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Estimating groundwater residence times by graphical analysis of conductivity time series in the Thur valley, Switzerland

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The aims of river restoration projects often contradict the interests of water suppliers operating groundwater pumping stations near the river. In Switzerland, the residence time of the groundwater used for drinking water supply is prescribed to exceed ten days to assure hygiene standards. This implies that the youngest groundwater component, i.e. the water infiltrating from the river, represents the largest hygienic risk. The residence time of this component is therefore of particular interest in order to evaluate the risks of drinking water contamination as a result of river restoration.

To assess groundwater residence times, a number of environmental tracers are available today. However, in groundwater where water components of different ages are mixed, the water residence times inferred from these tracers are dominated by the older components, and are thus not appropriate to assess the hygienic risks associated with the presence of young groundwater components. While the use of artificially injected tracers can help to overcome this problem, all these methods relying on chemical tracers require large expenses for sampling and analysis.

In many cases, however, time information already is available from previous long-term investigations of electric conductivity. Graphical analyses of such time series can yield valuable information on the groundwater dynamics. We correlated time series of conductivity in the river with respective time series in the groundwater. From the resulting diagrams, the travel time of the infiltrating river water to the pumping well can be inferred.

In our study site (Thur valley, Switzerland), river Thur is planned to be restored. Electrical conductivity time series of composite samples in the river and 11 groundwater samples were acquired during routine monitoring of the aquifer. Based on this data set, our method allowed the travel time of the water infiltrating from the river to be estimated to 20$\pm$10 days. In addition, high-resolution time series of conductivity were acquired (hourly values during 10 months). The travel times resulting from this data set were 34$\pm$12 and 16$\pm$5 days, depending on the weighting of short-term fluctuations in the river-water conductivity.

This simple method has the potential to help deciding already in the planning stage of restoration projects if the application of sophisticated tracer methods is needed, and which tracers are most suitable to study the local groundwater dynamics. This allows for a sustainable use of analytical and financial resources.