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A Laboratory Scale Aquifer-Well System for Analyzing Near-well Processes

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Managed Aquifer Recharge (MAR) is constantly gaining popularity and one very promising technique in this context is infiltration by vertical wells. However, the near-well surrounding of these wells is still object of many open questions, related to – among others – clogging, screen design and the effects of underground heterogeneities. As a tool for a better understanding of these processes, a physical laboratory-scale aquifer-well model was designed.
The physical model was assembled in a cylindrical tank with a height of 1.1 m and a diameter of 1 m. Water can be introduced via a small-diameter well screen (inner diameter: 2.54 cm) in the center of the tank and leaves the system via side outlets. These outlets were connected hydraulically to a single outflow system, allowing the adjustment of the same outflow head for all side outlets. Furthermore, a drainage system was attached to the tank's wall to assure circular flow from the well to the wall.
The drainage system was chosen after preliminary tests of different drainage materials to determine the best performing setup. Remaining impoundment heights of up to 30 cm were observed in the tank, due to pressure losses at the outflow system.
To include the resulting impoundment into a numerical model using Hydrus 2D/3D, a half-empirical formula was derived, plotting impoundment heights against infiltration rates and considering the pressure losses in the outflow system as well as in the drainage layer. Using the predicted impoundment heights for correction, the numerical model allowed satisfying simulation of the flow pattern in the tank for infiltration rates.
The study shows how to develop an approach combining numerical and physical modeling as a base for future investigation of near-well processes under well-defined laboratory conditions.