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Direct measurements of in-stream nitrate uptake with automated high frequency sensors

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Decades of nutrient studies have unveiled the importance of river networks in nutrient cycling. Still, direct methods to quantify instream removal in defined reaches have so far been limited to small streams. In rivers, where isotope tracer additions have been impracticable, uptake rates could only very rarely be measured and therefore have been mostly modelled by upscaling.

Recently, the expanding availability of high resolution stream solute signals from automated sensors offers new possibilities for uptake kinetic studies. Cohen et al (2012) assessed assimilation and denitrification rates based on daily nitrate amplitudes and longitudinal concentration gradients in spring- fed chemostatic rivers.
In higher order streams, overlapping of network, onsite and upstream signals require additional conceptual and methodological adaptation.

Here we present a new combined longitudinal lagrangian and mass balance approach with continuous measurements of nitrate uptake rates in the German lowland river Weiße Elster, to our knowledge the first direct measurement of nitrate kinetics with continues high frequency sensors. We used 10 minutes time step NO_3-N, pH, specific conductivity, dissolved oxygen, temperature and chlorophyl-a measurements and supplementing low frequency 15N isotope manual sampling. Longitudinal lagrangian measurements were conducted during day and night.

Our data from two morphologically highly contrasting reaches indicate that local, seasonal or even day to day changes in uptake kinetics can be of several orders of magnitude and that the disregard of intermediate storage and dispersion can lead to high errors. The natural river reach revealed considerably higher N uptake than the channelized river reach. Furthermore, river bottom related N-uptake rates were in the same order than those found in agricultural head water streams.

Besides depicting prospects and limits, we also provide important considerations for the set-up of measurement stations and for the interpretation of stream solute data.