利用熱示蹤劑試驗結合熱水耦合數值模式解析沿海含水層地下水流場與特性評估

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摘要

人類社會對於水資源的需求量持續增加，全球用水量增加的主要因城市擴張、農業活動增長、人口快速增長、經濟發展和生活水平提高，而地下水資源作為傳統水資源的替代來源，近年來更將沿海地下含水層補注至海洋之地下水視為潛在可用水資源來源，透過操作抽取與補注地下水作為替代水資源。本研究以中央大學 TaiCOAST 臨海工作站作為試驗區域，水文地質參數取得方法分為室內試驗與現地試驗，藉由室內試驗獲得水力傳導係數，進行材料熱傳導試驗，測量飽和狀態下土壤材料熱傳導係數與熱脈衝係數等參數，以此結果輔助辨識地質材料，將其放入 FEFLOW 數值模式，設定流場基本參數，以現地試驗量化含水層之地下水通量，推估可利用淡水資源總量。利用熱示蹤劑加熱試驗，針對井內垂直溫度分布進行高解析連續量測，利用地下水溫度變化、熱傳導係數與體積熱容量等參數，推估地下水通量並與現地鑽探岩心進行比對，評估地質分層及透水特徵區域。數值模式採用 FEFLOW 建立模型，以現地觀測水位、溫度、水文地質參數、熱傳導係數以及潮汐週期等邊界條件，建立之地下水流場分布概念模式。經加熱試驗之井內垂直溫度變化結果顯示，井深約 20-25M 區段熱傳導性較差，加熱時溫度上升相對顯著，而井深約 40M 處無顯著溫度上升，推估該處熱傳導性相較佳，並對應其岩心材料驗證結果，然而利用數值模式估算地下水通量並驗證與現地試驗相似，且大致符合材質透水性良好區段，可進一步探討沿海含水層海淡水交互作用與地下水抽取量之關係，提出適用於本區域地下水資源管理之參考根據，以實現永續發展管理之目的。

關鍵詞：熱示蹤劑試驗、地下水通量、地下水資源管理。

Analysis of groundwater flow of coastal aquifer in Taoyuan area by combing heat Tracer test and numerical model

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Abstract

The increase in global water consumption is mainly owing to urbanization, growing agricultural activities, population growth, economic development, and improving living standards. Forcing the water resource authority concerned to seek new water resources to catch up with the gap of growing demand. Groundwater recharged from coastal aquifers to the ocean is a potential alternative water resource have drawn more attention in recent years. To use this resource more efficiently, a systematically assess of the groundwater system is necessary to prevent further influence on the groundwater system and proposed groundwater resources management strategy for this region to achieve sustainable development of groundwater management. In this study, we aim to quantify the groundwater flux in coastal areas and response to the groundwater extraction operation. The heat tracer method was applied to estimate groundwater flux by using the DTS system to acquire high-resolution temperature variation of the aquifer system. The parameters such as hydraulic conductivity and thermal conductivity are obtained through laboratory test. The vertical temperature variation in the borehole shows that the temperature piles up rapidly at 20-25M which indicates the heat transfer is poor in this section, but at the 40M section, the temperature does not significantly increase. These results indicate that the heat transfer of the well are highly influence by the flow condition. The FEFLOW model was selected to conduct the simulation, and the model is calibrated and validated based on the long-term observation of water level, hydrogeological parameters, temperature field, thermal conductivity, and tidal cycle. The model will utilize to analyze the groundwater flow conditions of the aquifer under different pumping strategies and the relationship between seawater and freshwater in the coastal aquifer.

Keyword: Heat tracer test, Groundwater flux, Groundwater resource management.