

Prioritizing effectiveness and efficiency in pollutant removal: Recommended strategies for NJDEP's Watershed Improvement Plan

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What I will be presenting:

On January 1, 2027, municipalities and public complexes in New Jersey will be required to submit Watershed Assessment Reports to the New Jersey Department of Environmental Protection (NJDEP), fulfilling the Phase II portion of the agency's recently enacted Watershed Improvement Plan program. This overall program aims to address flooding and water quality concerns in New Jersey's impaired watersheds by requiring each permittee to provide proposed strategies for reducing pollutant loads. We will describe the work we have done with multiple clients to submit Phase I of this program, which was due January 1, 2026 and which included an inventory report of the flooding and water quality concerns within the subwatersheds. We will go on to describe the process of crafting Phase II, the Watershed Assessment Report, including how to balance effectiveness and efficiency when deciding between proposed strategies for reducing the watershed's pollutant loads, in terms of both impairments and TMDLs. Case studies will be presented specifically regarding the reduction of fecal coliform in subwatersheds with significant wild goose populations. We will discuss the merits of structural vs. non-structural approaches, emphasizing the use of non-structural strategies in order to maximize benefits while minimizing cost.

What the audience will learn:

The audience will leave with an understanding of the different categories of strategies that can be used for addressing pollution reduction, from source control to treatment to removal, with the relative benefits and drawbacks of each. They will learn how to submit Watershed Assessment Reports that balance both effective and efficient strategies for reducing water quality impairments in their watersheds, as well as the challenges associated with preparing a report for a new program with no precedents to reference. Audiences who work on behalf of municipal clients will gain an understanding of how to leverage and enhance existing MS4 permit requirements to meet regulatory pollution reduction requirements, building on existing municipal infrastructure to avoid starting from scratch. Audiences who don't work in New Jersey or aren't associated with a municipality or public complex will gain a general understanding of how to strategically decide between different approaches to pollutant reduction, whether for regulatory or voluntary purposes. We expect that at the very least, all audiences will walk away with a better understanding of the fecal coliform levels in goose feces than they may have ever expected or wanted.



Soil metal and carbon patterns in stormwater biofiltration GSI in Lancaster, PA

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Highlights

- Soils were sampled for metals and carbon analysis in 20 biofiltration GSI in Lancaster, PA
- Zinc concentration was highest in GSI inlets, and oldest GSI sites
- There were not clear soil carbon trends, though carbon did aid in zinc accumulation

Introduction

As green stormwater infrastructure (GSI) is increasingly implemented, we want to understand its hydrologic and water quality benefits, along with other co-benefits of interest. Water quality performance is most often evaluated using sampling of inflow and outflow water samples. While this provides accurate and detailed insights on pollutant removal, it is also time- and cost-intensive. Here we employ an alternate approach using soil cores from within GSI to evaluate accumulation of metals from filtered stormwater, since sorption of metals to GSI soil media is a primary retention mechanism. Thus, a focus on soil metals concentration can provide insight on removal of metals over GSI operation. Since carbon sequestration is a co-benefit of interest in GSI, soil carbon content was also evaluated.

Methodology

The focal area for this study was Lancaster, PA. In 2022, We sampled 20 biofiltration GSI (locally called rain gardens) throughout Lancaster that ranged in construction year from 2012 to 2020. GSI were similar in overall design approach, with some variation in vegetation palette and location (majority were in right-of-way, with several in parks). At each GSI, we took multiple soil cores within each GSI (e.g. inlet, middle, and far end) as well as from reference soils in each GSI that are not exposed to inflowing stormwater. We also sampled three lawn sites as an alternate reference. Copper and zinc concentration was evaluated with a Mehlich III soil digestion via ICP-OES analysis in the Penn State Agricultural Analytical Services Lab. This digestion evaluates plant-available metals. Percent carbon was analyzed on ground and sieved soil samples using an Elementar UNICUBE elemental combustion analyzer in the Penn State Soil Cluster Lab.



Figure 1. Photo of soil sampling

Key Findings

Concentrations of metals and carbon were compared between GSI and reference locations for each GSI site, as well as across all of the evaluated GSI. We observed significantly higher zinc concentrations near the GSI inlets compared to the reference and other locations within the GSI. Zinc concentration also increased with age of the GSI. Soil carbon patterns were less clear; while some GSI had higher soil carbon than reference locations, overall soil carbon was not significantly higher across all sampled GSI. There also was not an accumulation trend with GSI age. We did document a significant positive relationship between soil carbon and zinc concentration, which aligns with previous evidence that carbon helps sorb (retain) metals.

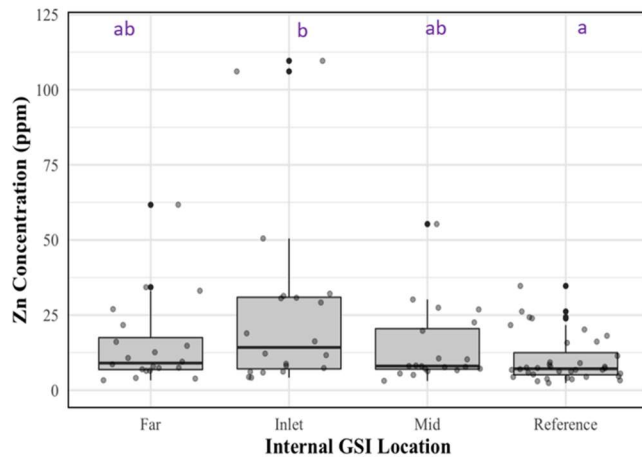


Figure 2. Boxplot of soil zinc concentration, grouped by soil sampling location within GSI

Recommendations

Further work should evaluate these characteristics (metals and carbon accumulation) in older and more diverse GSI. This work does show that GSI are performing their intended function of retaining metals, particularly in the inlet area where sediment is designed to settle. However, this does point to the importance of regular clean-out of inlets in order to maintain ongoing sediment accumulation (and its associated metals and other contaminants). This work also points to carbon amendments as aiding in metals accumulation, though clearly there are opportunities to better enhance carbon in GSI through further amendment of woody material or biochar.

Geosynthetic Based Stormwater Quality Rain Garden

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High Lights

-A geosynthetic based storm water quality rain garden will be presented that will improve performance, extend service life, simplify maintenance and lower costs.

Introduction

Stormwater quality objectives are ambitious. Only through innovation and collaboration can they be met.

Storm Water Quality Objectives:

- Remove maximum amount of pollutants (e.g. 80%+ of total suspended solids – TSS).
- Remove maximum variety of pollutants (e.g. trash, nutrients, metals, oils, PFAS and forever chemicals...).
- Long service life.
- Simple and economical maintenance at long interval periods.
- Sustainable and nature based.
- Low Cost.

Background

Filters clog. Many stormwater designs and testing protocols assume a TSS load of 600 lbs/acre/year for pavements. Rain Gardens take 3-5 years to establish mature vegetation. Sand filters, which have a higher porosity than filter media, are estimated to clog in 3-5 years. When nature-based solutions underperform, think of rain gardens with standing water and withering plants, it's a high-profile failure. Rain Gardens must maintain a high infiltration rate while sustaining robust plant life.

The stormwater flow path for a standard rain garden runs vertically down through vegetation, filter media, sand/stone and into the subgrade or a collection pipe directed downstream. Physical filtering provides most of the pollutant removal while plants absorb and convert nutrients (phytoremediation).

An underground horizontal flow path, like an open graded stone bed, can also be utilized for pollutant removal. Constraining the outlet increases the upstream residence time and increases absorption, adsorption, biological and chemical processes and sedimentation.

This presentation will present a system that combines these two design principals in series, The water quality system is comprised of geosynthetics and geosynthetic applications well established in the civil engineering market. The system offers many benefits.

Geosynthetic Based Stormwater Quality Rain Garden Benefits:

- Improved pollutant stripping.

- Sustainable, plant based green solution.
- Optimization of non-proprietary filter media. (e.g. ESCS, UL-FGA, TDA, IESF, biochar, anthracite, activated carbon, biopolymers, zeolites, metal, aluminum,...) enabling a Quality Assurance- Quality Control program
- Pretreatment.
- Extended service life.
- Extended maintenance intervals.
- Easily accessible maintenance that does not disturb the established vegetation.
- Topsoil focused on plant health without concessions for pollutant removal or infiltration rates.
- Bottom feeds plants promoting deep roots.
- Enables traditional catch basin and pipe design upstream.
- Localized infiltration at the source.
- Substantial material and installation savings for stormwater quality.
- Integrated stormwater storage and related storage cost savings.

Key Findings

A hypothetical design was completed using the NJCAT published performance data for Green Infrastructure MTDs. Using the NJDEP formula for Systems in series the TSS removal rate was calculated at 99%+. Material cost savings, when compared to Precast MTDs, were in the range of 90%.

Recommendations

The geosynthetic based system presented will enable researchers, engineers and regulators to investigate and optimize all filter media products. Concentrations, combinations, gradations, residence times, flow lengths and quantities can be varied to adjust flow rates, increase pollutant removal, target specific pollutants and increase service life.

References

NJCAT Technology Verification Database njcat.org/verification-process



Figure 1: Geosynthetic Based Rain Garden Elevation View

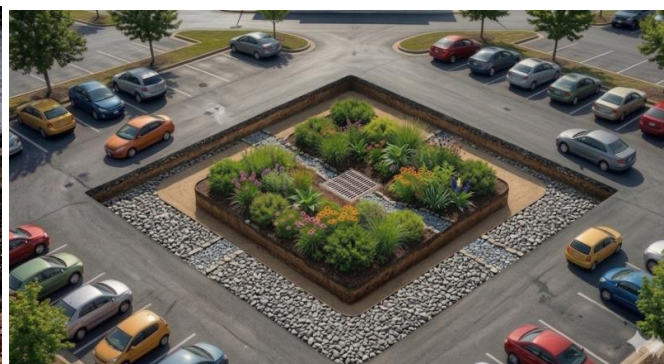
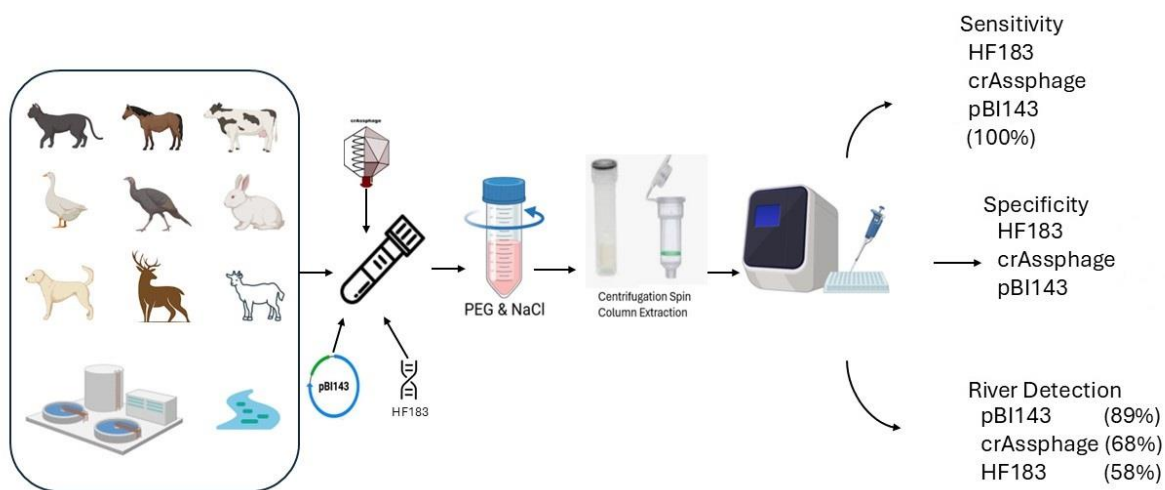


Figure 2: Geosynthetic Based Rain Garden Plan View

Assessment and Application of CrAssphage, HF183 and pBI143 as markers of human – fecal contamination in Maryland United States

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Abstract:

Prior assessment of the performance of host-specific markers is critical for accurately determining the source of fecal contamination for mitigation purposes. In this study, we first evaluated the performance of three human fecal markers (crAssphage, pBI143, and HF183) using 61 fecal-source samples collected from humans and 11 animal hosts and then applied them to assess human fecal contamination in river water from Baltimore, USA. All three markers were consistently detected in all six human wastewater samples, demonstrating 100% sensitivity. In contrast, detection rates among non-human (animal) fecal samples varied widely, to highlight the differences in the specificity of markers. The marker crAssphage was detected in 1 out of 6 goat samples (17%), 1 out of 7 dog samples (14%), 7 out of 8 chicken samples (88%), 3 out of 3 duck samples (100%), 1 out of 6 deer samples (17%), 3 out of 6 cow samples (50%), all 4 rabbit samples (100%), none of the 7 horse samples (0%), 1 out of 4 pig samples (25%), both turkey

samples (100%), and 1 out of 2 cat samples (50%). The marker pBI143 was detected in 2/6 goat samples (33%), 6/7 dog samples (86%), all 8 chicken samples (100%), all 3 duck samples (100%), 2/6 deer samples (33%), 2/6 cow samples (33%), 3/4 rabbit samples (75%), 6/7 horse samples (86%), 2/4 pig samples (50%), both turkey samples (100%), and none of the 2 cat samples (0%). Similarly, HF183 was detected in 3/6 goat samples (50%), 4/7 dog samples (57%), all 8 chicken samples (100%), all 3 duck samples (100%), all 6 deer samples (100%), none of the cow samples (0%), 2/4 rabbit samples (50%), 3/7 horse samples (43%), 1/4 pig samples (25%), both turkey samples (100%), and 1/2 cat samples (50%).

Keywords: Environmental monitoring, Fecal contamination, Host specificity, Microbial source tracking, Wastewater-based epidemiology.

Improving Infiltration Modeling in Urban Soils through Field Testing and Soil Moisture Sensor Data

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What I will be presenting:

To provide structural stability to buildings and roads, urban soils historically were compacted across the entire development site. The goal was to reduce the porosity of the soil to reduce water penetration. Often, after the site was developed, a shallow layer of topsoil and some vegetation were added to the exposed areas, resulting in a compaction layer a few inches below the surface, just below what appears to be a pervious area that would encourage infiltration. Due to the compaction layer and potentially due to reduced porosity, the amount of water that can be infiltrated in a storm event is likely restricted because deep infiltration is not available. Stormwater models such as SWMM are not capable in most cases of addressing this restrictive layer, especially using some of the more common methods of addressing infiltration. This project developed a rapid field procedure combined with longer-term soil sensor information to improve parameter estimation in SWMM. It also developed a method to use soil moisture data from a **single** sensor to derive the parameters to use the Horton equation. The shallow subsurface data revealed a different infiltration behavior than that obtained from surface double ring infiltrometers and was repeatable between storm events.

What the audience will learn:

As storms become more intense and flooding potential increases, especially in the mid-Atlantic, it is vital that stormwater modeling addresses gaps in the modeling, especially ones that can lead to a substantial underestimation of runoff. The urban compaction layer represents one such gap because it is not included in any of the common model frameworks. What the audience will learn is the field procedure to evaluate the depth and extent of the urban compaction layer, including necessary equipment and time required for field testing and how to calculate infiltration parameters for common model equations from the data of a single soil sensor. This will enable better predictions of runoff generation and thus flooding.