Using Lanthanum Bentonite, a Phosphorus Treatment, to Immobilize Arsenic in Lake Sediments

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Introduction

- Lake Killarney in Federal Way, WA, has some of the highest sediment arsenic concentrations (>200 ppm) in western Washington due to the ASARCO smokestack in Ruston, WA, operating from 1917-1993 (Gawel et al., 2014).
- Arsenic has 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).
- Arsenic contamination is prevalent across many lake sediments in the ASARCO deposition area, increasing human exposure, and making affordable remediation strategies vital for multiple communities (Gawel et al., 2014).
- Traditional arsenic remediation involves dredging all the bottom sediments, which is an expensive process not all communities have access to.
- Previous research has found lanthanum-modified bentonite (LMB), a phosphorus treatment, to successfully suppress arsenic remobilization from lake sediments over a two-month lab treatment (Cui et al. 2021).
- An in-lab mesocosm study at UWT, found that a high dose (1.0 kg/m2) of LMB, sequestered up to 99% of arsenic in a two-week span (Germeau 2024, unpublished data).

Our goal is to test if lanthanum-modified bentonite reduces arsenic concentrations in real aquatic environments through an in-situ mesocosm experiment.

Methods

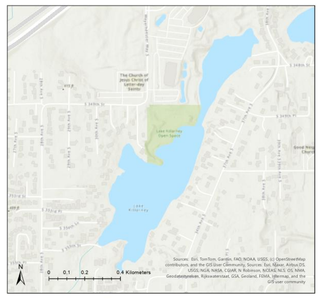

Fig. 1 Location of the experiment at Lake Killarney, Federal Way, WA.

- Water samples from the bottom and surface were collected in acid-washed polypropylene bottles for phosphorus and total arsenic analysis.
- Phosphorus was analyzed in lab at UW Tacoma using the ascorbic acid method (SM 4500-P E).
- Total arsenic was analyzed in lab at UW Tacoma using ICP-MS analysis.
- We installed six mesocosms made of tough plastic lining, hoops and weights (Fig. 3)(Fig.4) at Lake Killarney, Federal Way, WA (Fig. 1), and collected data from June 2024 to October 2024.
- Randomly selected mesocosms were treated with a medium (0.25 kg/m2) and high (1.0 kg/m2) concentration of lanthanum-modified bentonite (EustroSORB G, with a 10% La concentration by weight). Two mesocosms were left as a control.
- Temperature, conductivity, pH, and dissolved oxygen data was measured at the surface and bottom of each mesocosm, biweekly.

Fig. 2 Sample and data collection in the mesocosms at Lake Killarney, WA.

Results

Fig. 3 A constructed mesocosm, fitted with a weighted bottom and a flotation hoop at the top. Demonstrated at UW Tacoma

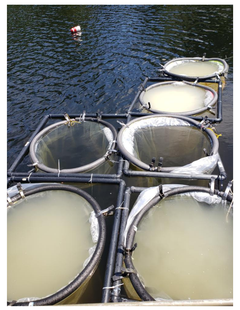

Fig. 4 The constructed mesocosm, installed at Lake Killarney, WA and treated with lanthanum-modified bentonite.

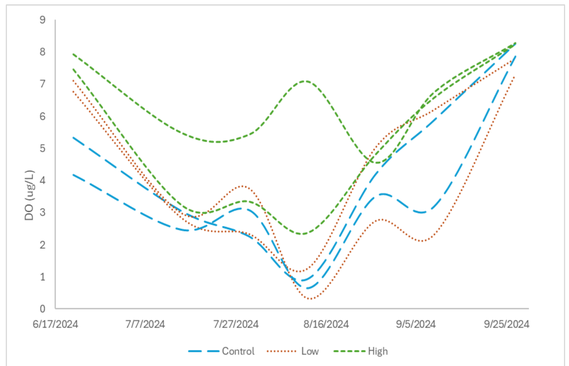

Fig. 5 Dissolved oxygen (µg/L) concentrations from the bottom of the mesocosms collected through June – October at Lake Killarney, WA. The dotted lines represent the different concentrations of lanthanum-modified treatment (EutroSORB) used.

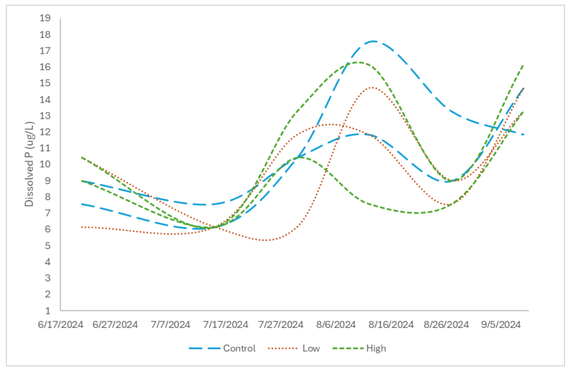

Fig. 6 Dissolved phosphorus (µg/L) concentrations from the bottom of the mesocosms collected through June – October at Lake KIllarney, WA. The dotted lines represent the different concentrations of lanthanum-modified treatment (EutroSORB) used.

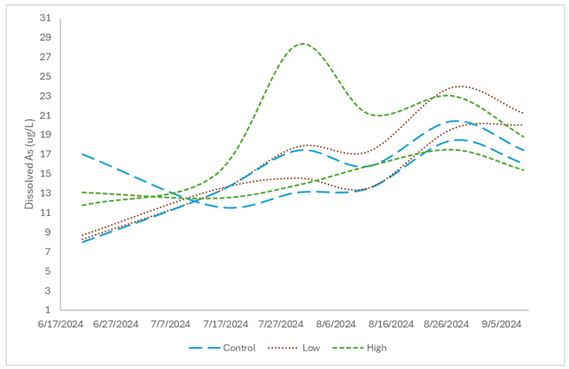

Fig. 7 Dissolved arsenic (ug/L) concentrations from the bottom of the mesocosms collected June – October at Lake KIllarney, WA. The dotted lines represent the different concentrations of lanthanum-modified treatment (EutroSORB) used.

Discussion

- Previous microcosm experiments in the lab showed promising results, with significant suppression of arsenic remobilization in lab experiments.
- Unfortunately, our field experiment did not indicate the same efficiency of arsenic suppression as seen in lab experiments. Arsenic concentrations increased throughout the summer season, a trend seen across the control and treated mesocosms (Fig. 7).
- The inconclusive results could be attributed to the involuntary mixing of mesocosm water with water outside of the treated mesocosms due to the porous nature of the mesocosm and shifting at the bottom.
- It is possible that the EutroSORB 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).
- The results do not allow us to conclude that Lanthanum-Modified Bentonite is a viable option for reducing arsenic remobilization in aquatic environments without further experimentation.

Conclusion

- The research was insufficient to determine the efficacy of lanthanum-modified bentonite as an arsenic treatment in lakes.
- The inconclusive results are attributed to the shifting of the mesocosms and mixing of waters in the mesocosms that cause disturbances in the lanthanum-modified bentonite sediment layer, lowering the sequestering rates of phosphorus and arsenic.
- Starting the treatment in June may have been too late to sequester As and P due to the mixing and release into the water column.
- Further research is necessary to test the efficacy of lanthanum-modified bentonite in the field with applied changes to the structure of the mesocosms and sampling procedures to diminish mixing in the mesocosm.

Acknowledgements

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References