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Characterization of solute transport properties of different types of constructed wetlands using multi-tracer data and transient storage modelling

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Constructed wetlands in agricultural headwater catchments may serve as simple treatment systems to improve retention and mitigation of agricultural non-point-source pollution. To calculate and predict retention capacities of 6 different constructed wetland systems concerning micro-pollutants, we used a one-dimensional solute transport model to compare the results of a series of multi-tracer experiments. The investigated wetland systems consisted of two surface flow wetlands with permanent through flow, two vegetated ditches, a forest buffer zone and a flood detention pond. Transport behaviour was investigated using different tracers: salt and two differently sorptive fluorescent dyes (Sulphorhodamine B and fluoresceine). The hypothesis that shallow and vegetated systems offer the highest sorption capacity for sorptive but mobile pollutants was tested applying a solute transport model to the observed tracer breakthrough.

The transport model OTIS (Runkel, 1998) which includes advection, dispersion and lateral exchange to a transient storage was optimized to observed breakthrough of applied tracers at defined cross-sections along the wetlands. Optimized model parameters include dispersivity, cross-sectional areas of both stream and transient storage, as well as an exchange coefficient. Sorption was included based on the KD value, mass of accessible sediment and a sorption coefficient. We assumed that each measurable cross-section is a combination of dead zones and flowing parts. For three of the wetland systems we could exclude lateral in- and outflows. For the other systems, a quantification of lateral flows was possible. We used the set of conservative tracer data to calculate conservative transport characteristics and cross-sections. Then we applied the calibrated model on the sorptive tracer data only using sorption capacity in the storage zone as a calibration parameter and observed KD values and mass of accessible sediment. The results for the different tracer experiments show that the chosen model is capable of reproducing the observed breakthrough of conservative and non-conservative tracers in a satisfactorily manner. As expected, shallow and vegetated systems offer the highest sorption capacity for sorptive pollutants. The approach can be used to predict solute transport within wetland systems and to design the optimal flow length for a specific wetland system, which may serve as a retention measure to mitigate agricultural non-point source pollution.