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Observation and modelling of dissolved gases as indicators for mass transfer during gas sparging in a contaminated aquifer

S. Oswald (1) and G. Balcke (2)

(1) Helmholtz Centre for Environmental Research - UFZ, Hydrogeology, Leipzig, Germany (sascha.oswald@ufz.de), (2) metanomics GmbH, 10589 Berlin, Germany

Degradation of organic contaminants in aquifers is often limited by the availability of electron acceptors, and the attenuation of contaminants could be enhanced by additional supply of oxygen. Gas sparging is a remediation technique that supplies additional oxygen to ground water via injection of air or oxygen gas. For the performance of this method the mass transfer of gases from the gas phase trapped after injection is a key process. Our study investigated kinetic gas-water mass transfer between trapped gas phase in porous media and groundwater by spatially and temporally resolved dissolved gas measurements in an unconfined model aquifer. The aquifer model was built on-site as a 12 m tall underground tank filled with aquifer material and recharged in vertical direction by the local, contaminated groundwater. For the injection of short gas pulses, oxygen and air as injected gas phase were studied in view of interfacial mass transfer, gas transport in the aqueous phase, and accumulation of trapped gas in the porous space. At several locations dissolved nitrogen, methane and oxygen were observed at different stages of gas dissolution. Kinetic gas-water mass transfer in presence of oxygen demanding reactions in the polluted aquifer material and the transport of dissolved gases were simulated numerically for heterogeneous distribution of gas phase as was observed. Partitioning of nitrogen played an important role in the accumulation of trapped gas and contributes additional information on gas transfer processes. While injection of pure oxygen resulted in complete dissolution of trapped gas within a few meters, nitrogen and methane showed distinct patterns of mass transfer into the gas phase and back into aqueous phase. Naturally occurring gases such as methane or nitrogen were demonstrated to be valuable tracers to describe multiple compound gas-water mass transfer and to assist in predicting gas dissolution and oxygen consumption in porous media.