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Performance of two small experimental bioretention cells during the first year of operation

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Due to increasing urbanization, bioretention cells are becoming an increasingly popular solution for stormwater management. The data on long term performance bioretention are still sparse. The aim of this study was to set-up two experimental bioretention cells designed for long-term monitoring and to evaluate the rainfall-runoff characteristics, assess the development of properties of the biofilter, and dynamics of plant growth during the first growing season.

Two identical experimental bioretention cells were established. The first collects water from the roof and the second is supplied from the tank for simulating artificial rainfall. The 30 cm thick biofilter soil mixture is composed of 50% sand, 30% compost, and 20% topsoil. Bioretention cells are isolated from the surrounding soil by a waterproof membrane. Both bioretention cells are instrumented by an identical system of sensors. Four time-domain reflectometry probes monitor soil water contents 20 cm below the surface. Five tensiometers record the water potential in a biofilter. The amount of a discharge from each bioretention cell is determined by a tipping bucket flowmeter. A ponding depth is recorded by an ultrasonic sensor.

Rainfall-runoff episodes were evaluated for the period from 18.6. 2018 to the 22.11.2018. 17 episodes were evaluated for bioretention cell with the inflow of stormwater from the roof. Six ponding experiments were done in the bioretention cell with an artificial supply. Rainfall depth, maximal rainfall intensity, episode duration, runoff coefficient, and maximal peak outflow rate from both bioretention cells were determined for each episode. The effective saturated hydraulic conductivity was determined using Darcy's law under the assumption of one-dimensional, vertical flow. The estimation method was verified by simulating two-dimensional variably saturated flow using HYDRUS-2D. Outflow water quality was measured from one bioretention cell during ponding experiments.

The runoff coefficient for the entire period of the growing season was 0.72, while the peak outflow reduction for individual rainfall events ranged between 75% to 95% for the bioretention cell connected to the roof. The runoff coefficient determined from artificial ponding events was 0.86 for the event started in the partially saturated biofilter, while it was nearly 1.0 for all subsequent artificial ponding events. The peak flow reduction ranged from 19% to 30%. The saturated hydraulic conductivity of biofilter with a natural rainfall supply ranged between $1.6\cdot10^{-6}$ to $8.6\cdot10^{-6}$ $m\cdot s^{-1}$, which is significantly less than hydraulic conductivity $1.3\cdot10^{-4}$ $m\cdot s^{-1}$ measured in the

laboratory on packed samples. Perennials Aster, Hemerocallis and Molinia have shown good growth and adaptation to conditions in bioretention cells. In the case of the current experiment, the gravel mulch layer has proven to be an effective barrier to reducing evaporation. The values of total suspended solids and turbidity were highly correlated and generally high, especially at the beginning of outflow in artificial ponding experiments. The value of electrical conductivity reached up to 2200 $\mu S \cdot cm^{-1}$, this may be due to the higher compost content in the soil. The monitoring of bioretention cells continues in order to record long term changes in the performance of the bioretention cells.