unine
Université de Neuchâtel
Centre d'hydrogéologie et géothermie

MSc in Hydrogeology and Geothermics
Thesis topic proposal 2026

Identifying and testing gas species as artificial hydrogeological tracers

Context and objectives

Over the last few years, dissolved (noble) gases have emerged as promising artificial tracers in hydro(geo)logical investigations following the development and increased adoption of portable, high-resolution dissolved gas measurement technology [1]. These tracers are ideal in sensitive environments, such as rivers or drinking water wellfields, as they are inert, non-toxic and invisible. Recent methodological developments, building in large part on work carried out during previous M.Sc. projects at the CHYN, now allow these tracers to be used in large-scale, operational settings [2,3,4]. These developments have generated much interest within the groundwater community, and noble gases are increasingly being adopted as artificial tracers for routine hydrogeological investigations.

Gas tracer methods are in theory compatible with any gas species. For the time being, only certain noble gas isotopes have been employed (^{4}He, ^{20}Ne, ^{84}Kr, and $^{129/131}Xe$). Several other candidate species have been identified (e.g., H_2, light alkanes, ^{22}Ne, etc.), but their applicability has not been fully assessed (either in laboratory or field settings). Before these gas tracers are implemented in real-world hydrogeological settings, practical constraints on required gas tracer quantities, injection methodologies into groundwater, and achievable concentrations at potential observation points (i.e., constraints related to tracer test dimensioning) must be thoroughly evaluated.

Different gas tracer species can be readily assessed with existing tracer infusion, injection, and measurement protocols, which will allow efficient translation from the lab to the field. Results from this work are of great practical interest, and may lead to the rapid deployment of novel tracer methods in a range of hydrogeological settings.

Methodology

For this project, the student will systematically assess the applicability of several gas species as artificial hydro(geo)logical tracers. To do this, he or she will (1) identify possible gas species based on desired physico-chemical characteristics, (2) employ existing gas infusion/dissolved gas measurement protocols in the lab to evaluate the transferability of different gas species to larger-scale field settings, and (3) conduct gas tracer tests using candidate gas species in field conditions.

The student will employ state-of-the-art membrane and mass spectrometer technology [1,4] for dissolved gas control and analysis [1]. He or she will benefit from close collaboration with the Eawag (Dübendorf, ZH). Lab work will be carried out at the CHYN and at Eawag. Initial field testing will be carried out at the Robinson site near Neuchâtel. Based on the results, large-scale testing of selected gas species may be carried out at a drinking water wellfield in the Canton of Bern.

Supervision and collaboration

This project will be supervised by Prof. Philip Brunner (UNINE) and Dr. Morgan Peel (Eawag).

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References

[1] Brennwald., M.S. et al. (2016) *A Portable and Autonomous Mass Spectrometric System for On-Site Environmental Gas Analysis.* Env. Sci.Technol 50(24), 13455-13463.

[2] Brennwald, M.S. et al. (2022) *New Experimental Tools to Use Noble Gases as Artificial Tracers for Groundwater Flow.* Frontiers in Water 4.

[3] Blanc, T. et al (2024) *Efficient injection of gas tracers into rivers: A tool to study Surface water–Groundwater interactions*. Water Research 254(121375)

[4] Peel, M., et al. (2026) *A controlled and scalable noble gas injection method for quantitative tracer tests in hydrogeological studies*. Water Research 294(125505)