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Can the Dupuit-Thiem equation accurately describe the flow pattern induced by injection in a laboratory scale aquifer-well system?

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The Dupuit-Thiem equation is normally used to assess flow towards a pumping well in unconfined aquifers under steady-state conditions. For the formulation of the equation it is assumed that flow is laminar, radial and horizontal towards the well. It is well known that these assumptions are not met in the vicinity of the well; some authors restrict the application of the equation only to a radius larger than 1.5-fold the aquifer thickness. In this study, the equation accuracy to predict the pressure head is evaluated as a simple and quick analytical method to describe the flow pattern for different injection rates in the LSAW.

A laboratory scale aquifer-well system (LSAW) was implemented to study the aquifer recharge through wells. The LSAW consists of a 1.0 m-diameter tank with a height of 1.1 meters, filled with sand and a screened well in the center with a diameter of 0.025 m. A regulated outflow system establishes a controlled water level at the tank wall to simulate various aquifer thicknesses. The pressure head at the bottom of the tank along one axis can be measured to assess the flow profile every 0.1 m between the well and the tank wall.

In order to evaluate the accuracy of the Dupuit-Thiem equation, a combination of different injection rates and aquifer thicknesses were simulated in the LSAW. Contrary to what was expected (significant differences between the measured and calculated pressure heads in the well), the absolute difference between the calculated and measured pressure head is less than 10%. Beside this, the highest differences are not observed in the well itself, but in the near proximity of it, at a radius of 0.1 m. The results further show that the difference between the calculated and measured pressure heads tends to decrease with higher flow rates. Despite its limitations (assumption of laminar and horizontal flow throughout the whole aquifer), the Dupuit-Thiem equation is considered to accurately represent the flow system in the LSAW.