Exact analytical solutions for two dimensional multispecies advective-dispersive equations sequentially coupled with first-order decay reactions in a semi-finite domain

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Abstract

Analytical solutions to a set of simultaneous multispecies advective-dispersive transport equations sequentially coupled with first-order decay reactions have been widely used to describe the movements of decaying or degradable contaminants such as radionuclide, chlorinated solvents, nitrogens and pesticides in the subsurface. However, most of these analytical solutions for multispecies advective-dispersive transport currently available in the literature are derived for one-dimensional transport system. Multi-dimensional multispecies transport analytical solutions are needed for real world applications, making them more attractive than one-dimensional solutions. This study presents an analytical model for coupled multispecies transport in a semi-infinite domain. A method of consecutive applications of Laplace and finite Fourier transform techniques in combination with sequential substitutions is adopted to derive the analytical solutions to the governing equation system. The developed analytical model is robustly verified with an example problem and applied to investigate the effect of exit-boundary conditions on the multispecies plume migration.

二維半有限域下多物種一階序列衰變反應耦合移流-延散傳輸之全解析解

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摘要

多物種傳輸解析解對於一階序列衰變反應耦合移流-延散傳輸方程式已經被廣泛的用來描述像是放射性核種、含氯有機溶劑、氨氮以及農藥等具有會衰變或降解反應之污染物在地下水中移動的情形。儘管在過去研究中已提出了一些多物種移流-延散傳輸解析解模式，但大多是發展在一維系統下。而多維度系統下又能考慮多物種之傳輸解析解現今更被需要應用在生活中也因此較一維解析解更具實用性。本研究提出一個解析解模式結合多物種傳輸考慮在半有限域下。當中依序應用 Laplace 及有限傅立葉轉換技巧並經由一系列逆轉換來推導出系統下控制方程式之全解析解，所發展之解析解將會透過一個例子來驗證解之正確性，並會探討多物種污染團遷移在出邊界條件的效應。