Stormwater Action Monitoring

Project Title

Bioretention reduction of toxicity to Coho salmon from urban stormwater

Effectiveness Study

Lead Entity

Puget Sound Stormwater Science Team

Partners

U.S. Fish and Wildlife Service

NOAA-Fisheries

Washington State University

Suquamish Tribe

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? Send an email to SAMinfo@ecy.wa.gov

Study questions

Bioretention is a common choice for stormwater treatment (filtration through an engineered soil mix) and infiltration in Washington State.

- Is the standard 60% sand 40% compost (60:40 mix) bioretention soil media (BSM) specified by Ecology's stormwater management manual effective enough to prevent toxic impacts of urban runoff from multiple storms to Coho salmon adult spawners and embryos?
- Do contaminants leached from the BSM contribute to water quality problems?

Stormwater management problem

Bioretention is shown to be a highly effective means of reducing many pollutants in stormwater runoff, especially contaminants associated with particulate matter. Bioretention treatment prevented toxicity from road runoff in a single test with juvenile Coho, mayfly nymphs, and daphnia. Pilot work filtering stormwater runoff through bioretention soil media columns showed reductions in metals and PAHs. Recent work has shown that toxicity of road runoff to developing fish is associated with dissolved contaminants rather than particulates.

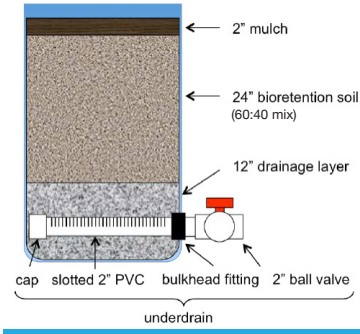


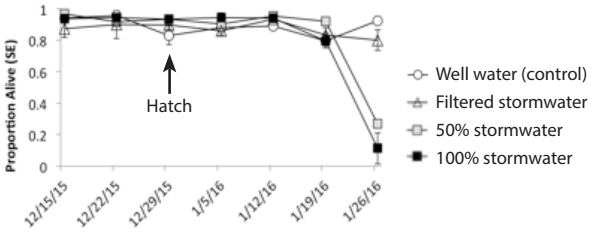
Diagram of bioretention unit using 55-gallon drum.

The 60:40 mix commonly used contains bacteria, nutrients, and metals that are sometimes leached out during stormwater treatment. There is concern that bioretention may be exacerbating water quality problems in some settings, particularly in salmon spawning streams and in lakes and other phosphorus-sensitive water bodies.

Project findings

Installing green infrastructure with bioretention treatment cleans urban stormwater runoff sufficiently to help protect sensitive life history stages of salmon species. Results showed the standard BSM provides adequate treatment across numerous storms. Bacteria, nutrients, metals, and polycyclic aromatic hydrocarbons (PAHs) were measured before and after filtration. Concentrations of all of these contaminants except arsenic, nickel, and nutrients were lower in filtered stormwater than in untreated stormwater for the same storm event.

Filtering stormwater through BSM prevents lethal stormwater impacts to adult Coho spawners. Unfiltered stormwater killed 100% of Coho exposed in these experiments, while 100% of Coho exposed to filtered stormwater survived. Bioretention filtration also prevented mortality in Coho embryos episodically exposed to urban stormwater runoff. However, some sublethal effects were observed. Untreated stormwater induced a gene responsible for PAH detoxification (*cyp1a*) on all sampling dates, with the highest induction during exposure and somewhat lower levels on days with clean water. Filtered stormwater rarely induced *cyp1a*. Evidence of cardiac stress (induction of the gene *nppb*) was only present during exposure to runoff, not days with clean water; however filtration through bioretention did not prevent *nppb* induction. The same chemicals may not be triggering the PAH detox and the cardiac stress.



Survival of Coho embryos in unfiltered stormwater runoff was high from fertilization until after hatching, when most coho died. Mortality in hatched coho was high in both diluted and undiluted unfiltered stormwater. By contrast, there was very little mortality among embryos in well water (the control) and in the filtered stormwater.

There was a net export of arsenic, nickel, nitrogen, and phosphorus from the BSM, with low concentrations that were higher in the effluent than influent water across the ten treatment events. Although the BSM also contained measurable amounts of other metals, there was a net removal of zinc, copper, chromium, lead, and cadmium from runoff. Most importantly, the study found that sufficient dissolved organic carbon is released from BSM to bind dissolved copper and make it biologically unavailable. More than half of the untreated stormwater samples were predicted to be neurotoxic, whereas none of the BSM filtered stormwater samples were predicted to be neurotoxic. BSM filtration also reduced bacteria. PAHs were always reduced by bioretention treatment, showing an overall 91% reduction. There was no apparent loss of chemical performance after repeated treatment of highway runoff through bioretention.

Recommendations

Bioretention filtration of urban stormwater runoff can prevent pre-spawn mortality in adult Coho salmon during 24 hour exposures and eliminate toxic impacts to Coho embryos developing in episodic exposure to runoff. Assessing the biological benefits of bioretention to receiving waters is mentioned only at the basin scale in the recent review. In contrast, biological impacts should be incorporated at smaller scales in order to increase the likelihood of ecological success as we move towards larger and more comprehensive installations.

Why does this study matter?

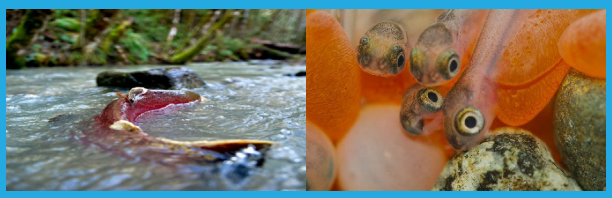
Untreated stormwater has been found responsible for Coho salmon pre-spawn mortality in streams in our region; stormwater also causes numerous sublethal effects. Bioretention is a promising solution to this problem. Knowing that the required treatment practices are protective of embryos and adult spawners provides confidence in widespread application of bioretention. These results confirm that treating stormwater using bioretention with the standard 60:40 mix prevents toxic and lethal effects to Coho salmon.

What should we do with this information?

Stormwater managers should continue to install bioretention systems as opportunities arise. Permittees should implement Ecology's guidance for applying bioretention to projects in Western Washington. Bioretention treatment with BSM can be incorporated at any scale, even very small scales, when planning stormwater retrofit projects. Permittees should encourage developers to include bioretention in all site plans for new development, redevelopment, and retrofit projects where bioretention is feasible.

What will Ecology do with this information?

Ecology's stormwater management manual will continue to specify the 60:40 mix as the standard BSM for bioretention. Ecology will continue to discourage underdrains below bioretention facilities due to the lack of flow control and likelihood of transporting nutrients to receiving waters. Meanwhile, stormwater management continues to evolve and Ecology will continue to support studies to improve BSM to reduce nutrient export and not increase toxicity.



For more information

See the project website at www.ecology.wa.gov/SAM for the full report and other SAM effectiveness studies.