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Streambed sediment controls on hyporheic greenhouse gas production - a microcosm experiment

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Hyporheic zones, as the interfaces between groundwater and surface water, can contribute significantly to whole stream carbon respiration. The drivers and controls of rates and magnitude of hyporheic greenhouse gas (GHG) production remain poorly understood. Recent research has hypothesised that nitrous oxide emissions resulting from incomplete denitrification in nutrient rich agricultural streams may contribute substantially to GHG emissions.

This paper reports on a controlled microcosm incubation experiment that has been set up to quantify the sensitivity of hyporheic zone GHG production to temperature and nutrient concentrations. Experiments were conducted with sediment from two contrasting UK lowland rivers (sandstone and chalk). Adopting a gradient approach, sediments with different organic matter and carbon content were analysed from both rivers.

Our analytical approach integrated several novel methods, such as push-pull application of the Resazurin/Resorufin smart tracer system for estimation of sediment microbial metabolic activity, high-resolution gas sampling and analysis of methane, carbon dioxide and nitrous oxide by gas chromatography with mass spectrometry, coupled with and high precision in-situ dissolved oxygen measurements.

Our results indicate strong temperature controls of GHG production rates, overlapping with the observed impacts of different sediment types. Experimental findings indicate that increased hyporheic temperatures during increasing baseflow and drought conditions may enhance substantially sediment respiration and thus, GHG emissions from the streambed interface. The presented results integrated with field experiments of respiration and GHG emission rates under different treatments. This research advances understanding of scale dependent drivers and controls of whole stream carbon and nitrogen budgets and the role of streambed interfaces in GHG emissions.