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Quantifying nitrate and oxygen reduction rates in the hyporheic zone using 222Rn to upscale biogeochemical turnover in rivers

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Quantifying and upscaling chemical turnover in the hyporheic zone (HZ) is difficult due to limited reaction rate data, unknown site specific characteristics, and few methods for upscaling local measurements to river networks. Here we present a method for quantifying reaction kinetics in-situ in the HZ and upscaling biogeochemical turnover to catchment scales. Radon-222 was used to quantify water residence times in the HZ of the Roter Main River (RM), Germany. Residence times were then combined with O_2, NO_3-, CO_2, DOC and carbon quality (EEMs, SUVA) data to estimate Monod and first-order reaction rates. Carbon quality was highly bioavailable in the HZ and is unlikely to be limiting. Reaction kinetics were incorporated into the FINIFLUX model to upscale NO_3- mass loss over a 32 km reach of the RM. The aim was to (1) estimate hyporheic efficiency in terms of nitrate turnover, and (2) calculate nitrate- mass loss in the HZ over at the reach scale. Damköhler analysis, based on characteristic transport and reaction times, suggests that the hyporheic zone is inefficient for nitrate processing, however this is somewhat misleading as the largest NO_3- mass loss occurs at the shortest residence times where Da«1. This is due to the largest water flux occurring in the uppermost part of the sediment profile. Total nitrate processing in the HZ for the 32 km reach accounted for 24 kg nitrate per hour, which was 20 % of the nitrate flux from the catchment.