Green Infrastructure Research Program
Providing Research Solutions to Manage Wet-Weather Flow

Rain Gardens

Introduction
Rain gardens are vegetated surface depressions, often located at low points in landscapes, designed to receive stormwater runoff from roads, roofs, and parking lots. The gardens’ sandy soils allow stormwater to infiltrate quickly to the native soils below and eventually contribute to groundwater recharge. Pollutants and nutrients in stormwater runoff are removed by rain garden vegetation and soils through biological and physical processes such as plant uptake and sorption to soil particles. In comparison with stormwater release to receiving waters through conventional storm drain systems, infiltrating stormwater through rain gardens reduces peak flows and stressor loadings. This reduction improves the physical and biological integrity of receiving streams by reducing stream bank erosion and negative effects on aquatic communities.

Current Issues
While local governments and individual homeowners are building many of the rain gardens in use, relatively few studies have documented the rain gardens’ pollutant and nutrient removal capability. Typical rain garden designs currently consist of gravel beneath a layer of sandy soil. A mulch layer on the soil supports plantings of trees, shrubs, and herbaceous plants. Although this design is successful for the removal of heavy metals and phosphorus, it does not provide the right conditions for nitrate removal.

A possible explanation for this pattern is that the currently-accepted rain garden design inhibits denitrification, a microbial process that converts nitrate to nitrogen gas, which is released to the atmosphere, removing it from the system. Microbes that carry out denitrification typically require wet conditions and a readily-available source of carbon to drive the reaction. Sandy soils drain quickly and have low levels of available carbon, creating poor conditions for denitrification.

Objectives
Comprehensive asset management is The National Risk Management Research Laboratory (NRMRL) rain garden evaluation is part of a larger collection of long-term research that evaluates a variety of stormwater management practices. The U.S. EPA recognizes the potential of rain gardens as a green infrastructure management tool to lessen the influence of development on aquatic resources.

The Green Infrastructure Research Program’s long-term rain garden research objectives are to address the issues of pollutant and nutrient removal capabilities of rain gardens by studying the following:

• The performance of rain gardens in removing pollutants.
• Whether currently-accepted design standards can be adjusted to improve nitrate removal capabilities.

Current Research
Eight rain garden mesocosms have been constructed in conical-bottom polyethylene tanks, and are filled with different experimental types and levels of substrate. The mesocosms are also vegetated; half of the tanks are planted with turf grass and the other half with native, herbaceous plants that are drought, flood, and salt tolerant. NRMRL’s current research investigates soil carbon amendments and saturation at depth in these rain gardens to promote conditions for denitrification, and thus, increase nitrate removal.

Controlled-condition research enables NRMRL to better manage research projects and collect high-quality information. Collecting data and performing experiments at field sites away from the laboratory limits research due to uncertainties in weather forecasts, site access, utility locations, vandalism, and other logistical issues that collectively add greatly to the costs and timelines of research projects.

Using on-site, experimental rain gardens enables NRMRL to collect high-quality data necessary for evaluating engineered structures. On-site experiments are inherently safer than attempting to monitor...
public rain gardens adjacent to roadways during rainstorms, avoiding unnecessary risks to people and equipment.

NRMRL operates a 20-acre Urban Watershed Research Facility that includes stormwater mesocosms, laboratories, greenhouses, fabrication space, a pipeline testing facility, swale and pervious parking lot performance testing, and storage for equipment and supplies. This unique facility is part of the larger 200-acre Edison Environmental Center operated by the U.S. EPA Region 2. This land area allows NRMRL to undertake this research on a scale that cannot be executed at any other U.S. EPA facility. The eight rain garden mesocosms, along with the supply and collection tanks, occupy ¼-acre of this land.

**Impacts**

A more complete understanding of how rain gardens function will enable the U.S. EPA to provide national guidelines on rain garden design, construction, maintenance, and monitoring which local organizations can use to reduce pollutant and nutrient loads to receiving waters. Reducing pollutants and nutrients in runoff will help our waters meet their locally-designated uses. Rain gardens and other management tools will help watershed managers assure that receiving waters meet the “fishable and swimmable” goals that Congress outlined in the Clean Water Act, and will better assure the continuing supply of high-quality, potable water.

**Contact**

Michael Borst
Chemical Engineer
U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
732-321-6631
borst.mike@epa.gov

**Resources**

Urban Watershed Management Research
http://www.epa.gov/ednnrmrl

U.S. EPA (2008). The Urban Watershed Research Facility, Edison, New Jersey (PDF) EPA/600/F-08/005