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The finite volume point dilution method: a tracer technique for monitoring transient Darcy fluxes

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Quantification of pollutant mass fluxes is essential for assessing the impact of contaminated sites on their surrounding environment, particularly on adjacent surface water bodies. In this context, it is essential to quantify but also to be able to monitor the variations with time of Darcy fluxes in relation with changes in hydrogeological conditions and groundwater – surface water interactions. The Finite Volume Point Dilution Method (FVPDM) is a new tracer technique that generalizes the single-well point dilution method to the case of finite volumes of tracer fluid and water flush. It is based on an analytical solution derived from a mathematical model proposed recently to accurately model tracer injection into a well. After a brief description of the underlying concepts and mathematical model, an analytical solution is derived for calculating straightforwardly the evolution of concentration of the tracer in the injection well during and after injection operations. It is shown that this new tracer technique is easier to implement in the field than the classical point dilution method while it further allows monitoring changes with time of the magnitude of estimated Darcy fluxes, which is not the case for the former technique. In the scope of the EU FP6 AQUATERRA project, the FVPDM was applied in two experimental sites with contrasted objectives, geological and hydrogeological conditions, and field equipment facilities. In site A, the objective was to estimate contaminant travel times in groundwater to a spring while assessing vertical variations in groundwater fluxes, using a combined FVPDM – classical tracer test, with "non-ideal" experimental conditions. In site B, the purpose was to estimate, in very well controlled experimental conditions, groundwater fluxes flowing out from a contaminated site to a neighbouring river. In both cases, field tracer concentrations monitored in the injection wells were used to fit the calculated modelled concentrations by adjusting the apparent Darcy flux crossing the well screens.

Modelling results are very satisfactory and indicate that the methodology is efficient and accurate, with a wide range of potential applications in different environments and experimental conditions, including the monitoring with time of changes in Darcy fluxes.