Stormwater Action Monitoring

Plant and fungi amendments to bioretention for pollutant reduction over time

Effectiveness Study

Lead Entity

U.S. Fish and Wildlife Service

Partners

Washington State University

Auburn University

King County Department of Natural Resources and Parks

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 to reduce pollution, improve water quality, and reduce flooding. We do this by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Questions about SAM?
See ecology.wa.gov/SAM

Study goals

To evaluate the role of plants and fungal amendments in the bioretention best management practice (BMP) on hydraulic performance, stormwater treatment, and toxicity to zebrafish.

Stormwater management problem

Ecology specifies design criteria for bioretention with a layer of engineered bioretention soil mix (BSM) of 60% sand and 40% compost by volume (60:40) between a surface layer of mulch and a bottom layer of drainage gravel. The biological elements of bioretention, such as plants and fungi growing in the mulch layer, may provide water quality treatment and other benefits. However, these biological benefits have not been quantified in standard bioretention systems.

Project findings

This two-year field-scale evaluation gathers new information about how local plants and mulch inoculated with *S. rugosoannulata* affect water quality and other bioretention performance parameters. Runoff from 32 acres of urban residential and Interstate 5 (I-5) surfaces was collected in an underground vault and used to dose 12 underdrain bioretention mesocosms at a realistic loading rate for two years. (See Table 1 for mesocosm components.)

Bare-root Pacific ninebark plants (deciduous shrubs) were used in half of the bioretention cells. Unfortunately, despite supplemental watering the summer 2017 drought killed some plants. By the end of the study, treatments with plants had reduced export of nitrogen and increased hydraulic conductivity. However, the failed establishment of the original plantings during half of the study period limited meaningful conclusions about plant impacts to water quality overall.

Fungi decomposed nearly all of the alderwood mulch mass over the two years. By mid-study, fungi were observed to be growing in all of the treatments, including the control; however, the fungi were far more abundant in the inoculated treatments. Differences in mulch mass between BSM treatments diminished by the end of the second year; these findings suggest that routine mulch resupply is likely needed for bioretention facilities.

Whereas plants increased hydraulic conductivity, fungi decreased it by the end of the study. Control and treatment with both plants and fungi showed no change in hydraulic conductivity, implying that these biological elements of bioretention offset their individual impacts on hydraulic conductivity. Fungi retained soil moisture needed for plants and microorganisms to thrive.

Winecap *Stropharia rugosoannulata*

Table 1. Bioretention treatments used in study; n = 3 for all treatments

Treatment label	Explanation
BSM (Control)	Bioretention soil medium with mulch
BSM + F	Bioretention soil medium with fungi-amended mulch
BSM + P	Bioretention soil medium with mulch and plants
BSM + F + P	Bioretention soil medium with fungi-amended mulch and plants

Water quality benefits of BSM, plants, and fungi
Bioretention systems, regardless of fungal and/or plant amendments, significantly improved water quality by removing metals, bacteria, solids, and organic compounds from urban runoff. Similar to previous study findings, nutrients and some metals were initially released from all bioretention systems. However, the export rate of orthophosphorus decreased over 70% during the two-year study period compared to the control. Bioretention was most effective for removing fecal coliform (including *E. coli*), lead, zinc, and total suspended solids. No contaminants in the BSM reached ecologically concerning levels.

The stormwater influent was inconsistently toxic to zebrafish, making it difficult to interpret the treatment effects. Neurotoxicity risk to fish was reduced in effluent waters from all treatments as a result of significant decreases in dissolved metal concentration. Toxicity reduction was more common during Year 2 than Year 1.

Fungi provided multiple water quality benefits to the systems including reduced phosphorus leaching from the BSM and improved removal of some metals, especially during the initial peak leaching stage.

Recommendations

For stormwater managers
To optimize water quality treatment, mulch should be renewed on a regular basis as a substrate for fungi. Plants roots maintain hydraulic conductivity, and plant selection should include evergreen varieties with tolerance to summer drought.

For future study
Future toxicity research should use more sensitive endpoints than zebrafish when stormwater with low suspended solids is the influent source for treatment effectiveness studies.

Why does this study matter?

As bioretention becomes more widely used, stormwater managers want to apply the most successful design options and maintenance requirements to local facilities. This study increases our understanding of the biological elements of bioretention.

What will Ecology do with this information?

The reduction of phosphorus export from the fungal-inoculated mulch layer is notable for the establishment year of a new bioretention BMP. Use of fungal-inoculated mulch to jump-start microbial activity and reduce phosphorus export during the installment year is allowed for new bioretention facilities. Ecology will maintain guidance limiting new bioretention facilities built with the 60:40 BSM within ¼ mile of phosphorus-sensitive waterbodies.

What should we do with this information?

Stormwater managers should continue to use bioretention-based BMPs with the 60:40 BSM wherever practicable.

Fungal colonization will occur naturally in any mulch layer over time. Because fungi improve soil moisture content and provide favorable conditions for plants, stormwater managers may consider fungal inoculation to the mulch layer in new bioretention installations. This may stimulate fungal community growth and lessen phosphorus export during the higher initial leaching period.

Annual resupply of the mulch layer will help maintain the benefits of fungal communities, retain soil moisture, and help with weed control.

Stormwater managers should remember that, with 60% sand in the default BSM, summer irrigation is needed for plant establishment and survival.

For more information

Visit the SAM website at www.ecology.wa.gov/SAM and search for "bioretention amendment with fungi."