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An analytical power series solution to the two-dimensional generalized advection-dipsersion equation with linearly distance-dependent dispersivity

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Dispersivity has been frequently shown to increase with solute travel distance in a subsurface environment owing to the significant variations in hydraulic properties of heterogeneous media. Deriving the analytical solution to an advection–dispersion equation with distance-dependent dispersivity is very difficult because of the variable dependence of governing equation's coefficients. In this study, an analytical solution is derived for describing two-dimensional solute transport in a uniform flow field with linearly distance-dependent dispersivity. The analytical solution is developed by application of the extended power series method coupling with the Laplace and finite Fourier cosine transform. The developed analytical solution is compared with the numerical solution to examine its accuracy and robustness. Results show that the breakthrough curves at different observation points from the analytical solution can agree well with those from the numerical solution. However, the computation of the developed solution can only be accomplished when the value of longitudinal dispersivity/distance ratio is greater than 0.15 and it does not permit evaluation of the power solution at the value of longitudinal dispersivity/distance ratio is smaller than 0.15 because of the difficulty in machine's arithmetic operation of extremely large values of the derived power series functions. The power series analytical solution may be a useful tool for verifying numerical transport codes used to describe the two-dimensional scale-dependent dispersive transport of contaminants.