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Temporal Estimation of Hydrodynamic Parameter Variability in Constructed Wetlands

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Abstract : The calibration of hydrodynamic parameters for subsurface constructed wetlands (CWs) is a sensitive process since highly non-linear equations are involved in unsaturated flow modeling. CW systems are engineered systems designed to favour natural treatment processes involving wetland vegetation, soil, and their microbial flora. Their significant efficiency at reducing the ecological impact of urban runoff has been recently proved in the field. Numerical flow modeling in a vertical variably saturated CW is here carried out by implementing the Richards model by means of a mixed hybrid finite element method (MHFEM), particularly well adapted to the simulation of heterogeneous media, and the van Genuchten-Mualem parametrization. For validation purposes, MHFEM results were compared to those of HYDRUS (a software based on a finite element discretization). As van Genuchten-Mualem soil hydrodynamic parameters depend on water content, their estimation is subject to considerable experimental and numerical studies. In particular, the sensitivity analysis performed with respect to the van Genuchten-Mualem parameters reveals a predominant influence of the shape parameters α, n and the saturated conductivity of the filter on the piezometric heads, during saturation and desaturation. Modeling issues arise when the soil reaches oven-dry conditions. A particular attention should also be brought to boundary condition modeling (surface ponding or evaporation) to be able to tackle different sequences of rainfall-runoff events. For proper parameter identification, large field datasets would be needed. As these are usually not available, notably due to the randomness of the storm events, we thus propose a simple, robust and low-cost numerical method for the inverse modeling of the soil hydrodynamic properties. Among the methods, the variational data assimilation technique introduced by Le Dimet and Talagrand is applied. To that end, a variational data assimilation technique is implemented by applying automatic differentiation (AD) to augment computer codes with derivative computations. Note that very little effort is needed to obtain the differentiated code using the on-line Tapenade AD engine. Field data are collected for a three-layered CW located in Strasbourg (Alsace, France) at the water edge of the urban water stream Ostwaldergraben, during several months. Identification experiments are conducted by comparing measured and computed piezometric head by means of the least square objective function. The temporal variability of hydrodynamic parameter is then assessed and analyzed.

Keywords : automatic differentiation, constructed wetland, inverse method, mixed hybrid FEM, sensitivity analysis
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