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Batch, column and sandbox experiments of flow and biodegradation of tetrachloroethylene

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Tetrachloroethylene (PCE) is a common and widespread contaminant of soil and groundwater. It is classified as a dense non-aqueous phase liquid (DNAPL), a liquid which has a higher density than water and is immiscible with water. In this research, we combine batch, column, and sandbox experiments and numerical modelling to investigate the potential for enhanced biodegradation of PCE at high concentrations, in a source zone.

Batch experiments have shown that reductive biodegradation of pure PCE may take place. Batches consisted of a pure DNAPL, i.e. PCE of TCE, and anaerobic groundwater containing a bacterial consortium that was known to be able to dechlorinate these compounds. Batches with a dye, Sudan IV, were conducted as preliminary work for the column experiments in which this dye is to be used to visualize the DNAPL.

In the column experiments, a small source zone of entrapped PCE is created in the upper part of a water-saturated column that is filled with a sandy soil. PCE is immobile in this case, but it will slowly dissolve and it will be subject to biodegradation within the remaining downstream part of the column. Water pressures, pH, dissolved PCE and biodegradation products will be monitored along the column, by using manometers and water sampling ports.

A 2D sandbox is designed, in which a horizontal groundwater and a vertical DNAPL flow will be established. A given volume of PCE will be infiltrated so that it will flow downwards into the sandbox but will not reach the head chambers and will not give rise to a large pool at the bottom of the sandbox.

Manometers, TDR probes, water sampling ports will allow for monitoring water pressures, DNAPL flow and saturation, biomass dissolved in water, pH, and dissolved PCE and biodegradation products. Visual observation of dyed PCE through the glass front wall will give a picture of the NAPL distribution and its variation with time.

In order to direct experimental efforts towards the most important parameters, numerical model studies of water and DNAPL fluxes and DNAPL dissolution in the experimental set-up are performed. Different scenarios are considered, where flow velocities of aqueous phase and DNAPL are varied. Results of these simulations have been used to make an optimum design of the sandbox setup.

Experimental methods and set-up will be presented and preliminary results will be discussed.