Mathematical Model for Conversion of Groundwater Flow from Confined to Unconfined Aquifers with Power Law Processes

Makosha Morakaladi
Institute for Groundwater Studies, University of the Free State, Bloemfontein, 9301, South Africa
Makoshamorakaladi@gmail.com

In this work, we propose a mathematical model to depict the conversion of groundwater flow from confined to unconfined aquifers. The conversion problem occurs due to the heavy pumping of confined aquifers over time, which later leads to the depletion of an aquifer system. The phenomenon is an interesting one, hence several models have been developed and used to capture the process. However, one can point out that the model has limitations, as it cannot capture the effect of fractures in the aquitard. Therefore, we suggest a mathematical model where the classical differential operator that is based on the rate of change is substituted by a non-conventional one including the differential operator that can represent processes following the power law to capture the memory effect. Moreover, we revise the properties of the aquitard to evaluate and capture the behaviours of flow during the process in a different aquitard setting. The figures obtained show an indication of long-tailed behaviours for the confined system, whereas, for the unconfined system, there is a crossover behaviour from a fast to a slow decline in the water level. The results obtained will help depict complex problems that produce a long-range behaviour of flow in fractures and give details of flow properties. Moreover, it will produce mean square displacement property to depict the conversion of the flow process. In conclusion, the presence of fractures in a geological formation raises an element of uncertainties and heterogeneity. To protect an aquifer during this transition, it can be recommended to implement regular monitoring of groundwater levels and quality, manage recharge zones, regulate water extraction, enhance aquifer protection of infrastructure and engage stakeholders, as well as put in more research into aquifer dynamics and management strategies to better understand and mitigate the impacts of aquifer transitions.