# Water table response to rainfall and groundwater simulation using physics-based numerical model: WASH123D

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## Abstract

Due to the uneven distribution of rainfall throughout the year (69% occurs from May to October) and the current situation of excessive groundwater pumping, land subsidence has occurred in southern Taiwan. Therefore, this study aims to calculate recharge from rainfall and determine the recharge potential for shallow aquifers in a sub-region of Kaohsiung City, Taiwan.

Long-term monitoring data (2001-2019) from 13 observation wells and 16 rainfall stations were analyzed to estimate hydraulic parameters. Regression analysis established strong linear relationships ($R^2$ = 0.83-0.96) between associated rainfall events and water table responses. Specific yield values, calculated as the inverse of regression slopes, ranged from 0.20-0.51, while hydraulic conductivity parameters derived from master recession curve analysis using the Rorabaugh equation fell within $10^{-4}$-$10^{-5}$ m/s for alluvial materials. The Water Table Fluctuation method used specific yield and drainage rate to calculate annual recharge rates of 244-1472 mm/year. The hydraulic parameters were calculated for the unconfined aquifer, combined with reference hydraulic parameters for the confined aquifer and hydrogeological unit data, were incorporated into a WASH123D model with coupled 2D surface and 3D subsurface components. This model demonstrated good performance (NSE > 0.96) when simulating real-time groundwater level responses to both rainfall and the operation of 63 pumping wells.

By simulating groundwater table responses to rainfall and pumping in complex settings, this study successfully quantifies pumping impacts on groundwater systems.

**Keywords:** Groundwater recharge, Recession analysis, WASH123D.

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# Water table response to rainfall and groundwater simulation using physics-based numerical model: WASH123D

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ABSTRACT

*Study region:* Four districts (Meinong, Qishan, Dashu, and Daliao) of Kaohsiung city, Southern Taiwan

*Study focus:* The understanding of aquifer recharge in terms of water table response to rainfall is of critical importance to groundwater systems management and various endeavors have been made to estimate the amount of recharge using rainfall data. The purpose of this study is to evaluate the groundwater level response to rainfall and determine the recharge potential for shallow aquifers. We showed a simple approach to estimate specific yield ($S_y$) and hydraulic conductivity ($k$) as functions of rainfall and water level data.

*New hydrological insights for the region:* Correlation method is applied to investigate groundwater level response to associated rainfall and it was found that the rise in water table linearly depends on the rainfall amount per event. Results show the annual recharge rates of 244–1472 mm year$^{-1}$, which represent 12–43% of rainfall in the study area. The estimated $k$ (order of $10^{-4}$ to $10^{-5}$ m s$^{-1}$) and $S_y$ (0.20–0.51) were used as prior values to setup groundwater numerical modeling using WASH123D. The real-time case scenario simulation using pumping and rainfall data indicated the reasonable hydrological response of groundwater levels to rainfall. The long-term simulations should be performed with WASH123D to deal with the subjectivity of sustained groundwater pumping and sustainability of aquifers for better groundwater resource planning and management.