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

Stormwater Action Monitoring

Effectiveness Study

Lead Entity

Partner

EVERGREEN STORMH2O

Collectively improving stormwater management

Stormwater Action Monitoring

(SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation.

SAM's goal is to improve stormwater management by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

ecology.wa.gov/SAM

Highlights

- Fine particle sizes carry more bound pollutants to stormwater systems, yet many existing BMPs target this and other size ranges.

Study Goals

The particle size distribution (PSD) of stormwater runoff can influence the types and amounts of pollutants that are present, as well as the way that pollutants are transported and interact with each other and the environment. BMP effectiveness in controlling the full range of particles in stormwater is typically not reported or even tested, which makes selecting a BMP more challenging. This literature review gathered the latest information on the size of particles in stormwater, the connection between particle size and stormwater chemistry, and the effectiveness of treatment approaches for particle sizes.

Findings

Methods for Measuring PSD

We identified common testing methods for PSD, and found that ASTM 3977-97 Method B with laser diffraction is most likely to have comparable results the TAPE method, The TAPE method ASTM D3977-97, is a modified version of ASTM 3977-97 Method B and Method C.

Sources of Particulates to Stormwater

Sources of particles to stormwater include automotive, local soil erosion products, and atmospheric deposition. The most transported sizes appear to be clay and silt sizes. There was not enough basin condition data in the literature to characterize particles and sources by land use or area.

BMP Effectiveness as a Function of PSD

To better understand pollutant transport, we identified what is known about the influence of PSD on stormwater chemistry. Literature reviewed focused on heavy metals, nutrients, and PAHs attached to particles, which suggests pollutant concentrations are generally higher for clay- and silt-sized particles. Targeting clay- and silt-sized particles may remove the highest amounts of metals, nutrients, and bacteria.

BMP studies with PSD influent and effluent data were located for 19 structural and 1 operational BMP. Most BMPs were highly effective at removing silt and fine sand sized particles (Table 1). These findings are based on only a few data points or a single study and there are many BMPs for which data were not located.

Recommendations for Future Research

- Encourage researchers to report more basin conditions and pollutant data that is portioned to particle size ranges. This information can inform BMP selection and pollutant load estimates.
- Conduct BMP effectiveness testing for PSD on more structural, operational, and source control BMPs.

Table 1 BMP Effectiveness Summary by BMP and Particle Size

BMP	# of Studies	# of Data Points	% Removal				
			<4 µm	4-62 µm	62-250 µm	250-500 µm	>500 µm
Biofiltration Swale	1	1	-65%	74%	100%	-233%	-40%
Bioinfiltration Swale	1	27	51%	100%	97%	37%	41%
Bioinfiltration Pond	1	34	75%	96%	96%	37%	49%
Vegetated Filter Strip	0	0	-	-	-	-	-
Bioretention	1	1	74%	92%	-	15%	22%
Bioretention Plus Jellyfish	0	0	-	-	-	-	-
Dry Detention Basin	0	0	-	-	-	-	-
Extended Detention Basin	2	1	-	60%	-	34%	18%
Filterra	1	4	-17%	100%	95%	61%	-
High Rate Media Filtration	1	1	11%	83%	90%	-	100%
Media Filter Drain	1	48	-	-	-	-	-
Oil/Grit Separator	3	1	36%	46%	0%	51%	41%
Porous Pavement – Modular Blocks	1	1	-	-	-	-	-
Sand Filter	1	4	-	-22%	58%	72%	-
Wet Vault	1	30	52%	92%	0%	51%	56%
MWS-Linear Modular Wetland	1	27	23%	33%	25%	35%	-
The BioPod BioFilter	1	17	-72%	-8%	22%	-	62%
StormGarden Biofilter System	1	17	83%	89%	77%	83%	85%
The Kraken	1	14	86%	88%	88%	93%	97%
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%

Why does this study matter?

This summary of recent literature on PSD (from clay to coarse sand sizes) in stormwater runoff and the effectiveness of BMPs is needed to understand pollutant transport and select suitable BMPs to protect downstream receiving waters.

What should stormwater managers do with this information?

Continue to target silt-sized and smaller particles (less than 62.5 µm) when selecting BMPs. While PSD effectiveness data for all size ranges is not typically reported, the BMPs in Ecology's Stormwater Manuals that meet 'basic' treatment goals capture much of finer particles benefitting downstream water bodies.

What will Ecology do with this information?

The relationship between particle size and pollutant transport is complex and not fully understood. However, the literature review confirms our assumption that finer particles (clay and silt-sized particles less than 62.5 µm) is of concern, as these particles can carry high concentrations of pollutants longer distances in stormwater runoff. Therefore, we will continue to recommend testing for clay and silt-sized particles when consulted on BMP effectiveness testing. Ecology will discuss with the TAPE program the added benefits of gathering more basin information for future TAPE studies.

For more information see the completed project at ecology.wa.gov/SAM or contact the study lead: Dr. Aimee Navickis-Brasch at aimee@evergreenstormh2o.com