Benny Selle, K. Rink, and O. Kolditz

Recharge and discharge controls on groundwater travel times and flow paths to production wells for the Ammer catchment in south-western Germany.

Travel time and flow paths of groundwater from its recharge area to drinking-water production wells will govern how the quality of pumped groundwater responds to contamination. Here we studied the 180 km² Ammer catchment in south-western Germany, which is extensively used for groundwater production from a limestone aquifer. Using a 3-D steady-state groundwater model, four alternative representations of discharge and recharge were systematically explored to understand their impact on groundwater travel times and flow paths. More specifically, two recharge maps obtained from different German hydrologic atlases and two plausible alternative discharge scenarios, i.e. (a) groundwater flow across the entire streambed of the Ammer River and its main tributaries and (b) groundwater discharge via a few major springs feeding the Ammer River, were tested. For each of these scenarios, the groundwater model was first calibrated against water levels; and subsequently travel times and flow paths were calculated for production wells using particle tracking methods. These computed travel times and flow paths were indirectly evaluated using additional data from the wells including measured concentrations on major ions and environmental tracers indicating groundwater age. Different recharge scenarios resulted in a comparable fit to observed water levels, and similar estimates of hydraulic conductivity, flow paths and travel times of groundwater to production wells. Travel times calculated for all scenarios had a plausible order of magnitude which was comparable to apparent groundwater ages modelled using environmental tracers. Scenario with groundwater discharge across the entire streambed of the Ammer River and its tributaries resulted in a better fit to water levels than scenario with discharge at a few springs only. In spite of the poorer fit to water levels, flow paths of groundwater from the latter scenario were more plausible which was supported by the observed major ion chemistry at the production wells. We concluded that data commonly used in groundwater modelling such as water levels and apparent groundwater ages may be insufficient to reliably delineate capture zones of wells. Hydrogeochemical information relating only indirectly to groundwater flow such as the major ion chemistry of water sampled at the wells can substantially improve our understanding of source areas of recharge for production wells.