Dynamics of an unconfined aquifer

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Abstract

Rainwater infiltrates into the ground to join a groundwater reservoir, where it flows slowly towards a river. We use a tank filled with glass beads to simulate this process in a simplified laboratory experiment. A sprinkler pipe simulates rain, which infiltrates into the porous material. Groundwater exits this laboratory aquifer through one side of the tank. The resulting water discharge increases rapidly during rainfall, and decays slowly after the rain has stopped.

A theory based on Darcy's law and the shallow water approximation reveals two asymptotic regimes. At the beginning of a rain event, the water discharge increases linearly with time, with a slope proportional to the rainfall rate at the power of 3/2. Long after the rain has stopped, it decreases as the inverse time squared, as predicted by Polubarinova-Kochina (1962). These predictions compare well against our experimental data.

These asymptotic regimes depend on the geometric configuration of the flow. However, field measurements from two distinct catchments exhibit the same asymptotic behaviours as our experiment. This observation suggests that these results could be extended to a broader class of groundwater flows.