Regional groundwater flow and karst evolution-theoretical approach and example from Switzerland

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In regional scale aquifers in the Rhine Valley and Tabular Jura east of Basel (Switzerland), the groundwater circulation was investigated using regional-scale geological and hydraulic 3D models. The main aquifers in the area comprise the Quaternary aquifer of unconsolidated gravel deposits along the River Rhine and its tributaries, as well as the regional scale karst aquifer within the Upper Muschelkalk. Land subsidence, a process likely associated with salt solution mining, indicates further subordinate groundwater bearing segments and complex groundwater interactions along fault zones. In the aquifer systems we investigated, regional-scale groundwater circulation was simulated and visualized in relation to the geological settings. Lithostratigraphic units and fault structures were parameterized and analyzed, including the sensitivity of hydraulic properties and boundaries. Scenario calculations were used to investigate the sensitivity that the aquifer systems had to hydraulic parameter changes during Quaternary aggradation and degradation in the main valley. Those calculations were also done for base-level changes in the Rivers Rhine and Birs. For this purpose, this study considered probable historic base-levels before river regulation occurred, and before river dams and power plants were constructed. We also focused on scenarios considering increased groundwater recharge rates, e.g. due to exceptional long-lasting precipitation, or heavy rainfall events in the catchment area. Our results indicate that increased groundwater recharge rates in the catchment areas during such events (or periods) are associated with orders of magnitude increases of regional inflow into the Upper Muschelkalk karst aquifer. Furthermore, the groundwater fluctuations and groundwater saturated regions within the karst aquifer shift to places where high densities of sinkholes are documented. When the surface water base-levels adapt to probable historic levels, it leads to increased hydraulic gradients (i.e. local lowering of the groundwater level by up to 7 m). Those increased gradients are associated with increased groundwater flow within some aquifer regions that are particularly prone to karst development.

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