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# Tracking groundwater signature in the stream to characterize flow and denitrification in the aquifer

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Predicting the evolution of nitrate pollution at the catchment scale implies a global evaluation of residence times and denitrification rates in the aquifer. Data acquired in wells only result from processes occurring in their capture zone and are rarely representative of the whole aquifer [1]. Stream data, on the opposite, integrate the processes occurring along all contributing groundwater flowpaths and thus could be more relevant for upscaling. But stream signal is also controlled by soil, hyporheic zone and in-stream processes. Here we investigate the possibility of extracting groundwater signature from such a complex stream signal.

In-stream spatially-distributed measurements were performed during low flow over a 35 km2 crystalline agricultural catchment in Brittany, Western France. Groundwater inputs into the streams were localized and quantified using radon mass balance. In conjunction with radon, dissolved gases ($O_2$, $CO_2$, N2, N2O, CH4, Ar), wet chemistry and nitrate isotopes were measured at each site. Quantification of in-stream processes was further realized by performing tracer injections in three selected reaches. Injections were coupled with continuous in-situ measurement of dissolved gases using membrane inlet mass spectrometry (MIMS). Helium injections allowed to calculate gas exchange rates, while nutrient injections (acetate, nitrate) allowed to characterize in-stream biological activity (oxygenic respiration, denitrification).

Radon mapping reveals a high localization degree of groundwater inputs into the streams. Groundwater-surface water exchanges are strongly concentrated after a major topographic slope that separates two geological units, showing that geomorphology is a major control of hydrogeological circulations. These results are consistent with a 3D-groundwater flow model of the catchment calibrated with age tracer data acquired in wells [1]. Close to groundwater input zones, stream chemistry is strongly impacted by groundwater signature. Helium and nutrient injections evidence that gas exchanges between stream and atmosphere constitute the main eraser of groundwater signature as water is flowing dowstream. Groundwater signature is lost specifically at highly turbulent sites, such as small cascades, where measured gas exchange rates are one to two orders of magnitude higher than in calm reaches.

[1] Kolbe, T., J. Marcais, Z. Thomas, B. W. Abbott, J. R. de Dreuzy, P. Rousseau-Gueutin, L. Aquilina, T. Labasque & G. Pinay, 2016. Coupling 3D groundwater modeling with CFC-based age dating to classify local groundwater circulation in an unconfined crystalline aquifer. Journal of Hydrology 543:31-46 doi:10.1016/j.jhydrol.2016.05.020.