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Reactive transport modelling of the fate of organic micropollutants during bank filtration accounting for seasonal temperature changes and redox zonation

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Organic micropollutants are frequently detected in rivers and the adjacent groundwater, especially in effluent impacted streams, for example when receiving relatively large amounts of effluents from sewage treatment plants or urban areas in general. However, surface water is often used indirectly for drinking water production via bank filtration. Bank filtration typically leads to an improved quality of the infiltrate due to filtration and biodegradation, but estimates of in-situ degradation rates especially in dependence of subsurface temperature patterns and redox zonation are still rare.

In this study we developed a two-dimensional cross-sectional reactive transport model to simulate the temporal and spatial variations of temperature, redox species as well as selected pharmaceuticals during bank filtration at a study site downstream of the city of Berlin. The model was implemented in ORTI3D, a 3D interface for MODFLOW and the reactive multicomponent transport code PHT3D. The 160 m long transect and the corresponding hydraulic and thermal boundary conditions were extracted from a calibrated, larger-scale three-dimensional flow model following a flow path from the river towards a drinking water production well. Water levels, temperatures and concentrations of redox species and pharmaceuticals had been measured in observation wells nearby the chosen transect every four weeks over a time period of two years.

The calibrated 2D model shows a good agreement between measured and modeled temperature data providing an accurate representation of the hydro-thermal system. Observed concentrations and underlying degradation behavior of the investigated micropollutants indicated a strong dependence on the redox zonation and on seasonal temperature variations and thus accurate, site specific estimates of the temperature dependent reaction rates were needed to achieve a good agreement between measured and simulated concentrations. This study reveals in-situ degradation rates of redox sensitive species and common micropollutants and emphasizes the relevance of temperature dependent reactive processes during river bank filtration as factor substantially contributing to the attenuation and degradation of surface water constituents.