Adsorption of Dissolved Metals from the Berkeley Pit using Thiol-SAMMS

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Objective

Determine the ability of thiol-SAMMS to remove dissolved metal contaminants from Berkeley Pit water.

Introduction

- Thiol-functionalized Self-Assembled Monolayers on Mesoporous Supports, or thiol-SAMMS, is a selective adsorbent developed at Pacific Northwest National Laboratory (PNNL).
- The Berkeley Pit in Butte, Montana, was an open pit mine.
- Today the pit contains over 40 billion gallons of water contaminated with dissolved metals due to groundwater and surface water runoff into the pit.
- Berkeley Pit water is acidic (pH ≈ 2.5).

The Berkeley Pit as seen from space, photo taken on August 2nd, 2006. (NASA 2008).

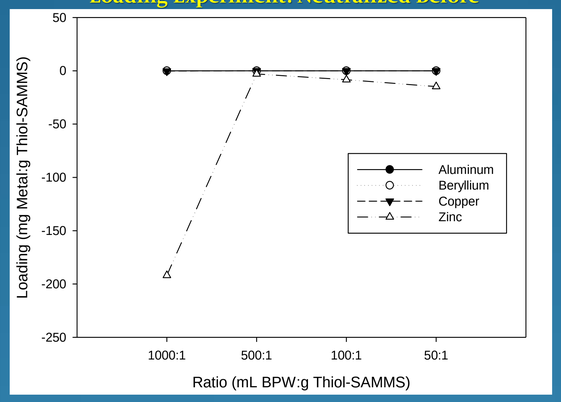
Materials and Methods

- Different ratios of Berkeley Pit water to thiol-SAMMS were tested.
- Loading experiments: Berkley Pit water was neutralized before or after adding thiol-SAMMS. Solutions were shaken for at least 24 hours, followed by sampling.
- Kinetics experiments: Berkeley Pit water was neutralized before adding thiol-SAMMS or not neutralized. Solutions were shaken for 8 hours and samples were taken over time.
- Analysis was done with inductively-coupled plasma – mass spectrometry (ICP-MS) and ICP – optical emission spectrometry (ICP-OES)

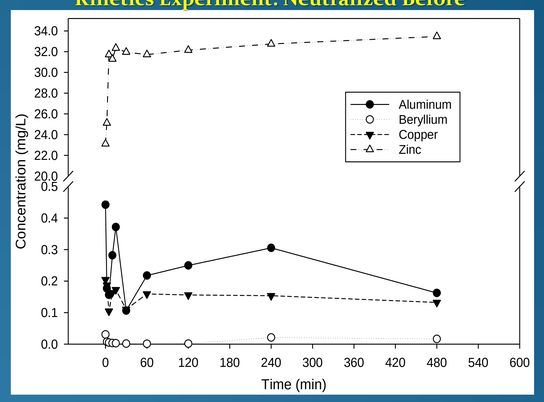
Berkeley Pit Water Neutralized Before Adding Thiol-SAMMS

- Loading is a measure of how much metal (in milligrams) is adsorbed per gram of thiol-SAMMS.
- Neutralization caused a significant amount of metals to precipitate from solution.
- Increased zinc concentration (negative loading) was observed in experiments. As thiol-SAMMS binds to metals, hydrogen ions are released, possibly lowering pH, causing precipitated zinc to dissolve.
- Concentrations of aluminum, beryllium, and copper fluctuate and eventually decrease. Fluctuations in concentrations may be caused by competition between dissolved metals for binding sites on thiol-SAMMS.

Loading Experiment: Neutralized Before



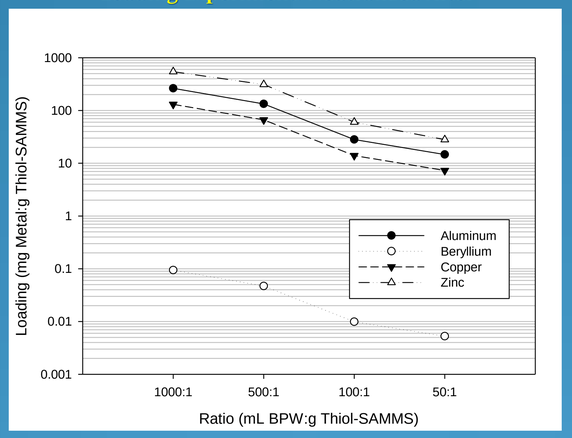
Kinetics Experiment: Neutralized Before



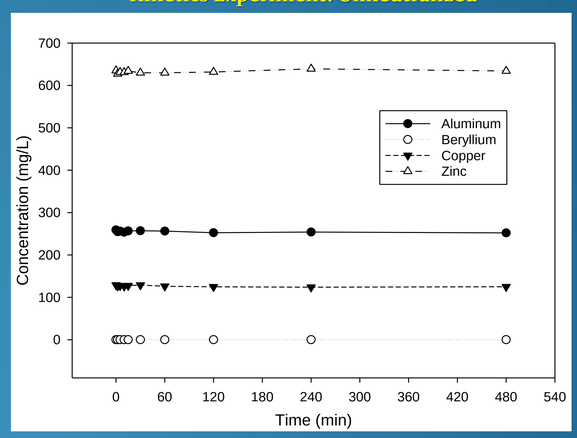
Berkeley Pit Water Neutralized After Adding Thiol-SAMMS and Unneutralized

- For solutions neutralized after adding thiol-SAMMS, thiol-SAMMS appeared to adsorb dissolved metals.
- However, in the solution that was not neutralized, the concentrations of each metal remained constant. The low pH likely caused hydrogen ions to compete with dissolved metals for thiol-SAMMS binding sites.
- Thus, observed loadings were likely due to neutralization and not metal loading on thiol-SAMMS.

Loading Experiment: Neutralized After



Kinetics Experiment: Unneutralized



Conclusions: Neutralization of Berkeley Pit water results in a significant decrease in dissolved metal concentration. The combination of neutralization followed by thiol-SAMMS sequestration could reduce contaminants to below drinking water standards. Results suggest thiol-SAMMS is more selective for binding to aluminum, beryllium, and copper, but more research is necessary to determine for which metals thiol-SAMMS is selective. Future research is necessary to more thoroughly evaluate the results presented here.

References

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3. PitWatch2009. "Berkeley Pit News and Notes". Summer 2009. http://www.pitwatch.org/Accessed 21 July 2009.

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