Modelling groundwater recharge in a dual media aquifer system

Tlotliso Nape

Institute for Groundwater Studies, University of the Free State, Bloemfontein, 9301, South Africa

t12nape@gmail.com

The decline in the global groundwater table and increased stress on groundwater resources calls for greater investigation of its replenishment. Groundwater recharge models are important tools for managing the resources at quaternary catchments. Understanding the geological setting of the area is also an important consideration before every intervention is made in terms of studies. The focus of this research was to model groundwater recharge in a dual-layered and shallow unconfined aquifer where the top homogenous layer is underlain by a non-homogeneous formation. The lower layer was assumed to be characterized by non-Darcian flow, with a combination of matrix flow and fracture flow. The top layer is characterized by highly porous and uniformly distributed permeability factors. This geological arrangement is normally found in where Calcretes have formed. In this study, we consider the EARTH model as our governing equation. In this study, we solve the model analytically using the classical derivative in the bottom layer and numerically via integral approximation with the Caputo and Atangana-Baleauno fractional derivative. The first approach includes obtaining an exact solution to the last module of the EARTH model then by applying the Laplace and inverse Laplace transform. The Caputo and the Atangana-Baleanu derivatives were applied, and the numerical solutions were obtained for each operator. Due to their memory formalism, fractional derivatives can capture memory-dependent processes and the effects of formation heterogeneity. Our findings indicate that both operators are a long tail exponential growth for the upper layer. An early critical time is identified, and both derivatives predict a crossover behavior. Caputo does not capture alpha-to-alpha cross-over at early times like ABC. Thus, the nature of being scale invariant applies. It was determined that the notion of fractional differentiation, in conjunction with the generalized Mittag-Leffler law, provides a clear description of groundwater recharge within a heterogeneous and homogeneous geological formation. This study is of vital importance to understand the inflow of recharge by the behavior of the water table. Furthermore, if recharge behavior in both homogeneous and heterogeneous spaces is understood, then it is easier also to understand the spread of dissolved contaminates in aquifer systems.