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Pharmaceutical residues in rivers: Quantification of transient storage and travel times by tracer experiments as key parameters for the determination of mass balances

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Pharmaceutical residues are commonly detected micropollutants in the aquatic environment. To derive mass balances of these substances in river stretches and to quantify their elimination, besides highly sophisticated analytical methods precise discharge measurements are inevitable. Two additional key parameters are the travel time of water along a river stretch and the hyporheic exchange of water and solutes. Knowledge of travel times is essential to compare concentrations at the upstream and downstream end of an investigated site. As biodegradation in sediments is assumed to be a potentially significant removal process for organic micropollutants in rivers, flow of water and solutes across the sediment-water boundary and their transient storage in the hyporheic zone are also pivotal processes.

To determine these river characteristics, tracer experiments using the fluorescent dye uranine were conducted at a 15 km stretch of a small river in Northern Bavaria (Roter Main) in summer 2008. Three sub-reaches were studied in separate tracer tests, and river discharge was simultaneously determined using the ultrasonic doppler technique. The travel time of uranine for the total stretch amounted to almost 1.5 days, corresponding to a mean flow velocity of about 0.4 km/h. Strong tailing of the breakthrough curves could indicate significant transient storage in the hyporheic zone. However, we tentatively attribute this tailing to the merging of two river channels having different flow characteristics and not to transient storage, and thus the hyporheic exchange is expected to be small along the river stretch. The results of the experiments are currently being analyzed by the OTIS model in order to report the exchange rates of surface and pore water on a quantitative basis.