Mercury Cycling in a Hyper-eutrophic Reservoir: Consequences of inorganic mercury, organic carbon, and microbial inhibitors on mercury methylation in profundal sediment of Hodges Reservoir

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Hodges Reservoir

- Backup water supply
- 37 million m$^3$ volume
- ~20 m maximum depth
- 2 monitoring stations:
  - Deep site (A ~ 20m) & shallow site (B ~ 12m)
- Hyper-eutrophic
- 303(d) listed for mercury in fish tissue

Dissolved Oxygen
Sulfide

Dissolved Iron

MeHg

TSS
Microcosm Incubation Experiment

• Designed to replicate lake conditions
• Performed once monthly during stratification period
• Sediment taken from Sites A and B
• 1 gram of sediment + 30 mL of bottom water in airtight glass vial
• Treatments added according to next slide
• Held at 15 C for 48 hours
• Measured dissolved MeHg
<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Treatment</th>
<th>Theoretical Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>No treatment</td>
<td>Provides 2 day impact on methylation</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Leave cap off of vial</td>
<td>Inhibit all anaerobic bacteria</td>
</tr>
<tr>
<td>Hg2+</td>
<td>3 ng/L HgCl₂</td>
<td>Increase concentration of Hg</td>
</tr>
<tr>
<td>Pyruvate</td>
<td>100 mM Pyruvic Acid</td>
<td>(1) Reduce redox/ORP (2) Provide fuel for most favorable bacteria</td>
</tr>
<tr>
<td>Molybdate</td>
<td>20 mM Sodium Molybdate</td>
<td>Inhibit SRB</td>
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<td>Pyruvate + Molybdate</td>
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<tr>
<td>BES</td>
<td>30 mM 2-bromoethane Sulfonate</td>
<td>Inhibit Methanogens</td>
</tr>
</tbody>
</table>
Interpreting the Results

Treatment Response Rate (TRR) > 1 shows the treatment released more dissolved MeHg than the control on average (3 replicates). A TRR of 10 signifies that the treatment released 10x as much dissolved MeHg per gram of sediment than the control.

Control Response Rate (CRR) is the same comparison, but for the control compared with the time zero control.

Treatment Response Rate (TRR) < 1 shows the treatment released less dissolved MeHg than the control on average (3 replicates). A TRR of 0.1 signifies that the control released 10x as much dissolved MeHg per gram of sediment than the treatment.
Site A

Site B

Hg²⁺

Pyruvate (Carbon & Redox)
Takeaways

• CRR more intense at deep site (both + & -)

• Hg2+ bound by sulfide and organic matter = no short term impact

• Oxygen generally effective BUT... possible oxidative dissolution

• Redox goldilocks, especially at deep site
Molybdate (SRB Inhibitor)

Site A

Molybdate & Pyruvate (IRB test)

Site B
Takeaways

• SRB = key methylators in summer, but impact varies seasonally

• IRB = active early and after partial mixing

• Methanogens = huge negative impact (demethylation)
Implications & Next Steps Forward

• Role of IRB requires more research
• Peak release of MeHg during mid-summer due to SRB
• Decline in MeHg in fall due to Methanogens

• Shallow site = more stable, (+) net methylation; may be more of a concern
• Oxygen should reduce MeHg production, but impact on release should be studied

• Details to be included in article in Water Research:
  “Consequences of inorganic mercury, organic carbon, and microbial inhibitors on mercury methylation in profundal sediment of a hypereutrophic reservoir”
Questions, Comments, or Collaborations?

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