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Development of new analytical solution for land-derived solute transport under tidal fluctation

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A one-dimensional semi-analytical solution of land-derived solute transport, subject to tidal fluctuation in a coastal confined aquifer, was derived using the generalized integral-transform technique (GITT). To investigate the plume migration of land-derived contaminants within a tidally influenced aquifer, both spatially and temporally varying expressions of the Darcy velocity and dispersion coefficients obtained from the analytical solution of the groundwater head response, which were subject to sinusoidal boundary conditions due to tidal fluctuation, were considered. This new semi-analytical solution was verified against a numerical solution, as well as the peak location trajectory obtained using the Predictor-Corrector method. Sensitivity analyses of tidal amplitude, hydraulic conductivity, and storage coefficient using the proposed solution were performed to understand plume behavior with regard to plume shape, plume spatial moments, and macrodispersion coefficients to gain a better understanding of the transport mechanisms. As the tidal amplitude, hydraulic conductivity, and storage coefficient were increased, the peaks were travelled faster, and peak concentrations were decreased. In addition, an increase in tidal amplitude, hydraulic conductivity, and storage coefficient caused an increase in variance as well as the macrodispersion coefficient. It was observed that negative macrodispersion appeared when the storage coefficient was largest, as well as when the difference between landward-directed advective velocity at the leading and trailing edges of the plume was greatest. This newly developed semi-analytical solution provides a useful mathematical tool for validating numerical models and understanding the physical mechanism of the migration of plume discharge to the sea or estuaries within a tidally influenced aquifer.