An Analysis of Potential Conservative Tracers to Differentiate between Water Column and Pore Water in Lacamas Lake, WA

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Background

- Water Quality is important because it affects aquatic ecosystems and affects the drinkable water quality. Lacamas Lake is used by many for recreational purposes but the water quality itself is not well understood.
- In addition ions in water can be used as environmental tracers that can help researchers estimate rates of consumption and production of non-conservative elements.
- For a tracer to be considered useful, its physical and chemical behavior must be understood **in redox, reactivity, and be easy to detect across the water column and pore water.**
- So this study was completed to better understand Lacamas Lake quality and **identify potential conservative tracers.**

Research Questions

- What is the water quality of Lacamas lake and how does it compare to other reservoirs?
- Which ions can be used as conservative tracers to understand rates of water and chemical transfer at the sediment-water interface?

Methods and Study Site

Study site:
Lacamas Lake is a small eutrophic reservoir in Clark County, Washington that becomes thermally stratified with anoxic hypolimnion from June to October.

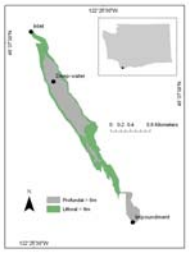


Figure 1. Map of Lacamas Lake showing sampling site for this study; inset location in WA

- Three sets of water column (WC) and pore water (PW) samples were collected from the deepest part of Lacamas Lake: one in May 2017 under oxic conditions and the other two in June and July 2017 under anoxic conditions.
- All samples were analyzed for concentrations of cations on an inductively coupled plasma mass spectrometer (ICP-MS) and anions on an ion chromatograph (IC).
- Criteria used to evaluate the utility of compounds as conservative tracers included:
  - Reactivity (good tracers are non-reactive – either biologically or geochemically)
  - Measurability (good tracers need to be measureable in all end-members- surface water and groundwater)
  - Different in different source waters

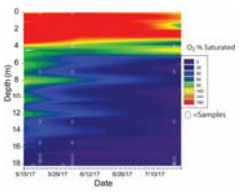
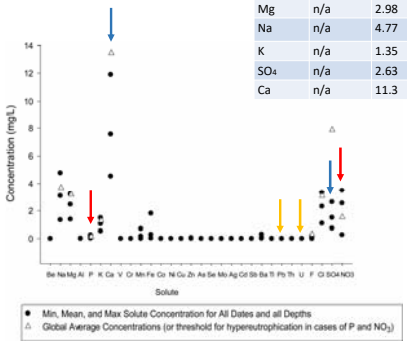


Figure 2. Oxygen (% saturated) at the study site (Fig. 1) over the course of this study. Depth and timing of samples indicated by white ovals.

Results

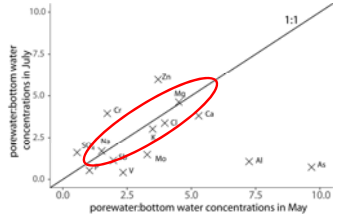
Figure 1: Concentrations of Min, Mean, and Max for all Dates comparing to Global lake Average and EPA Drinking Standards

Element	EPA Standard	Max Conc. In Lacamas	Global Lake avg.
Ba	2	0.53	n/a
U	0	2.17 E-5	n/a
Cd	0.005	2.77 E -5	n/a
Cr	0.1	0.000549	n/a
Cu	1.3	0.0039	n/a
Pb	0	0.000819	n/a
Se	0.05	0.000485	n/a
Cl	n/a	8.82	8.3
F	n/a	0.17	0.26
Mg	n/a	2.98	3.15
Na	n/a	4.77	3.66
K	n/a	1.35	1.25
SO_4	n/a	2.63	7.83
Ca	n/a	11.3	13.43



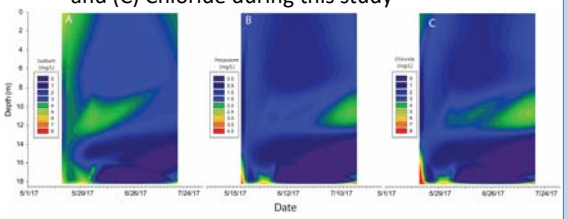
- Nitrate and Phosphate are both well above the threshold of being hypereutrophic (red arrows).
- Lacamas is well below the global average in Calcium (Ca) and Sulfate (SO_4) (blue arrows).
- Lacamas lead (Pb) and Uranium (U) concentrations exceed **EPA** drinking water standards (yellow arrows).

Figure 2: Ratio of pore water concentrations to bottom water concentrations by element in May vs. July. Elements that have stable ratios through time should fall on the 1:1 line (also shown).



- Elements falling close to the 1:1 line with ratios greater than 1 (Na, Mg, Cl, and K) are reasonable candidates for use as conservative tracers.
- However, magnesium (Mg) is redox active, precluding its use in the variable redox hypolimnion of Lacamas Lake.
- Na, Cl, and K remain as potentially useful tracers.

- **Figure 3:** Contour plots of potential conservative tracers: (A)Sodium, (B) Potassium, and (C) Chloride during this study



- Strong correspondence spatially and over time between all three constituents (R> 0.9 in all cases, just for surface water)
- However, need to exercise care in treating these ions as porewater tracers because concentrations can be elevated higher in the water column, suggesting two potential sources to bottom waters
- Implications?? Add bullet point here.

Conclusions

- Water in Lacamas Lake abides by EPA standards for all metals and radioactive material except for U and Pb.
- When compared to the Global Lake averages Lacamas was found to be very similar to most lakes throughout the world in Cl, F, Mg, K, but significantly lower SO_4, Ca, and Na
- Additionally, Nitrate and Phosphate were noted to be higher than eutrophic and have entered a hypereutrophic state.
- Based on the criteria used in this experiment, Na was found to be the best potential conservative tracer for Lacamas Lake as well as Cl and K.

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