Beginning the Search for Polyphosphate Accumulating Organisms in the Landscape

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Project Goal

- To better understand the contributing factors of phosphorus movement in natural soils
Phosphorus Facts

- Essential nutrient for plant growth
- Deficiencies limit crop performance
- Manure and other fertilizers used to add phosphorus to soils
Phosphorus Problems

- Over fertilization adds excess phosphorus to lakes and rivers
- High dissolved phosphorus levels promote eutrophication,
- Eutrophication threatens water health
Unexplained Trends

- Higher levels of dissolved phosphorus found during summer months

**Fig. 1:** Trends in P concentrations in stream water from an agricultural watershed (Town Br., NY)
Polyphosphate Accumulating Organisms (PAOs)
Polyphosphate Accumulating Organisms (PAOEs)

- Microorganisms that remove phosphorus in waste water treatment plants
Polyphosphate Accumulating Organisms (PAOs)

- Microorganisms that remove phosphorus in waste water treatment plants

Diagram:
- Anaerobic Conditions
  - PHA → PolyP
  - Volatile Fatty Acids → Dissolved P

- Aerobic Conditions
  - PHA → PolyP
  - O₂ → H₂O, CO₂
  - Dissolved P
Hypothesis

- PAOs are present in the landscape
- Wetting and drying cycles promote phosphorous release

Irrigated field
Soil collection - Cornell’s Teaching and Resources Facility
Soil collection - Cornell’s Teaching and Resources Facility

Ditch Soil – drainage ditch near dairy barns

Dairy barns
Soil collection - Cornell’s Teaching and Resources Facility

Ditch Soil – drainage ditch near dairy barns

Dairy barns

Field Soil – bordering a young corn field

Corn field
1. Soil Columns
   - 450 g soil
   - Wetting/drying cycles
   - 25 ml samples collected from bottom port
   - Air pump attached during drying cycle to promote aeration
   - 3 separate trials
Soil Column Arrangement
<table>
<thead>
<tr>
<th>Trial #</th>
<th>Soil Type</th>
<th>Column Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ditch Soil</td>
<td>2 – untreated soil</td>
</tr>
<tr>
<td>2</td>
<td>Ditch Soil</td>
<td>2 – untreated soil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – autoclaved soil</td>
</tr>
<tr>
<td>3</td>
<td>Field Soil</td>
<td>2 – room temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - 4° C</td>
</tr>
</tbody>
</table>
Dissolved Phosphorus Through Aerobic/Anaerobic Cycles

- Saturation 1
- Aeration 1 (2 hrs)
- Saturation 2
- Aeration 2 (1.5 hrs)
- Saturation 3

= replicates

Time (hrs): 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25
Dissolved Phosphorus Through Aerobic/Anaerobic Cycles

- Anaerobic
- Aerobic (4 hrs)
- Aerobic (15 hrs)

- Dissolved Phosphorus (ppm)

- Untreated soil replicates
Dissolved Phosphorus Through Aerobic/Aerobic Cycles: Temperature Dependence
Experiment Designs – Reactors

2. Benchtop Reactors
   - 100 g soil, 1 L water
   - Continuously stirred
   - Aerobic/anaerobic cycles
   - 1 mL samples collected with pipette
Benchtop Reactors
## Reactor Trials

<table>
<thead>
<tr>
<th>Trial</th>
<th>Soil Type</th>
<th>Jug Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Ditch and Field soil</td>
<td>2 – Field soil, 1 jug cycling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Field soil</td>
<td>2 – Ditch soil, 1 jug cycling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – both jugs cycling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – both jugs anaerobic</td>
</tr>
</tbody>
</table>
Dissolved Phosphorus in Benchtop Reactors Undergoing Aerobic/Anaerobic Cycling

- control Field (○)
- cycling Field (●)
- control Ditch (△)
- cycling Ditch (▲)

Controls – no bubbling

Time (hrs)
Dissolved P in Benchtop Reactors Undergoing Aerobic/Anaerobic Cycling

Controls – no bubbling

Controls

\[ \text{Dissolved Phosphorus (ppm)} \]

\[ \text{Time (hrs)} \]

\[ \triangle, \Delta = \text{cycling} \]

\[ \circ, \bullet = \text{anaerobic control} \]
Conclusions

- There is a large difference in phosphorus trends between soil types
- Phosphorus trends show fairly repeatable patterns, even between soil types
- Preliminary data shows several positive indications of PAO activity
- Further research will be needed
Further Research

- Continue experimental variations
  - Soil treatments, cycling timescales, soil types

- DAPI staining for polyphosphates
  - Visualize changes through anaerobic/aerobic cycling

- DNA testing on microorganisms extracted from soil
Thank you!

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Questions ?