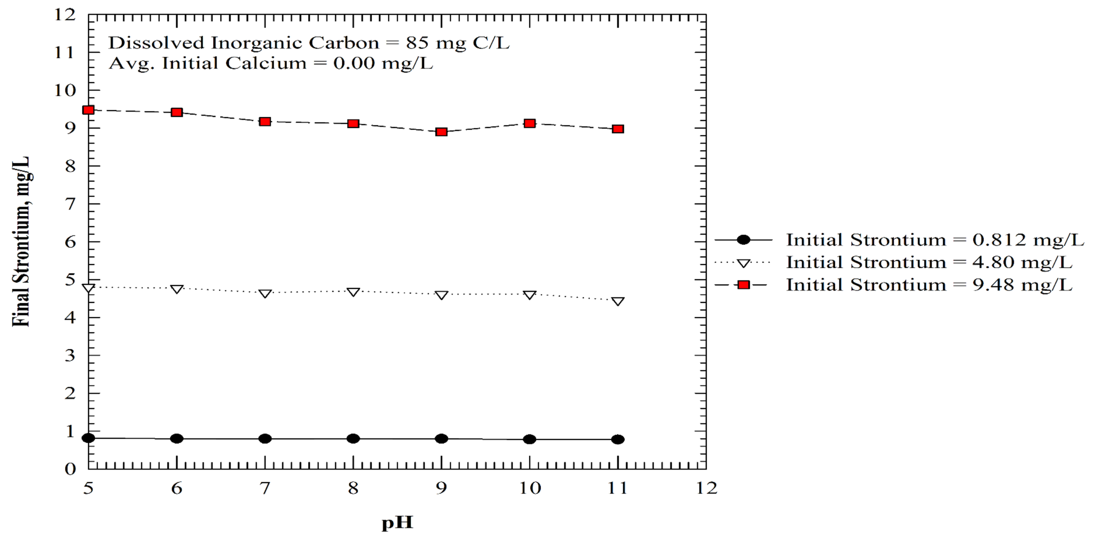

Figure 2. Effects of pH and initial strontium (no calcium added) on strontium removal

Expected Use

- Assist in regulatory determination processes and regulation development.
- Provide assistance for public water systems that have elevated strontium levels in source water.
- Aid in the study of how Strontium's lack of regulations has affected water quality.

Future Direction

- Future research includes sampling different sites at various water treatment plants that have naturally occurring strontium in their raw water sources to examine the feasibility of strontium removal in large scale treatment plants.
- Full scale ion exchange softening and an analysis of potential for consistent regulatory practices is another direction for future research.
- The study of lime and ion exchange in removing Strontium and how the varying processes compare to one another at removal are also expected to be areas of future research.

Collaborators

This project was a collaboration between Darren Lytle, Alissa J. O'Donnell, Stephen Harmon, Kevin Vu, Hannah Chait and Dionysios D. Dionysiou.