Use of drinking water treatment residuals in green stormwater infrastructure retrofits for enhanced P removal

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Urbanization and climate change driving increased stormwater volumes
Green stormwater infrastructure increasingly used to manage urban runoff

Bioretention  Stormwater Ponds  Gravel Wetlands
Managing stormwater at its source with GSI

**Hydrologic Control:**
- Temporarily hold water on the landscape
- Reduce peak flow rates

**Water Quality Control**
- Remove contaminants (*sediments, nutrients, heavy metals*)
Phosphorus control particularly important for freshwater ecosystems
P removal in GSI is highly variable

Bioretention

Stormwater Ponds
P sorbing amendments

Fly Ash

Steel Slag

Water Treatment Residuals
Challenging tradeoff

P Sorption

Hydraulic Conductivity
Tradeoff pronounced in urban bioretention
My Research: How can we use DWTRs in bioretention to enhance P removal without restricting flow?
Research methodology

1) Material Characterization
2) P Sorption Capacity
3) Sorption Kinetics

Bioretention Media Design
Media Blends

Control

- 90% Sand + 10% Low P Compost
- 100% Sand
- Pea Stone
- Gravel

Layer

100% Sand
90% Sand + 10% Low P Compost
Pea Stone
Gravel

12"
12"
3"
9"
Media Blends

Control

- 90% Sand + 10% Low P Compost
- 100% Sand
- Pea Stone
- Gravel

Solid Layer

- 12”
- 10.8”
- 1.2”
- 9”
Media Blends

Control
- 90% Sand + 10% Low P Compost
- 100% Sand
- Pea Stone
- Gravel

Solid Layer
- 12”
- 10.8”
- 1.2”
- 9”

Mixed Layer
- 12”
- 12”
- 3”
- 3”
- 9”
Large Column Study
Large column results: hydraulic conductivity
Large column results: \( P \) removal

Graph showing the removal of phosphorus (P) over simulated storm numbers for solid and mixed layers. The graph includes data points for different treatment types: Control, CWD, Port, and UNH, with error bars indicating variability. The y-axis represents P removal (%) and the x-axis represents simulated storm number.
1) P sorbing materials can provide long-term P removal in GSI

2) Tradeoffs can be mediated through design
Challenges and opportunities

**Bioretention:**
- Full system retrofits are expensive
- Cartridge filters have potential, but practically challenging
  a) placement *(inside or outside the system?)*
  b) hydraulic restrictions
  c) hydraulic bypass
- Woodchips coated in DWTRs
- Granularization of DWTRs
Challenges and Opportunities

**Stormwater Ponds:**
- Placement (*pond sediment vs end of pond filter*)?
- Reliance on diffusion vs flow?
- How to create hydraulic head?
- Risk of clogging and localized flooding

- Combining DWTR-based filters with pond fountains for simultaneous aeration and P removal?
Questions?