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中文题名	水源热泵系统对地下水环境影响的数值模拟研究
英文题名	Numerical Simulation on the Enviromental Impact of a Groundwater Source Heat Pump
中文关键词	水源热泵系统；地下水环境；地下水水质
英文关键词	Groundwater Source Heat Pumps, groundwater environment, numerical simulation
中文文摘	地下水式水源热泵系统作为一种利用浅层地下水源的新型节能空调技术，正成为国内许多省市地区小型商用建筑和一般民用建筑中首选的制冷取暖方案。但是，目前国内的水源热泵空调系统应用处于过热、盲目和无序的状态，考虑到国内工程实际水平存在着回灌技术粗糙、管井布设不科学等问题，有必要就该系统利用地热能的方式可能存在对地下水环境潜在污染的问题进行探讨，以避免因盲目地大规模应用这一技术造成对地下水环境的破坏，保证此项新技术能够在国内健康有序地发展。本文通过北京某开发区地下水水温水质的实测资料，分析出在水源热泵空调系统运行期间地下水水温和当地细菌数目（大肠杆菌和细菌总数）的关系，拟合出两者的包络线图，并总结出两者的经验公式。根据上述经验公式，本文建立地下水环境下微生物生长的数学模型，并以美国地质调查局开发的 HST3D 地下水模拟软件为基础进行二次开发，添加描述微生物在水温变化条件下生长规律的模块，使其能够同时模拟计算含水层的流动、传热及水质（大肠杆菌数目和菌落总数）变化规律，并根据实测资料对模型进行参数率定和计算验证。在模型率定和验证的基础上，本文对水源热泵系统不同工况下对地下水环境的影响进行了模拟计算和分析评价。计算结果表明水源热泵系统会显著改变地下水原先均匀的温度分布，其回注冷水（热水）团基本是以对流为主的运动方式在含水层中向抽水井位和其它地方输移和扩散。大肠杆菌和菌落总数的变化在冬季运行工况中变化不很明显，在冷水锋面温度梯度较大的地方细菌数目变化也较大，细菌数目的等值线图分布形状与温度等值线分布形状类似，其它区域（未受影响区域和温度稳定区域）细菌数目变化不大。在上述工况模拟计算和评价的基础上，本文建议：需要在充分进行区域内的地质调查的基础上慎重考虑回灌井群的布设方案。如果抽水井和回灌井的距离不合理，将会导致回灌冷水（热水）在短期内到达抽水井位，造成取水温度下降，影响空调系统的正常运行。而且如果抽注水的水温发生较大变化也必然造成锋面处细菌数目发生较大变化，从而局部的影响了地下水的水质。
外文文摘	As a renewable and clean energy source, Groundwater Heat Pumps (GWHPs) have become the first consideration in some of mini-commercial and common civil buildings in China. However, considering the application of this promising technique is overheated and unguided, it is necessary to carry out the research on potential environment impact possibly resulted by the utilization method of geothermal energy. The study will help protect groundwater environment from polluted by large-scale application of this technique and ensure its development in a healthy and order way. The study will also contribute to the further research on GWHPs' application. Firstly, an empirical equation on the relation of microbe population and groundwater temperature is summed up on the basis of analysis of long-term data on groundwater temperature and quality of a certain site in Beijing. Secondly, a numerical model on groundwater microbe growth is constructed based on the empirical equation and incorporated into HST3D code; enabling it to simultaneously compute groundwater fluid, heat transport and microbe's growth. Thirdly, modeling and analysis of environmental impact on GWHPs under different function modes are carried out. The results show that GWHPs system will enormously affect the groundwater temperature distribution. In contrast, microbe population is not largely affected in the whole region except the boundary of cold and warm water's mixing area. In the end, suggestions on GWHPs' long-term running are put forward: distribution of injecting and recharging wells is a critical factor in the application of GWGPs. Improper distance between injecting and recharging wells will make injecting cold or warm water arrive at the recharging sites in a short period, so called "heat short circuit phenomena", which will affect air conditioners' normal running due to lower recharging water temperature and pollute regional groundwater quality by high temperature disturbance around the recharging wells.

答辩日期	2003.06.11