Reactive transport of dichloromethane in porous medium under dynamic hydrological conditions: from experiments to model including isotope fractionation and bacterial effects

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Reactive transport in porous medium involves complex processes relative to water (phases ?) flow, transport of elements, chemical reactions and microbial activities [1]. In surface-groundwater interfaces, the role of the capillary fringe is of particular interest. Water table variations strongly impact the transfer of gases (and especially oxygen), the evolution of redox conditions and the adaptation of bacterial populations that control biodegradation pathways of contaminants [2, 3, 4]. Although understanding of individual processes is advanced, their interactions are not yet fully understood. This challenges efficient reactive transport models for predictive applications [5]. In this context, the combination of microbial approaches with isotope measurements and modeling is a powerful strategy to better understand reactive transport of contaminants in hydrogeologically dynamic systems [6].

Dichloromethane (DCM) is a highly toxic and volatile solvent, and one of the most common groundwater contaminants [7]. Although DCM bacterial degradation under both aerobic and anaerobic conditions has been described [8, 9], little is known about the relationship between the hydrogeochemical variations associated with water table fluctuations, and the diversity and distribution of bacterial communities and degradation pathways. In this study, two laboratory aquifers were designed to collect fluid samples at high-resolution through time and the aquifer matrix at the end of the experiment. The reactive transport of DCM is investigated in porous medium under dynamic hydrological conditions (see Figure 1 for experimental design). Hydrological measurements – water and air pressure, in- and out-flowing gases and DCM fluxes collected in a gas chamber, isotope fractionation (C and Cl) of DCM and microbial characterisation (qPCR of functional genes and 16S rRNA high-throughput sequencing) are performed. The obtained data can be used to investigate the effect of water table variations on the geochemistry, the evolution of biomass and microbial populations and the degradation pathways of DCM. A reactive transport model based on a two-phase flow representation, including biological processes (growth, decay, attachment, detachment or dormancy), isotope fractionation of DCM and water/gas mass exchange of DCM (local non-equilibrium), is in development. The model will be tested on the obtained experimental results. This will assist the interpretation of observed biogeochemical processes, and help determine the best-suited formalism to address the processes involved in the biogeochemical development of a contaminated aquifer.

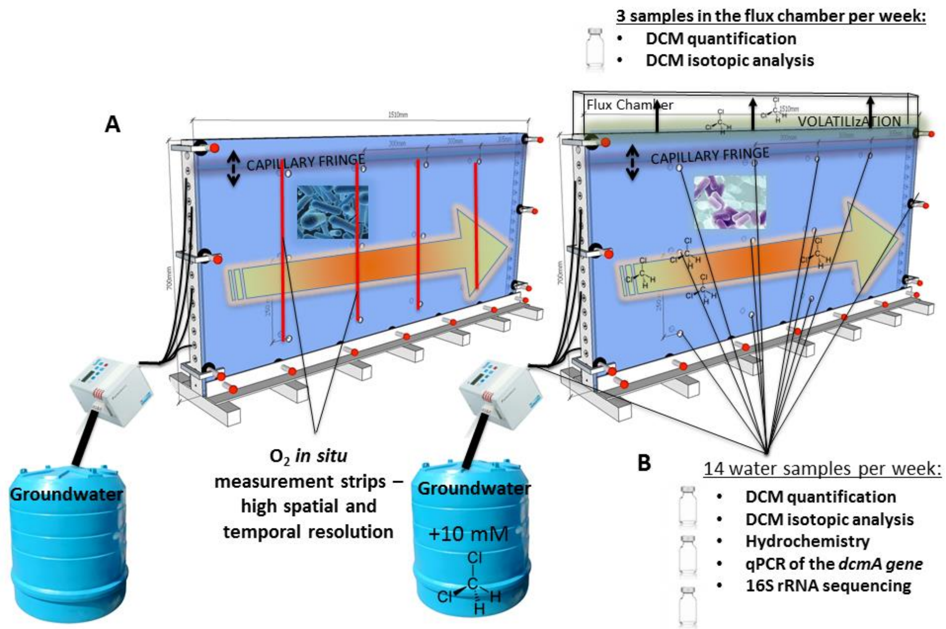

Figure 1: Experimental design of the two laboratory aquifers, with measurements/sampling points and strategy

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