

## 多層次反應牆對於受四氯乙烯污染之含水層整治評估及污染傳輸模式發展

Zengguang Xu, Yanqing Wu, Fei Yu, 2010. A Three-Dimensional Flow and Transport Modeling of an Aquifer Contaminated by Perchloroethylene Subject to Multi-PRB Remediation. DOI 10.1007/s11242-011-9847-1, *Transp Porous Med* (2012), 91:319–337.

報告者: 何佑婕

指導教授: 陳瑞昇 老師

Date: 2023/05/05

### 摘要

有機化學物質是常見的地下環境污染類別，而滲透性反應牆作為一種原位 (in-situ) 整治技術，可為地下水污染場址提供有效整治。實驗發現，結合零價鐵及厭氧微生物 (FeMB) 可有效促進四氯乙烯之脫氯生物降解反應，其降解途徑為：四氯乙烯→三氯乙烯→1,1-二氯乙烯→乙烯→乙烷。依據實驗結果及研究數據，本研究以 MODFLOW-2005 V1.7/MT3DMS V5.2 為基礎程式進行降解反應模擬，並使用 FeMB 作為反應材料，建立三維多層次滲透性反應牆 (multi-permeable reactive barriers) 之四氯乙烯整治評估模式；其中針對吸附及降解反應相關特性參數，以基因演算法 (genetic algorithm) 進行曲線擬合及參數推估。整體而言，本研究目的為使用 FeMB 作為多層次滲透性反應牆反應材料，延伸擴展地下水模式 MODFLOW/MT3DMS 並建立受污染含水層中四氯乙烯及其降解產物之傳輸模式。結果顯示，FeMB 對於受四氯乙烯污染之含水層整治具有相當潛力，且多層次滲透性反應牆可有效處理單層反應牆造成的二次污染物。最後將本模式應用於多物種傳輸及降解反應模擬，評估結果發現反應速率及反應牆流通係數的降低對於含水層整治效益有重大影響。

**關鍵字:** 四氯乙烯、多層次滲透性反應牆、MODFLOW、MT3DMS

## A Three-Dimensional Flow and Transport Modeling of an Aquifer Contaminated by Perchloroethylene Subject to Multi-PRB Remediation

Zengguang Xu · Yanqing Wu · Fei Yu

Received: 20 January 2010 / Accepted: 25 August 2011 / Published online: 16 September 2011  
© Springer Science+Business Media B.V. 2011

**Abstract** Although subsurface contamination by organic chemicals is a pervasive environmental problem, a permeable reactive barrier (PRB) as a typical in-situ remediation technology is often successful at many sites. Laboratory tests have shown that perchloroethylene (PCE) can be dechlorinated by the combination of zero-valent iron and anaerobic microbial communities (FeMB), and the degradation pathway was:  $\text{PCE} \rightarrow \text{TCE} \rightarrow 1, 1\text{-DCE} \rightarrow \text{ethylene} \rightarrow \text{ethane}$  (Ma and Wu *Environ Geol* 55(1):47–54, 2008). Based on Ma's experimental results, we have extended MT3DMS to simulate mother-daughter chain reactions using MODFLOW-2005 V1.7/MT3DMS V5.2. Second, using FeMB as multi-PRB's reactive media, a 5-component transport model for a three-dimensional aquifer contaminated by PCE subject to multi-PRB remediation was built. Third, the adsorption and degradation parameters of reactive media were estimated by means of genetic algorithm. Finally, the three-dimensional, homogeneous aquifer contaminated by PCE subject to multi-PRB remediation was simulated. Overall, the purpose of this paper was to use FeMB as multi-PRB's reactive media, and develop a modified MODFLOW/MT3DMS that can simulate a three-dimensional aquifer contaminated by PCE and its daughters. Results demonstrated that FeMB could be a potential reactive media for PCE-contaminated groundwater. Multi-PRB could be a preferred option for secondly pollution caused by application of one-stage PRB. The modified MODFLOW/MT3DMS can effectively simulate multispecies mother–daughter chain kinetic reactions. Sensitivity analysis showed that losses of reactivity and permeability may have a significant effect on remediation's success.

**Keywords** Model · Perchloroethylene · Multi-permeable reactive barriers · MODFLOW · MT3DMS