考量隨時間變化之多個任意污染源的非平衡吸附多物種污染物傳輸半解析解模式

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摘要

含氯有機溶劑是生產多種工業產品時使用的化學品，在不當處理的情況下會滲入地下水造成污染，其中四氯乙烯(Tetrachloroethene，PCE)及其降解的子物種為工業場址中常見的含氯有機污染物。在現地污染場址內常見多個內部污染源釋出的情況，即便過去的研究已發展了一些模擬含氯有機溶劑污染地下水的傳輸模式，但多數研究裡考慮的邊界源傳輸模式在模擬多個內部污染源的場址污染問題時會受到限制且難以廣泛應用。考慮內部污染源的傳輸模式可以模擬場址內任意污染源的注入情形，且模式中使用限制速率吸附可以避免低估可降解污染物的濃度。本研究發展隨時間變化的具多個任意污染源的多物種污染物傳輸半解析解模式，並考慮移流、延散、限制速率吸附和一階降解反應等傳輸機制。此半解析解推導依序應用 Laplace 轉換、finite Fourier cosine 轉換及廣義型積分轉換消去時間及空間微分項，將偏微分方程式轉換為代數方程式進行求解，再利用一系列逆轉換求得半解析解。本模式的最大特點在於模擬現實場址中常見的內部污染源釋放情形，並作為初步評估污染整治的基礎。

Semi-analytical model of non-equilibrium multi-species transport subject to multiple arbitrary time-dependent pollution sources

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Abstract

Chlorinated organic solvents are the chemicals used in the production of many industrial products, they can seep into groundwater and cause pollution if improperly executed. The PCE (tetrachloroethylene) and the daughter species of it are the common chlorinated solvents in industrial sites. The release of multiple internal pollution sources is common to see at in-situ contaminated sites. Although some models have been proposed to simulate the transportation of multi-species contaminants polluted by chlorinated solvents in the past, boundary sources considered in most studies are limited and difficult to be widely used when simulating the site pollution problems of multiple internal pollution sources. Model which consider internal sources can simulate the injection of arbitrary pollution sources at the contaminated site, and the use of rate-limited sorption in the model can avoid underestimating the concentration of degradable pollutants. This study develops a semi-analytical model of multi-species contaminant transport subject to multiple arbitrary time-dependent pollution sources, which also consider advection, dispersion, rate-limited sorption and first-order decay. The derivation of this semi-analytical model applies Laplace transform, finite Fourier cosine transform, generalized integral transform and a series of inverse transform. The greatest contribution of this study is to simulate the release of internal pollution sources which are common in real world sites and serve as the basis for preliminary assessment of pollution remediation.