水 利 学 报
JOURNAL OF HYDRAULIC ENGINEERING
SHUILI XUEBAO

考虑弥散尺度效应的一维反应性溶质运移两区模型及应用

One-dimensional two-region model for reactive solute transport with scale-dependent dispersion and its application

中文关键词: 弥散尺度效应 两区模型 反应性溶质 模型应用

英文关键词: scale-dependent dispersion two-region model reactive solute model application

基金项目:

作者	单位
高光耀	中国科学院 生态环境研究中心 城市与区域生态国家重点实验室，北京 100085;中国农业大学 中国农业水问题研究中心，北京 100083
冯绍元	杨州大学 水利科学与工程学院，江苏 杨州 225009;中国农业大学 中国农业水问题研究中心，北京 100083;中国农业大学 中国农业水问题研究中心，北京 100083
马 英	杨州大学 水利科学与工程学院，江苏 杨州 225009
詹红兵	美国德克萨斯农工大学 地质与地球物理系，美国 德克萨斯州 77843

中文摘要:

为考虑溶质运移的弥散尺度效应，将弥散度概化为运移距离的线性和指数函数，并考虑溶质的吸附和降解，建立了非均质介质中溶质运移的一维两区模型 （TRM） ，采用Laplace变换和de Hoog数值逆变换方法求得了模型的半解析解，分析了考虑弥散尺度效应与弥散度为常数的TRM之间的对应关系，利用算术平均方法计算了考虑弥散尺度效应的TRM的等效弥散度，并应用模型模拟了长度为1 250cm的一维非均质土柱中的溶质运移过程。结果表明：等效弥散度反应了弥散尺度效应的影响，可以近似作为区域弥散度的平均值，但当弥散尺度效应增强时，这种近似会有一定误差；不考虑弥散尺度效应或将弥散度概化为运移距离线性函数的TRM的模拟结果与实测值存在较大偏差，而弥散度为运移距离指数函数时的TRM的模拟精度有了较大提高，能够更好地模拟非均质长土柱中溶质的不规则运移过程。这说明，非均质介质中弥散度并不是随距离无限制地增加，弥散度为运移距离指数函数时的TRM能够较好地模拟溶质在较大尺度上的运移过程。

英文摘要:

This study proposed a two-region model （TRM） to describe reactive solute transport with scale-dependent dispersion in heterogeneous porous media. The model was derived from the conventional TRM but assumed the dispersivity to be a linear and exponential function of travel distance. The linear adso-rption and first-order degradation of solute were also considered in the model. The Laplace transform tech?nique and de Hoog numerical inversion method were applied to solve the developed model. The break?through curves （BTCs） obtained from TRM with scale-dependent and constant dispersion were comp-ared, and the effective dispersivity for TRM with scale-dependent dispersion was calculated by averaging the dis?tance-dependent dispersivity with arith-metic method. This effective dispersivity could reflect the accumulated scale-dependent dispersion effect over the entire travel domain, but dis-crepancy will occur if the dispersion effect is great. The applicability of the proposed model was tested with concentration data obtained from a1 250cm long and highly heterogeneous soil column. The simulation results indicated that the TRM with constant and linear distance-dependent dispersivity were unable to describe the measured BTCs in the column adequately, while the TRM with exponential distance-dependent dispersivity satisfactorily captured the evolution of BTCs. Therefore, the proposed TRM with scale-dependent dispersion by assuming the dispersivity to be a function of distance is a simple and practical approach to describe solute transport at relatively large scale in heterogeneous porous media, but the increase of dispersivity with distance is limited as it has bounds.

查看全文 查看/发表评论 下载PDF阅读器