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Spatial and temporal variability of nitrate sinks and sources in riparian soils of a restored reach of an Alpine river

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In order to assess the effects of river restoration on water quality, the biogeochemical functions of restored river reaches have to be quantified. Of particular interest is the ability of riparian functional processing zones (FPZ) to remove nitrate from infiltrating river water or agricultural runoff. Processes involved are removal of nitrate by denitrification and immobilisation of nitrogen in plant or microbial biomass. On the other hand, mineralisation followed by nitrification can lead to an increase in leachable nitrate. The latter process is fueled by the frequent input of fresh dissolved or particle bound organic matter, characteristic for temporarily flooded riparian zones. The objective of this study was to characterize the spatial and temporal variability of nitrate concentrations in the soil solution of a restored reach of the Alpine river Thur in northeastern Switzerland. The study was part of the interdisciplinary project cluster RECORD, which was initiated to advance the mechanistic understanding of coupled hydrological and ecological processes in river corridors.

The studied river reach comprised the following three FPZ representing a lateral successional gradient with decreasing hydrological connectivity (i.e. decreasing flooding frequency and duration). (i) The grass zone developed naturally on a gravel bar after restoration of the channelized river section (mainly colonized by canary reed grass Phalaris arundinacae). The soil is composed of up to 80 cm thick fresh sediments trapped and stabilized by the grass roots. (ii) The bush zone is composed of young willow trees (Salix viminalis) planted during restoration to stabilize older overbank deposits. (iii) The mixed forest is a mature riparian hardwood forest developed on older overbank sediments with ash and maple as dominant trees.

The study period was between summer 2008 and winter 2009/2010 including three flood events in August 2008, June 2009 and July 2009. The second flood inundated the grass zone and lower part of the bush zone while the first and third floods were bigger and swept through all the FPZs. Soil solution was sampled periodically using suction cups installed at several soil depths and operated at a constant vacuum. There were six spatial replicates for each FPZ and depth.

Overall there was high spatial and temporal variability of leachable nitrate. The local history of environmental conditions was as important as the characteristic behavior of a given FPZ. While the subsoil of the grass zone and the mixed forest often acted as nitrate source when compared to river and groundwater, the bush zone was generally characterized by low nitrate concentrations. The latter were attributed to strong uptake by willow and the occurrence of denitrification hot spots in the subsoil. In the topsoil of all FPZ, however, locally very high nitrate concentrations occurred for short periods after major floods. In this presentation we will relate the variability of nitrate concentrations to (i) groundwater level, (ii) soil environmental parameters, chiefly moisture and temperature, (iii) concentration of related substances in soil solution, (iv) chemical, physical and biological properties of the soil solid phase, and (v) rates of biological nitrogen transformations including nitrification, denitrification and plant uptake.