Modelling uniform and preferential flow in bioretention systems

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Bioretention systems are increasingly used worldwide to mitigate the impacts of urban stormwater runoff on the water cycle. The proper management of bioretention systems requires accurate modeling of physical processes occurring within these systems. This study developed and tested a generic and physically-based model called Infiltron-mod. This model makes use of the Darcian approach (assuming Mualem-van Genuchten model for the description of the soil hydraulic properties) and mass conservation. The first version of the model considers evapotranspiration, overflow, exfiltration to surrounding soils, along with the filter hydraulic head and underdrain discharge. The proposed model was tested against field data from a monitored bioretention basin in Melbourne, Australia. We used two rainfall events to calibrate the model and 20 rainfall events for its validation. We achieved quite nice fits of experimental data with median NSE values in the order of 0.7-0.75 for the outflow rates. Despite good performance for outflow rates, we noticed the potential for improvement for the simulation of the height of water in the systems. Such discrepancy is probably the result of preferential flows.

As a second step, we developed a specific module to implement the dual permeability approach to model preferential flow. Such an approach may simulate the concomitancy of matrix flow in part of the system and rapid preferential infiltration into macropores. The new module Infiltron-mod-pref was implemented and investigated. Prior to its use for field data, we validated the new module against more straightforward water infiltration experiments. Several large ring infiltration tests were performed on a field dedicated to infiltrating stormwater, and the two versions of the proposed model, Infiltron-mod and Infiltron-mod-Pref. We clearly showed the benefit to account for the preferential flow in the model. The next step will be the use of Infiltron-mod-Pref for field data from the monitored bioretention basin in Melbourne.

The proposed approach then seems a useful first step to assess both performance and impact of bioretention basins for catchment-scale flow regime management and has real potential for application where user-friendly and simple model calibration and deployment are desired.