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Groundwater Residence Times: A Key Parameter for Investigating Effects of River Restoration on Riverbank Filtration

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Many Swiss municipal pumping wells, located near the banks of a losing river, are designed to capture a mixture of freshly infiltrated river water and old alluvial groundwater. Riverbank filtration is assumed to substantially reduce concentrations of pathogens, pesticides, and organic pollutants relative to the river water. Although the number of river restoration projects increases, the effects of river restoration on riverbank filtration are still not well understood. River restoration includes widening of the riverbed and removal of bank armoring in order to establish a more natural sediment transport regime and give the river more space. These measures improve ecological habitat diversity and contribute to flood protection. However, they may cause conflicts with groundwater abstraction for drinking water, because travel times from rivers to pumping stations may be significantly reduced. In Switzerland the minimum mean travel time required for the protection of a drinking-water well is 10 days. Thus, for detailed investigation on river water infiltration into the aquifer, the distribution of groundwater travel times from rivers to observation and production wells and mixing ratios of freshly infiltrated and older alluvial groundwater are key parameters.

Due to the high hydraulic conductivity of most Swiss prealpine gravel aquifers, the residence time of water entering many pumping wells is the range of weeks. Therefore, special methods are needed to assess residence times of young groundwater. We analyze time series of electrical conductivity in the river and adjacent groundwater observation wells to investigate travel times of young hyporheic groundwater in adjoining channelized and restored sections of the River Thur in North-East Switzerland. The test site has been established by the RECORD Project (Assessment and Modeling of Coupled Ecological and Hydrological Dynamics in the Restored Corridor of a River (Restored Corridor Dynamics)). To quantify residence times and mixing ratios we perform cross-correlation analysis and non-parametric deconvolution of the electrical conductivity time series. Measurements of radon-222 in the groundwater samples validate the calculated residence times. Our results show no clogging effects of the riverbed. Moreover, no relationship between travel time and distance to the river has been observed. Therefore, we speculate that the lateral position and depth of the thalweg as well as the type of bank stabilization might control the infiltration processes in losing rivers. The presented approach is suitable for assessing the effects of restoration projects and other hydraulic projects (e.g. construction of dams) on riverbank filtration. A particular benefit originates from such studies, if data before and after the restoration exist.