Hydrologic and Water Quality Modeling of Bioretention Columns in Cold Regions

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January 16, 2023

Abstract

Bioretention is widely used in urban sustainable stormwater management. However, limited numerical research has been conducted on its performance in cold regions, particularly for winter snowmelt, spring runoff and summer large storms (> 50 mm) for urban flood mitigation. In this study, HYDRUS 1D was used to explore these knowledge gaps. The model was comprehensively calibrated and validated against 2-year hydrologic and water quality data of four bioretention columns with different designs under lab-simulated cold region conditions. The Morris method was used to measure the sensitivity and interaction of the calibrated hydraulic parameters. The model revealed that the effective hydraulic conductivity (K_S) values of the soil media were similar for winter snowmelt and spring runoff when the soil temperature was around -0.5 °C. Preferential flow is likely to occur in soil media during winter or spring of cold regions. The summer modeling showed that the bioretention could substantially reduce peak flow, ponding depth and duration for large storm events (even for 1:100 local storm with 83.4 mm in 4 hours). The water quality modeling confirmed experimental results that the bioretention effectively removed phosphate and ammonium but had leaching issues for chloride and nitrate. Finally, optimization and recommendations of bioretention columns were provided.

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