Effect of Lime Rock Substrates on Stormwater Treatment Area Water Quality and Vegetation Characteristics

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Outline

• Rationale for study of LR-based systems
  • Internal P Loading in the outflow region
  • Evidence of soil P mining by SAV
• “Capping” of P-enriched soils with limerock
  • Effects on water quality
  • Effects on periphyton and macrophyte development
• Implications of Findings
Rationale for studying LR-based treatment in STAs

Internal P Loading

- Modeling study by Juston et al. (2013) showed SAV P mining from muck soils could account for ~1/3 of back-end C* (16 ppb) in STA-2 Cell 3.

- *Potamogeton* may be a primary "P miner", with rooting depths > 20 cm (through the floc, and into the underlying muck).

- However, direct experimental evidence still required.
PSTA - Limerock Substrate Wetlands:
Muck removal, or addition of a limerock “cap” over muck

- Overlying muck in the STA-3/4 PSTA cell was removed. Cell achieved outflow TP ≤13 µg/L for nearly 10 years.
- Muck removal can be costly, however, and likely not suitable in STA locations with deep mucks.
- An alternative may be to cover existing muck soils with a LR cap.
Potential Benefits of Limerock Substrate or LR “Cap”

- Short-term incubations revealed that a LR cap can reduce flux from newly flooded, P-rich soils.
- Physical/chemical barrier to curtail soil P flux
- May promote calcareous periphyton growth, and limit macrophyte growth
Important considerations include:

• Rooted macrophytes’ ability to access soil P below a LR cap

• Availability of fluxed or "macrophyte - mined" P to benthic and/or epiphytic periphyton. Will fluxed P inhibit periphyton growth?

• Whether the nutritional status of the SAV/periphyton affect the mass and P content of accreted sediments?

**Key Questions:** Can a LR cap improve P removal on P-rich soils? Is the improvement sustainable in the long-term?
Mesocosm-scale Investigation

- P-enriched muck (679 mg/kg) capped with 0, 5, 15 cm LR
- Flow through operation: 5-day HRT using STA outflow water
- Stocked with SAV and periphyton from STA 3/4 PSTA Cell
Periphyton, *Chara* and *Potamogeton* collected from the STA 3/4 PSTA Cell
Periphyton, Chara and Potamogeton collected from the STA 3/4 PSTA Cell
LR Cap is effective at improving long-term P removal performance in mesocosms

LR cap providing additional polishing of “typical” STA outflow waters
Effect of SAV on P Removal Performance

- Clear benefit of SAV without LR (Control)
- Negative effect of macrophytes in the LR treatments
- Lowest TP achieved on +15 cm LR without SAV
Temporal changes in SAV relative density

- **Potamogeton** (rooted species) growth initially restricted by LR cap. Roots eventually penetrating LR cap?

- **Chara** (non-rooted species) growth initially restricted by LR cap
After 5 and 11 months, tissue P content of *Potamogeton* and epiphytes evaluated.

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<th>Control, 0LR</th>
<th>+5 cm LR</th>
<th>+15 cm LR</th>
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Evidence of *Potamogeton* accessing soil P

- *Potamogeton* tissues increased in P content
- 15 cm LR limited SAV P-enrichment
- Epiphyte enrichment delayed, but increasing over time
Benthic periphyton response to LR caps

- After 8 weeks, periphyton had grown in, and increased in P content (sourced from muck?)

- LR cap improved periphyton biomass, and resulted in lower tissue P than controls
Synopsis: Implications of LR Substrates for STAs

• Initial mesocosm results show LR cap can be effective in suppressing flux from high-P soils, and help achieve lower outflow TP

• After 12 months of flow-through operations, P removal to ultra-low levels continues in treatments with a LR cap and no SAV.

• Longer-term operation of this experimental platform will enable us to define sustainability: (i.e., will the nutritional status of the macrophytes/periphyton affect the mass and P content of accreted sediments?)

• Feasibility and cost-effectiveness of large-scale LR capping remains unknown