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Using Helium as artificial tracer to characterize surface water - groundwater interactions

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Understanding surface water – groundwater interactions (SGIs) is fundamental for sustainable water management, particularly in the context of climate change and river restoration, which might affect both the quality and availability of groundwater pumped near streams. Tracer methods are particularly well-suited to the study of SGIs, as they provide information on the sources, pathways, and residence times of groundwater, even in highly complex systems. We spiked river water with the noble gas Helium (He) to characterize the infiltration of river water into an alluvial aquifer.

He was injected continuously into a Swiss pre-alpine river (river Emme, Bern) over a period of several weeks by diffusion through 800 m of gas-permeable silicone tubing, which were installed on the riverbed. He concentrations were monitored 200 m downstream from the injection point as well as in a nearby pumping well with two portable mass spectrometers, allowing quantitative determination of dissolved gas species under field conditions (miniRUEDI, gas-equilibrium membrane-inlet mass spectrometer (GEMIMS), Gasometrix GmbH, Brennwald et al., 2016). Despite relatively high river discharge rates (> 4 m^3/s), He was in general supersaturated in the river by a factor of 10 compared to natural concentrations in surface waters (ASW). He breakthrough was clearly observed in the pumping well, approximately three days after the start of the injection.

In summary, our experimental setup allows the identification of SW infiltration into an adjacent alluvial aquifer in an unambiguous and straightforward manner. The diffusion-injection system requires only moderate amounts of He, and is compatible with long-term tracer injection (weeks to months). Moreover, this method is completely safe and non-toxic, and can be implemented in a wide variety of hydrological settings with minimal regulatory constraints.

Brennwald, M. S., Schmidt, M., Oser J., Kipfer, R. (2016) A portable and autonomous mass spectrometric system for on-site environmental gas analysis. Environ. Sci. Technol., 50, 13455-13463.