Seasonal Changes in the Phosphorus Composition of Missisquoi Bay Sediments

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Phosphorus in Missisquoi Bay

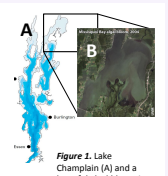


Figure 1. Lake Champlain (A) and a harmful algal bloom in Missisquoi bay (B) [1].

- Exogenous and endogenous nutrient loads perpetuate algal blooms in freshwater systems.
- Lake bottom sediments are a source of endogenous phosphorus (P) [2]
- Inorganic and organic forms of P occur in sediments, some of which will be 'reactive' (mobilized under reducing conditions, ascorbate-extractable).
- Seasonal differences in endogenous P have not yet been studied in Missisquoi Bay.

Objectives

1. Determine the relationships between total reactive P (TRP), organic P (Po), manganese (Mn) and iron (Fe) within the profile of Missisquoi Bay sediments on a seasonal basis.
2. Conduct seasonal comparison of sediment geochemical and water column chemistry at Missisquoi Bay research buoy.

Sediment Collection

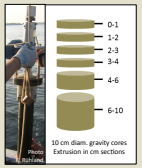


Figure 2. Gravity coring device for sediment sampling on 8/15/12 (summer) and 1/20/13 (winter).

Water Column Chemistry

Figure 3. YSI Sonde with a 650 data-logger measured temperature, pH, dissolved oxygen (DO), conductivity, turbidity, blue-green algea (BGA), and chlorophyll A (Chl A) within the water column.

Figure 4. Deploying buoy in June 2012 in Missisquoi Bay. Location of sediment core collection.

Sediment Analysis

Organic P by Ignition [3]

$P_{Organic} = P_{Ignited} - P_{Non\text{-}Ignited}$

Ignition
0.5g soil ignited at 550°C, 3 h

Extraction
For ignited and non-ignited sediments, 25 ml 0.5M HCl, 16 h shaking

Malachite Green Colorimetry [4]

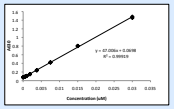


Figure 5. Standard curve from malachite green colorimetry.

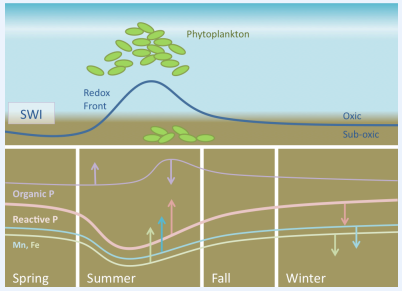
Total Reactive P and Metals (Fe, Mn) [5]

Extraction
0.25g soil, ascorbic acid extract, shake for 24 h

Inductively coupled plasma optical emission spectrometry (ICP-OES) was used for the determination of total P and metals in ascorbic acid extracts

Figure 6. ICP-OES, University of Vermont, Department of Geology

Seasonal Phosphorus Cycling in Lake Sediments



Hypotheses

1. Reactive P will be associated with iron and manganese minerals in sediment .
2. Reactive P will accumulate during the winter due to decreased biological activity and temperature.
3. Organic P levels will be higher in the summer due to increased biological activity and deposition of organic material

Figure 7. Expected seasonal behavior of phosphorus fractions and metals in Missisquoi Bay sediments in relation to algal bloom and redox front dynamics. When the redox front is below the sediment water interface (SWI), surface sediments are well-oxygenated (oxic), whereas a redox front above the SWI indicates sub-oxic or reduced oxygen conditions. Arrows indicate the expected direction of flux for P and metals at different times of year.

Missisquoi Bay Sediment Profiles

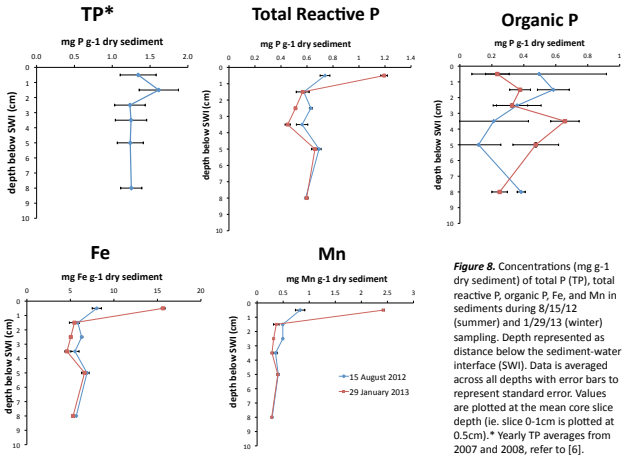
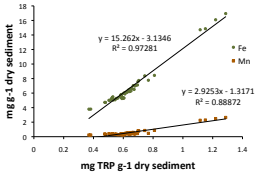


Figure 8. Concentrations (mg g-1 dry sediment) of total P (TP), total reactive P, organic P, Fe, and Mn in sediments during 8/15/12 (summer) and 1/29/13 (winter) sampling. Depth represented as distance below the sediment-water interface (SWI). Data is averaged across all depths with error bars to represent standard error. Values are plotted at the mean core slice depth (ie. slice 0-1cm is plotted at 0.5cm).* Yearly TP averages from 2007 and 2008, refer to [6].

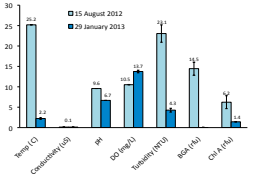
Total Reactive Phosphorus Relationships with Metals



- Total reactive P is strongly associated with Fe and Mn in sediments
- TRP, Fe, and Mn accumulate in top 2 cm in winter but are depleted in the summer

Figure 9. Total reactive P (TRP) and iron (Fe)/ manganese (Mn) concentrations display strong linear correlations.

Water Column Chemistry



- The greatest seasonal differences in water column chemistry were in temperature and in primary productivity (BGA and Chl A)

Figure 10. Water column chemistry of Missisquoi Bay obtained from YSI Sonde for summer and winter sampling dates. Data is averaged across all depths. Error bars represent the standard error of the mean.

Conclusions

- Reactive P associated with sediment metals may represent an important endogenous source of phosphorus in Missisquoi Bay
- Organic P levels may reflect seasonal variations in biological activity
- Changes in climate that result in warmer surface water temperatures and diminished ice-cover in the winter could lead to (1) more rapid and prolonged turnover of P due to biological activity and (2) earlier depletion of reactive P from sediments

Future Studies

- Continue to monitor sediment and water geochemistry at a finer timescale (e.g., monthly)
- Determine the proportions of inorganic and organic P to the total reactive P pool in sediments
- Study the spatial-temporal variation within enzyme-labile P for archived Missisquoi Bay Sediments

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