Using Lanthanum Modified Bentonite to Immobilize Arsenic in Lake Sediments

Riley McElroy, Sasha Vinogradova, Jim Gawel
Environmental Science – University of Washington, Tacoma

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Introduction

- Lake Killarney in Federal Way, WA, that has some of the highest sediment arsenic concentrations (>200 ppm) in western Washington due to the ASARCO smelter in Ruston, WA, releasing contaminants from 1917-1993 (Gawel et al., 2014).
- Arsenic has also been found at higher concentrations in the surface water of shallow contaminated lakes, including Lake Killarney, due to periodic mixing in a weakly stratified water column (Fung et al. 2024).
- Arsenic is a known carcinogen that also causes other non-cancerous health conditions (Yoshida et al. 2004).
- Increased exposure to humans calls for viable lower cost remediation options.
- Previous research has found lanthanum-modified bentonite, a phosphorus treatment, to successfully suppress arsenic remobilization from lake sediments over a two month lab treatment (Cui et al. 2021).

Our objective is to test if lanthanum-modified bentonite is viable for reducing arsenic concentrations in aquatic environments through an *in situ* mesocosm experiment.

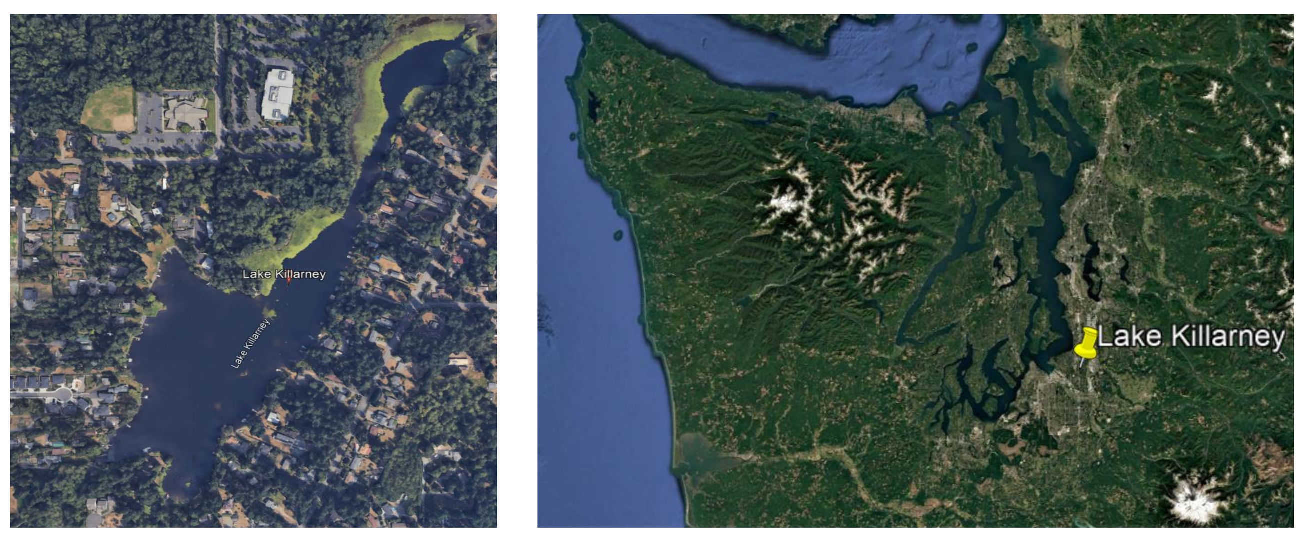

Figure 1: Location of Lake Killarney, Federal Way, WA.

Methods

- Six mesocosms (Figure 3) were installed and monitored in Lake Killarney (Figure 1) in Federal Way, WA from June 2024-October 2024.
- Duplicate mesocosms were treated with a low (0.25 kg/m²) and high (1.0 kg/m²) concentration of lanthanum-modified bentonite (EustroSORB G). Two mesocosms were left as duplicate controls (Figure 3).
- Biweekly measurements of temperature, pH, conductivity, and dissolved oxygen were collected at the surface and bottom of each mesocosm (Figure 2).
- Water samples from the surface and the bottom were collected in acid-washed polypropylene bottles for phosphorus (SM 4500-P E, ascorbic acid method) and total arsenic (ICP-MS) analysis at UW Tacoma.

Figure 2: Collecting water samples from mesocosms

Results

Figure 3: The mesocosms were pre-built in the lab and placed inLake Killarney, WA, with different concentrations of lanthanum-modified bentonite (EurtoSORB G).

Treatment	EutroSORB dose (kg m^{-2})	µg As L^{-1}			
		3/4/2024	3/7/2024	3/11/2024	3/13/2024
A	0.01	45.6 ± 50.7	152.6 ± 14.1	97.6 ± 124.9	84.3 ± 100.5
B	0.10	14.5 ± 14	4 ± 3.9	33.9 ± 16.2	47.5 ± 63
C	1.01	3.8 ± 0.7	1.8 ± 1.7	1.4 ± 1.5	1 ± 0.4
Control	Control				267.2 ± 30.7

Figure 4: Arsenic concentrations in lanthanum-modified bentonite in-lab treatments shows reduction is arsenic concentrations (Germeau, unpublished data).

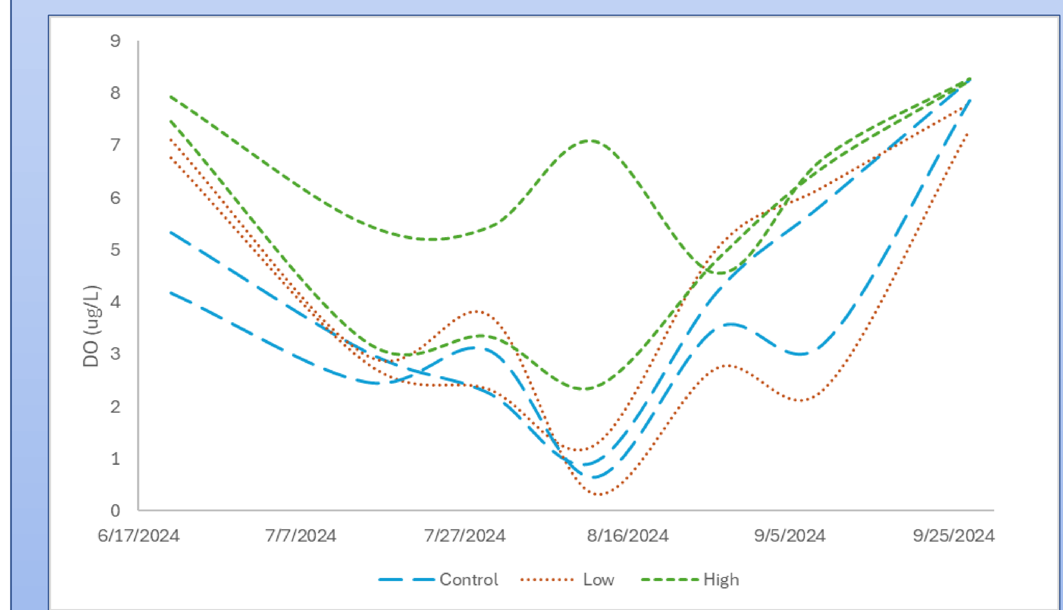

Figure 5: Dissolved oxygen (µg/L) in the bottom of the mesocosms collected throughout the summer season at Lake KIllarney, WA. The dotted lines represent the different concentrations of lanthanum-modified treatment (EutroSORB) used.

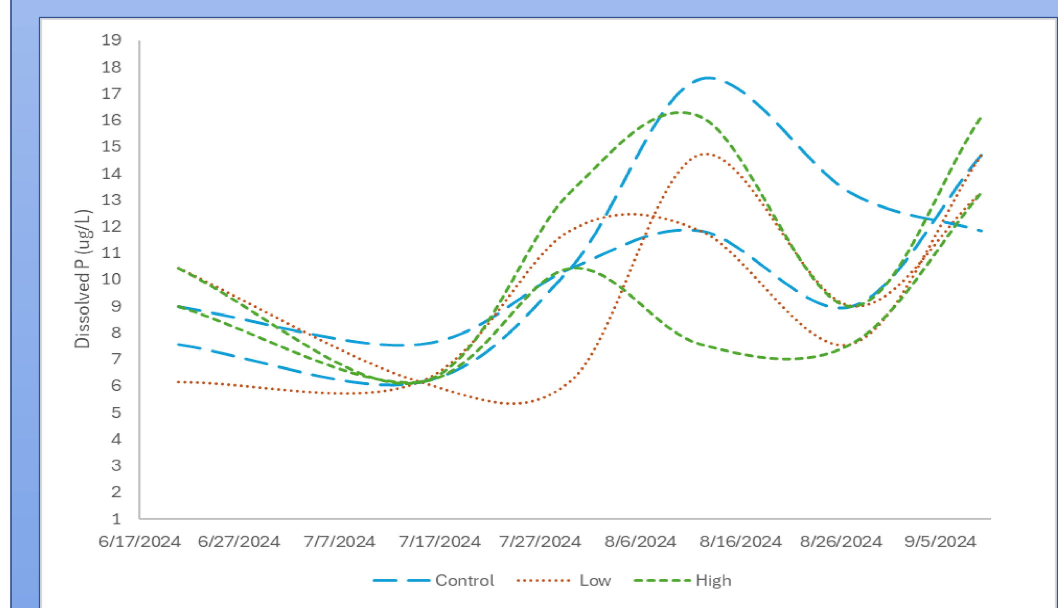

Figure 6: Dissolved phosphorus (µg/L) in the bottom of the mesocosms collected throughout the summer season at Lake KIllarney, WA. The dotted lines represent the different concentrations of lanthanum-modified treatment (EutroSORB) used.

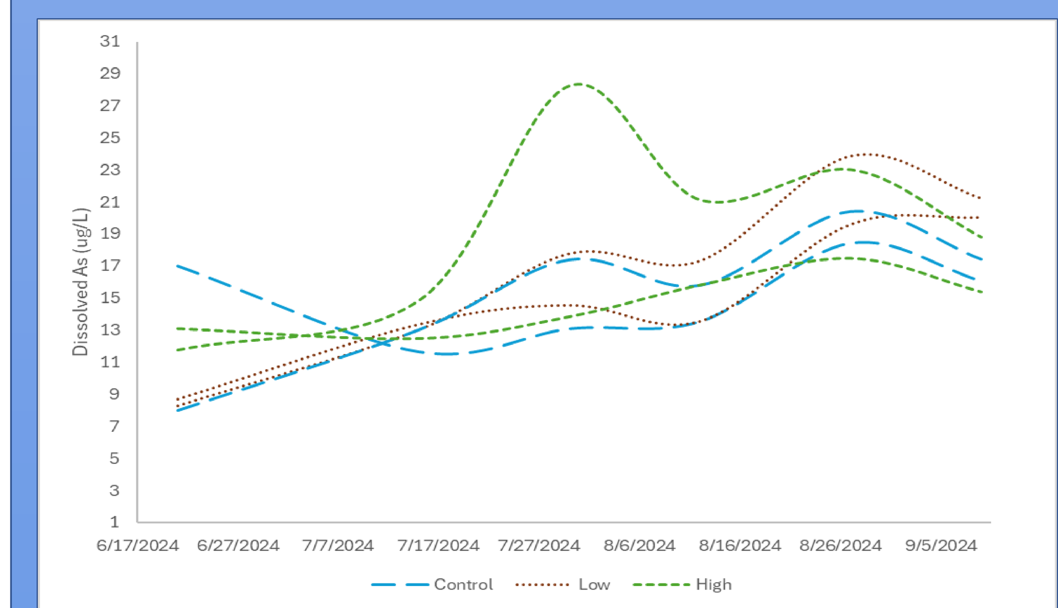

Figure 7: Dissolved arsenic concentrations in the bottom of the mesocosms collected throughout the summer season at Lake KIllarney, WA. The dotted lines represent the different concentrations of lanthanum-modified treatment (EutroSORB) used.

Discussion

- Previous microcosm experiments in the lab showed promising results, with significant suppression of arsenic remobilization in lab experiments (Figure 4).
- Unfortunately, in our applied field experiment the lack of a clear suppression of arsenic release from sediments into the water column does not allow us to conclude that Lanthanum-Modified Bentonite is a viable option for reducing arsenic remobilization in aquatic environments (Figure 7).
- It is possible that the EutraSORB G treatments were possibly flawed as both P and As concentrations increased over the course of the experiment (Figures 6 and 7), and Lanthanum-Modified Bentonite is proven to treat lakes for P.
- The weather over the summer of 2024 was unique and had a significant cold snap that may have prevented anoxia in bottom waters over most of the summer and suppressed greater release of arsenic from sediments (Figure 5).
- Additional samples of sediments in the mesocosms will be analyzed for lanthanum concentrations to check treatment concentrations after-the-fact.

Conclusions and Future Work

- There is not sufficient evidence to prove that lanthanum-modified bentonite can be used in aquatic environments to reduce arsenic remobilization from sediments in shallow lakes.
- Further testing is still necessary to determine if this treatment can show positive results with greater monitoring of treatment concentrations and effects in the sediment porewater and at the sediment-water interface.
- Redesign to ensure no water exchange into the mesocosms from the surrounding lake is recommended
- Treatment in June may have been too late to sequester As and P in the sediments before release into the water column.

Acknowledgements

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References: