Stormwater Particle Size Distribution (PSD) & Implications for BMP Effectiveness

Stormwater Work Group Presentation

September 2023

EVERGREEN STORMH2O

SAM Stormwater Action Monitoring

WASHINGTON STATE DEPT OF NATURAL RESOURCES

Presentation Overview

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- Team Introduction
- Study Background & Overview
- Review Findings Related to Study Objectives
- Highlights & Takeaways
- Future Research Recommendations

Team Introduction

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Study Background & Overview

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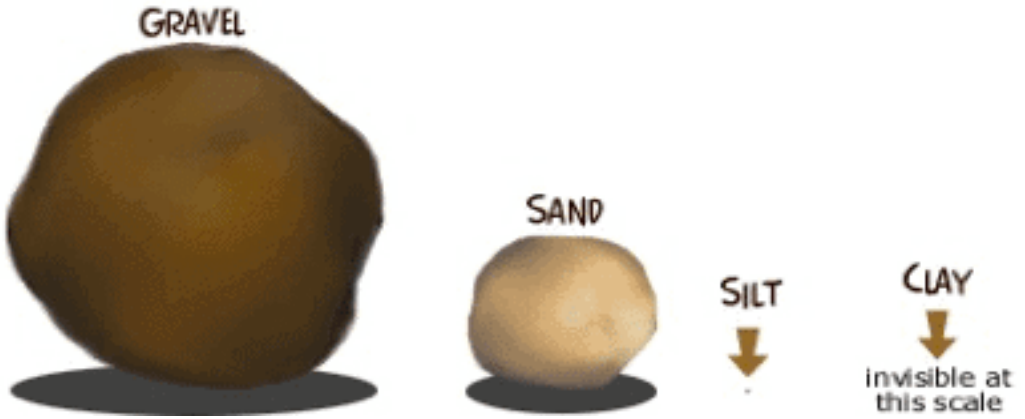
Project Background

- In Washington, the highest concentration of stormwater particles is believed to be silt-sized
  - TAPE & monitoring studies require PSD testing
- PSD BMP effectiveness is rarely reported
- It is challenging to find laboratories that perform methods defined in TAPE Manual

Study focused on:

- Particle sizes sampleable in stormwater runoff
- Particle physical size



Very Coarse Sand & Larger	Medium to Coarse Sand	Very Fine to Fine Sand	Silt	Clay
>1000µm	250-1000µm	62-250µm	4-62µm	<4µm

Study Background & Overview

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Goal

Evaluate how pollutant types & loads vary with particle size & summarize the pollutant removal mechanisms & effectiveness of a range of BMP types. Use results to develop guidance for selecting effective BMPs for a site based on anticipated PSD.

Summary - Does particle size matter? If so, where does it matter, and which BMPs are best given specific site conditions?

Objectives

- Identify and recommend PSD test methods
- Characterize PSD sources (basin characteristics)
- Identify the influence of PSD on stormwater chemistry
- Identify detrimental impacts of particle sizes on receiving waters
- Determine BMP effectiveness as a function of PSD

Methods

- Conduct systematic literature review
- Synthesize information into narratives
- Compile & analyze data

Findings

Identify & recommend PSD test methods

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- Identify Test Methods
  - PSD, Sediment Concentrations, TSS
- Develop Criteria
  - Compare & Rank Methods
  - Assess Data Quality
- Recommendation
- ASTM Method D3977-97B
  - Laser Diffraction

Pair

Criteria Categories

- ✓ Detection limits
- ✓ Reproducibility
- ✓ Time to perform analysis
- ✓ Cost per test
- ✓ Availability of testing

- Reasoning
  - ASTM Method → account for larger particles
  - Laser Diffraction → better fine particle representation

Findings

Characterize sources to stormwater

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Purpose: Identify how basin characteristics influence PSD; use to estimate pollutant loads and BMP selection.

Findings: Insufficient data to correlate basin characteristics to PSD.

- Collected PSD data
  - PSD data reported with multiple unit types & different testing methods
  - Basin characteristics often not reported
    - Most commonly reported: roadway land use & basin area
- PSD dry deposited particles on roadway are either:
  - Evenly distributed between silt and very coarse sand, OR
  - Most particles are smaller than very fine sand
- In stormwater runoff, most particles in silt size range
  - Though coarser sizes can still comprise a significant portion of the load

Bias Concerns:

Site Selection & Sampler

Findings

Identify PSD influence on stormwater chemistry

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Purpose: Identify what is known about the influence of PSD on stormwater chemistry to aid in understanding pollutant transport & BMP treatment mechanisms needed to remove pollutants.

Findings: Insufficient data on land use types & basin characteristics.

- Most studies focused on heavy metals attached to particles
  - Some studied nutrients, PAHs attached to particles
- Heavy metals tend to attach to clay/silt-sized particles
- High nutrient concentrations associated with clay/silt-sized particles
- PAHs tend to attach to silt- and very coarse sand-sized particles
- Particle size associated with pollutant loads differs between monitoring sites

Findings

Identify impacts to water bodies

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Purpose: Identify detrimental impacts of different particle sizes on receiving water bodies.

Findings: No studies were located that focused on the specific impacts of PSD ranges on receiving water bodies.

- Few sources reported stormwater PSD ranges that reach water bodies
  - Metals, nutrients, & bacteria concentrations higher in clay & silt-sized particles
  - Targeting this particle size could reduce highest concentrations
- WA State may be approaching removal in a way that best benefits water bodies
  - More research needed to confirm
- Insufficient data to determine threshold related to PSD in water bodies

Findings

Determine BMP effectiveness

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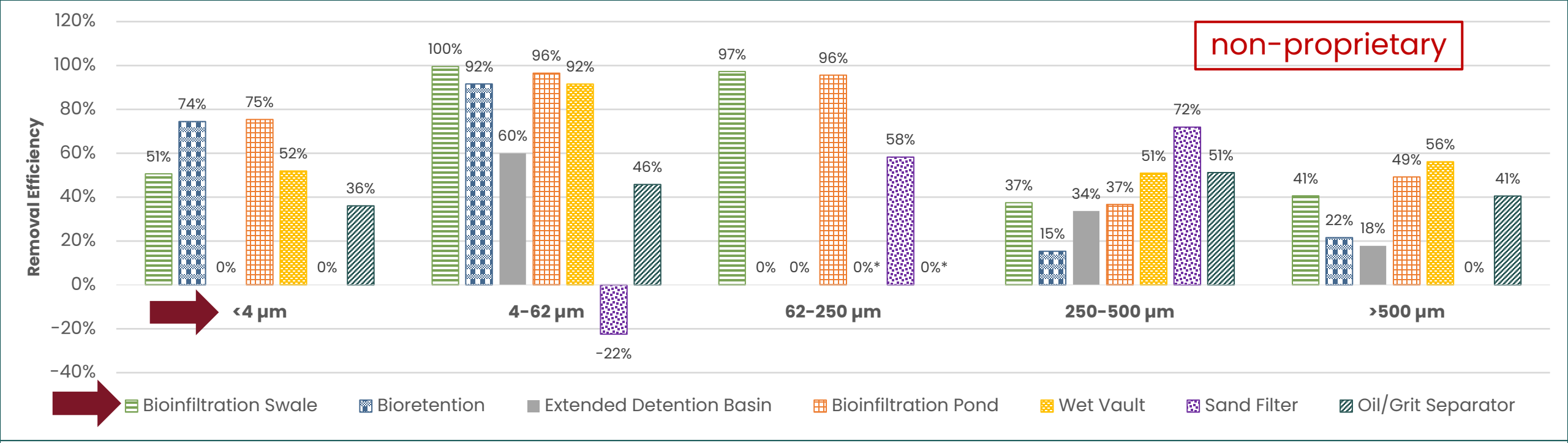
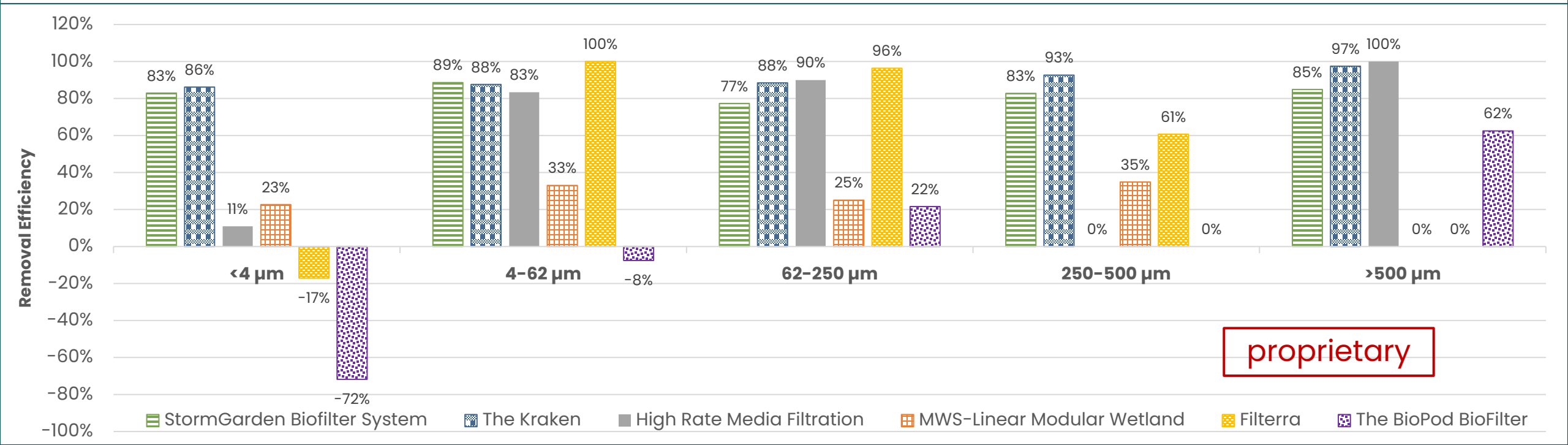
Purpose: Identify and report on structural, operational, & source control BMP effectiveness based on the range of particle sizes.

Findings:

- BMP data located:
  - 19 structural BMPs
  - 1 source control BMP (street sweeping)
  - Most findings based on only a few data points
  - Other Ecology-approved BMPs with no data
- BMPs generally achieve highest removal for silt-sized particles
- Proprietary BMPs achieved highest removal across particle sizes


non-proprietary
Removal Efficiency
120%
100%
80%
60%
40%
20%
0%
-20%
-40%
51%
74%
0%
75%
52%
0%
36%
100%
92%
60%
96%
92%
-22%
46%
97%
0%
0%
96%
0%*
58%
0%*
37%
15%
34%
37%
51%
72%
51%
41%
22%
18%
49%
56%
0%
41%
<4 µm
4-62 µm
62-250 µm
250-500 µm
>500 µm
Bioinfiltration Swale
Bioretention
Extended Detention Basin
Bioinfiltration Pond
Wet Vault
Sand Filter
Oil/Grit Separator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-8%
77%
88%
90%
25%
96%
22%
83%
93%
0%
35%
61%
0%
85%
97%
100%
0%
0%
62%
<4 µm
4-62 µm
62-250 µm
250-500 µm
>500 µm
StormGarden Biofilter System
The Kraken
High Rate Media Filtration
MWS-Linear Modular Wetland
Filterra
The BioPod BioFilter

Findings

Determine BMP effectiveness

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- Street sweeping achieved removal across particle sizes
  - Except for regenerative air sweeper (due to one source)

BMP	Units	Sources	% Removal				
			<4	4-62	62-250	250-500	>500
Mechanical Street Sweeper	%	2	-	56.5	52.9	44.4	61
Vacuum Street Sweeper	%	2	-	65.0	69.9	85.9	87.7
Regenerative Air Street Sweeper	%	3	-133	-73.5	41.8	80.0	79.0

Highlights & Takeaways

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- Stormwater PSD concentration is highest for clay/silt-sized particles
- Pollutant concentrations appear higher for clay/silt-sized particles, but particle size associated with highest pollutant load varies.
  - Most BMPs appear to target these sizes
- Application of study results not always possible due to lack of data
  - Addressing data gaps on following slide may allow for future application

Future Research Recommendations

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Testing Methods	Use consistent PSD testing method; correlation between laser diffraction and TAPE method
Basin Characteristics	Report basin characteristics (e.g., AADT, surface conditions, land use, basin area) with PSD results
Pollutant Concentrations	More data reporting pollutant concentration in terms of particle size
Water Bodies	Research to understand how particle sizes impact different water bodies
BMP Effectiveness	More data for BMPs; additional data for BMPs identified in the report at different sites
Sampler Bias	Research to understand potential bias from automated samplers, site selected for testing, etc.

Questions?

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