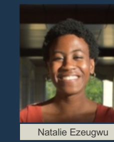
Contaminant mobilization from free chlorine during managed aquifer recharge in Orange County, California

Smart managed aquifer recharge technologies (SMART)

Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt)



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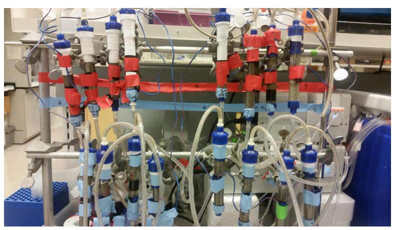
Background

- Managed aquifer recharge (MAR) is a process in which treated wastewater is either pumped into shallow ponds and allowed to percolate into the ground, or directly injected into deeper formations.
- As groundwater use rises, groundwater supplies for drinking and agricultural use are supplemented by MAR.
- The storage and intermittent pumping of treated wastewater in California may cause the mobilization of contaminants such as arsenic due to changes in the electrochemical properties of the water and surrounding sediments.
- Goal: Determine how changes in groundwater properties resulting from various concentrations of free chlorine may lead to contaminant mobilization from aquifer sediments.

Approach

Analyzing Orange County Sanitation District's Managed Aquifer Recharge:

- Mix sediment with sand in a 1:2 ratio by mass
- Pack sediment mixture into columns
- Prepare water of pH 8.4 and pH 9.0 with varying free chlorine concentrations through sediment samples
- Run water through packed columns to simulate the percolation or injection of water into soil
- Collect final product water; measure pH, and electrical conductivity
- Analyze water for trace contaminant concentrations using inductively-coupled plasma mass spectroscopy (ICP-MS)
- Contaminants Analyzed: Arsenic and Uranium



Columns packed with sediment

Results

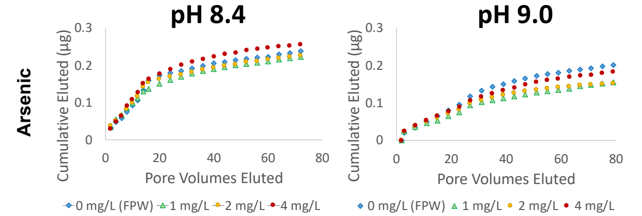


Figure 1. Cumulative mass of arsenic eluted at pH 8.4 (left) and pH 9.0 (right).

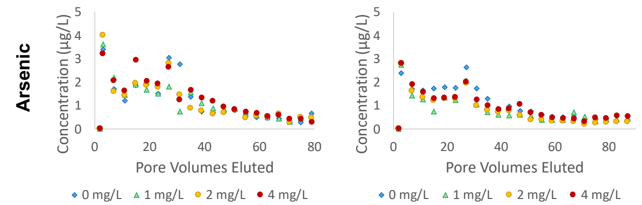


Figure 2. Concentrations of arsenic per pore volume eluted at pH 8.4 (left) and pH 9.0 (right).

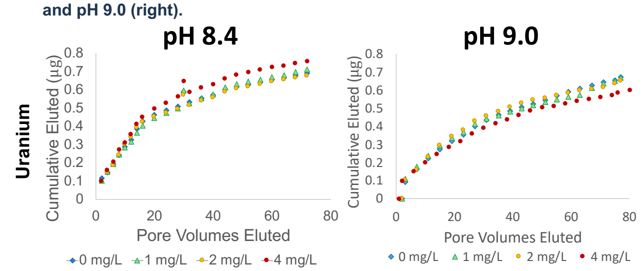


Figure 3. Cumulative mass of uranium eluted at pH 8.4 (left) and pH 9.0 (right).

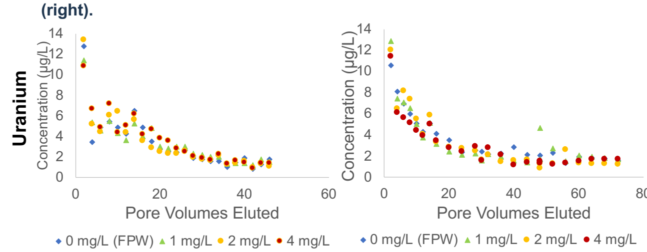


Figure 4. Concentrations of uranium per pore volume eluted at pH 8.4 (left) and pH 9.0 (right).

Conclusions

- The concentrations of both contaminants decreased with increasing pore volumes eluted for both pH 8.4 and pH 9.0.
- Arsenic's maximum contaminant level, as set by the EPA, is 10 µg/L. The measured arsenic concentrations fell between 4µg/L and 1 µg/L, so the concentrations are well below the maximum level.
- The maximum contaminant level for uranium is 30µg/L, and the levels measured ranged from 14µg/L to 1µg/L, well below the maximum.
- The concentrations of contaminants are therefore below their maximum levels, indicating that managed aquifer recharge may not pose a significant risk to the groundwater quality.
- Increasing the concentration of chlorine in the water had no significant effects on total mass eluted, although 4 mg/L was consistently higher than 1 and 2 mg/L at pH 8.4 for both As and U.
- Arsenic concentrations resulting from final product water appear to be closer to the 4 mg/L free chlorine, suggesting there may be more than one mechanism at work in the columns.
- The total mass eluted was higher for pure final product water than the 4 mg/L at pH 9.0 compared to pH 8.4.

Next Steps

- Analysis of concentrations of other contaminants
- Additional analysis of final pH and electrical conductivity of product water
- Use of x-ray fluorescence (XRF) to determine the elemental composition of the sediment samples
- Testing of water from other districts
- Testing of water of different pH values
- Use of higher concentrations of chlorine to determine potential effects on contaminant concentrations

Acknowledgements

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