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Kinetic and equilibrium sorption modeling of arsenite and arsenate onto Lake Whatcom sediments and activated carbon.

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Kinetic and equilibrium sorption modeling of arsenite and arsenate onto Lake Whatcom sediments and activated carbon

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Background

Arsenic from anthropogenic sources and geological weathering is a contaminant of concern in sediment environments of Washington State. Legacy contamination can be attributed to extensive application of lead-arsenate pesticides and industrial smelting processes. Arsenic contamination of sediment provides an exposure pathway into groundwater and can potentially contaminate drinking water. Metal bioavailability of contaminated sediment is greatly influenced by the presence of acid volatile sulfides and organic carbon. Activated carbon (AC) has been shown to be an effective in-situ treatment for decreasing bioavailability of organic contaminants in sediment (Patmont et al. 2015). Less is known about the applicability of AC to decrease metal mobility in the sediment environment.

Project Overview

In this study we will assess sorption behavior of arsenite and arsenate onto locally collected sediment particles. We will test how the presence of AC affects the predicted mobility of each arsenic species between the aqueous and solid phase.

Objectives

- 1) Determine distribution coefficient (K_d) of arsenite and arsenate
- 2) Determine if AC influences partitioning behavior
- 3) Understand fate and transport processes of arsenic in a simplified environment

Figure 1. Exposure pathway of arsenic in the sediment environment. Activated carbon, shown as black diamonds, can sorb arsenic (red) and reduce its concentration in the water column.

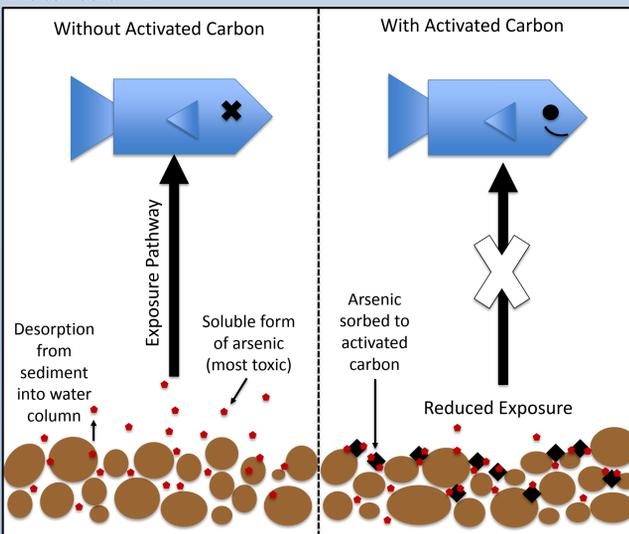


Figure 2. Authors Fischer Young and Holly Young collect sediment from Lake Whatcom using an Ekman dredge.



Figure 4. Hyperkeratosis and skin lesions as a result of chronic arsenic exposure. Photo credit: Steven Lamm

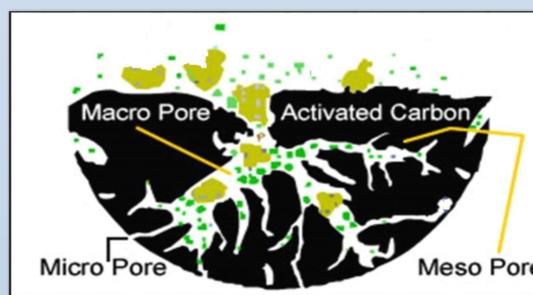


Figure 5. Activated carbon can sorb contaminants within its porous network. Photo credit: Begg Cousland Envirotec

Methods

Batch series will be conducted for sediment to determine time to equilibrium and distribution coefficients of arsenite and arsenate

Arsenic Concentrations: 0.1-100 ppm range chosen to include background and Model Toxics Control Act cleanup levels for freshwater sediments

24 hour Exposure Period: experimental chambers are agitated continuously at 100 rpm at 22°C

ICP-MS Analysis: arsenic concentration in solution are analyzed by collecting samples at 0, 2, 6, 12, and 24 hour time steps

Distribution Coefficient or K_d of a chemical species is expressed as:

$$K_d = \frac{\text{mass of solute on solid phase}}{\text{mass of solute in solution}}$$

Sediment Characterization: particle analysis will be conducted using a hydrometer method

Analysis

- Establish time to equilibrium
- Compare distribution coefficients between treatments

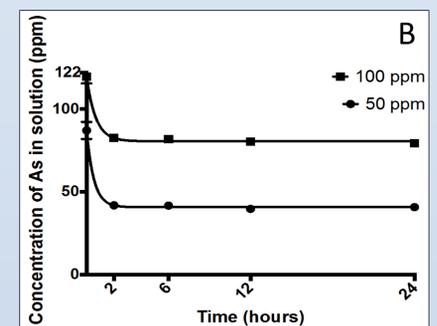
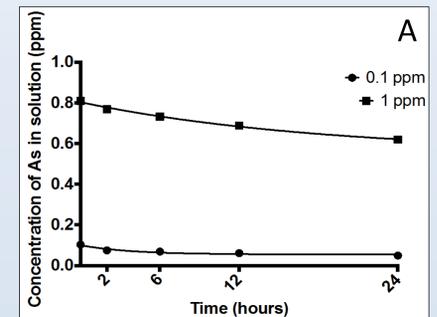


Figure 6. Concentration of arsenite (ppm) in solution with untreated sediment over a 24 hour exposure period of low (A) and high (B) arsenite concentrations.

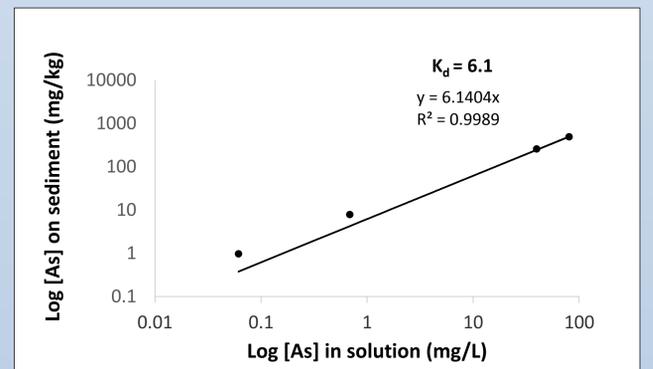


Figure 7. Arsenite concentration in solution verse concentration sorbed to sediment at equilibrium among different concentrations. The distribution coefficient (K_d) is determined by the slope.

Status

- Repeat sediment experiments with arsenate
- Compare distribution coefficients between arsenic species
- Produce applicable models of arsenic sorption onto sediment and activated carbon

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Patmont CR, Ghosh U, LaRosa P, Menzie CA, Luthy RG, Greenberg MS, Cornelissen G, Eek E, Collins J, Hull J, Hjartland T, Glaza E, Bleiler J, Quadri J. 2015. In situ sediment treatment using activated carbon: a demonstrated sediment cleanup technology. *Integrated Environmental Assessment and Management*. 11(2): 195-207.

Acknowledgements

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Figure 3. Holly Young pipettes samples from treatment chambers into nitric acid for ICP-MS analysis.

