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Continuous monitoring of dissolved gases with membrane inlet mass spectrometry to fingerprint river biochemical activity

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Water quality in rivers results from biogeochemical processes in contributing hydrological compartments (soils, aquifers, hyporheic and riparian zones) and biochemical activity in the river network itself. Consequently, chemical fluxes fluctuate on multiple spatial and temporal scales, leading eventually to complex concentration signals in rivers. We characterized these fluctuations with innovative continuous monitoring of dissolved gases, to quantify transport and reaction processes occurring in different hydrological compartments.
We performed stream-scale experiments in two headwater streams in Brittany, France. Factorial injections of inorganic nitrogen ($NH4NO_3$), inorganic phosphate (P2O5) and multiple sources of labile carbon (acetate, tryptophan) were implemented in the two streams. We used a new field application of membrane inlet mass spectrometry to continuously monitor dissolved gases for multiple day-night periods (Chatton et al., 2016). Quantified gases included He, O_2, N2, CO_2, CH4, N2O, and 15N of dissolved N2 and N2O. We calibrated and assessed the methodology with well-established complementary techniques including gas chromatography and high-frequency water quality sensors. Wet chemistry and radon analysis complemented the study.
The analyses provided several methodological and ecological insights and demonstrated that high frequency variations linked to background noise can be efficiently determined and filtered to derive effective fluxes. From a more fundamental point of view, the tested stream segments were fully characterized with extensive sampling of riverbeds and laboratory experiments, allowing scaling of point-level microbial and invertebrate diversity and activity on in-stream processing. This innovative technology allows fully-controlled in-situ experiments providing rich information with a high signal to noise ratio. We present the integrated nutrient demand and uptake and discuss limiting processes and elements at the reach and catchment scales.

Eliot Chatton, Thierry Labasque, Jérôme de La Bernardie, Nicolas Guihéneuf, Olivier Bour, Luc Aquilina. 2016. Field Continuous Measurement of Dissolved Gases with a CF-MIMS: Applications to the Physics and Biogeochemistry of Groundwater Flow. Environ. Sci. Technol.