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Effect of transverse dispersion on solute transport in a vertical dipole flow test with a tracer

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Vertical dipole flow test with a tracer (DFTT) has been proposed to simultaneously determine the longitudinal dispersivity as well as the radial and vertical hydraulic conductivities from analysis of the concentration breakthrough curves (BTCs) recorded in the extraction screened interval and the drawdowns in the extraction and injection screened intervals. The essential assumption imbedded in a DFTT for estimating the longitudinal dispersivity is that only the longitudinal dispersion has the effect on the BTCs, whereas the effect of transverse dispersivty on BTCs is invisible in the extraction screened interval. When tracers are introduced into the injection screened interval, the resulting tracer plume undergoes transverse dispersion during migration toward the extraction well in a DFTT. The presence of transverse dispersion allows tracer particles moving across streamlines, thus changing the travel paths of tracer particles. Tracer particles move along the high-velocity and short travel paths adjacent the well, resulting in early first arrival, whereas tracer mass move slowly along low-velocity and long travel paths far from the well, causing along BTC tail. Accordingly, transverse dispersion can affect the travel time distribution of the tracer particles and ultimately modify the resulting BTCs observed in the extraction screened interval. When the transverse dispersion has also an effect on BTCs, the longitudinal dispersivity can not be uniquely determined based on analysis of the BTCs in the extraction screened interval. In this study, a mathematical model which considers the transverse dispersion process is applied to investigate the effect of the transverse dispersion on the BTCs of a DFTT and to examine the limitation of validity of a DFTT for determining the longitudinal dispersivity. Simulated results demonstrate that the transverse dispersion exert significant effects on the BTCs for an aquifer has a large hydraulic conductivity anisotropy ratio and a large longitudinal dispersivity. This finding suggests that longitudinal dispersivity can not be uniquely determined from analysis of the BTCs because that the BTCs are simultaneously affected by both the longitudinal and transverse dispersions. It should be cautious that execution of a DFTT for evaluating the longitudinal dispersivity is only valid for an aquifer with small hydraulic conductivity anisotropy ratio and small longitudinal dispersivity.