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Characterizing denitrification in the aquifer and transit times based on spatially-distributed measurements in streams

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Human activity has more than doubled reactive nitrogen delivery to Earth's ecosystems. In the past several decades, efforts have been made to reduce agricultural inputs of nitrogen, but the decrease of the nitrate concentration in rivers is also controlled by natural processes, especially by flow and denitrification in the aquifer. Yet, with current knowledge, it remains difficult to characterize transit times and groundwater denitrification rates at scales relevant for mitigation actions (catchment scale to regional scale).

Data directly obtained in piezometers generally display large variabilities without any obvious correlation to any landscape, geological or geomorphological characteristics. Here we propose an alternative method based on in-stream measurements to get a representative view of the role of the aquifer in the temporary storage and degradation of nitrates. We performed spatially-distributed measurements in low-order streams within a 35 km2 agricultural catchment underlain by a crystalline, fractured bedrock aquifer. Measurements were performed during low-flow. Stream discharge and radon activity were used to determine the groundwater discharge into the streams. Silica was used as an age-tracer [1]. Nitrate concentrations and isotopic ratios allowed to characterize the denitrification in the aquifer.

Results show that in-stream measurements provide a representative view of transport and denitrification in the aquifer. They highlight that the scale of homogenization is larger than the studied catchment, and reveal an unexpected correlation between the mean residence time and the characteristic denitrification time. This allows to hypothesize a common control on residence time and denitrification in the aquifer, that could be exercised by the depth of the weathered zone. Unraveling such a correlation could be a first step towards a global characterization of aquifer processes through geophysical imagery methods.

[1] Marcais, J., et al. 2018. Dating groundwater with dissolved silica and CFC concentrations in crystalline aquifers. STOTEN.