Better considering tracer distribution within boreholes while FVPDM tests

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Characterizing groundwater fluxes is essential in many hydrogeological studies, especially to assess contaminant transport in the subsurface. In this context, the Finite Volume Point Dilution Method (FVPDM) is a single-well experiment consisting in continuously injecting a tracer into a well and monitoring the evolution of the tracer concentration into the same well. A part of the injected tracer is carried out of the well by the groundwater flow and therefore the higher the tracer dilution, the lower the tracer concentration remaining in the well. In such tests, the water within the tested interval has to be continuously mixed using a mixing pump in order to perfectly homogenize the tracer concentration. Yet in practice, when FVPDM are performed in long-screened boreholes or in very permeable aquifers, it can be technically difficult to maintain a mixing important enough so that the tracer concentration is homogenous along the well. In order to assess the effect of non-perfect mixing on FVPDM results, we introduce here a new discrete model that explicitly considers the recirculation flow rate. The mathematical developments are validated using field measurements resulting of FVPDM tests performed under pumping conditions in a high hydraulic conductivity aquifer. Additionally, a sensitivity analysis was performed in order to assess the effect of recirculation flow rate and to define the limits of the FVPDM and the advantages of the discrete model. Results confirm that it is essential to accurately consider the recirculation flow rate when performing FVPDM in the field. Non-perfect mixing occur as soon as the recirculation flow rate applied is not high enough compared to the groundwater flow rate. In this case, the tracer concentration is not uniform with decreasing tracer concentrations along the tested interval. Since the tracer concentration is measured within the recirculation loop (which helps the mixing of the tracer), neglecting the recirculation flow rate during field data interpretation can lead to significantly overestimate groundwater fluxes if the classical analytical solution is applied to interpret tracer concentration evolution. The discrete model introduced here, which was validated through field measurements, can be used instead to properly estimate groundwater fluxes and assess the tracer distribution within the tested interval.