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Spatial and temporal water quality dynamics during baseflow in an agricultural headwater catchment

Tobias Schuetz, Markus Weiler, and Manuel Saroos
University of Freiburg, Institute of Hydrology, Faculty of Forest and Environmental Sciences, Freiburg, Germany (tobias.schuetz@hydrology.uni-freiburg.de, 0049 761 2033594)

Understanding the interaction of time variant source areas and biogeochemical in-stream processes and the determination of resulting spatial and temporal signatures of stream water composition will improve the prediction and management of water quality at the catchment scale. During baseflow periods runoff source areas can change over time depending e.g. on storage depletion rates, actual wetness, groundwater level or local evapotranspiration rates. Due to the resulting space/time variant water fluxes, these effects are also expressed in the physico-chemical composition of surface waters. Unfortunately the resulting signature is often overlain by biogeochemical in-stream processes, which make it difficult to identify physico-chemical signatures of specific runoff source areas. We studied these interactions in a 1.7 km^2 agricultural headwater catchment. A dense artificial drainage network and a predominantly impervious streambed allowed for detecting distinct locations of groundwater inflow and determining ongoing biogeochemical in-stream processes. The analysis of sub-catchment storage depletion and resulting time variant quantitative and qualitative impacts on stream water composition was based on observations made during 11 catchment wide synoptic sampling campaigns during the summer baseflow period. We measured stream discharges with salt dilution gauging as well as water temperatures (T) and electrical conductivity (EC) upstream, downstream and inside all active drain pipes. During two campaigns we took additional water samples for major ion analysis at all sampling points. Discharges, T and EC stream-network data sets were used to spatially determine groundwater contributions using mixing equations for 2 and 3 components, respectively. Thereby we derived local baseflow recessions in relation to the catchment wide stream discharge. Using a water balance approach we determined active runoff source areas for each drain pipe and identified the dominant land use. In a 110 m stream reach without detectable groundwater inflows biogeochemical in-stream processes were studied with a focus on nitrate transport and uptake kinetics. Air temperatures, incoming radiation, discharges, T and EC data were analysed and a kinetic first-order uptake model was applied to explain regularly measured reach scale nitrate data sets. Resulting process rates and drivers allowed the up-scaling of in-stream nitrate-uptake processes to the whole stream network. Due to the spatially explicit baseflow contributions we used the snap shots of stream and drainage network major ion/ nitrate composition and the kinetic first-order uptake model to simulate the space/time variant impact of sub-catchments on catchment nitrate export. Thus we could distinguish between conservative mixing and dilution processes and biogeochemical in-stream processes on the network scale. Considering these findings, we could draw a comprehensive picture how the transition of dominant runoff source areas and their dynamic impact on observable spatio-temporal variations of nitrate loadings is functioning in the study catchment.