Geophysical Research Abstracts
Vol. 13, EGU2011-9821-1, 2011
EGU General Assembly 2011

Laboratory experiments on redox-sensitivity of organic trace pollutants in groundwater

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Waste water bound trace organic compounds, for example pharmaceuticals and personal care products, are increasingly detected in ground- and drinking water, especially in urban partly closed water cycles. Detection of compounds in these waters typically is attributed to their poor biodegradability under the prevailing aquifer hydrogeochemical conditions. Recent field studies at bank filtration sites in Berlin, Germany found that the fate and transport behavior of some trace organic compounds were strongly influenced by the spatial and temporal dynamics of the redox conditions on the flow path, indicating that the aquifer's redox environment plays a key role for the biodegradation of these compounds. Except the information derived from field investigations, no systematic research was done until now in order to gain a quantitative knowledge about redox sensitivity of organic trace pollutants in the aquatic environment.

The present study aims in investigating and quantifying the redox dependent degradation behavior of waste water bound organic compounds. In a preliminary assessment redox screenings were performed via incubation experiments under oxic and anoxic conditions, investigating the analgesic compounds phenazone and propyhenazone and their metabolites 1-Acetyl-1-methyl-2-dimethyl-oxamoyl-2-phenylhydrazide (AMDOPH), 1-Acetyl-1-methyl-2-phenylhydrazide (AMPH), Acetylamino-antipyrine (AAA), Formylaminoantipyrine (FAA) and 1,5-dimethyl-1,2-dehydro-3-pyrazolone (DP). A total of seven stainless steel tanks were filled with anoxic groundwater from a field site in Berlin. The utilized water already contained the investigated substances in relevant concentrations. Three tanks were aerated in order to create oxic conditions. The four other were flushed with argon in order to maintain anoxic conditions. Samples were taken after 1, 5, 11, 22 and 46 days. The analytical procedure included solid phase extraction and high pressure liquid chromatography coupled to tandem mass spectrometry (HPLC-MS/MS).

The results of the experiments indicate that the degradation of six of the seven investigated compounds is influenced by the redox environment. AMDOPH has proven to be very persistent independent of prevailing redox conditions. Phenazone, propyphenazone, AMPH, AAA, FAA and DP showed better removal under oxic conditions, whereas they persisted in the anoxic tanks. The next step in this study is to determine redox specific biodegradation rate constants for the phenazone type and other potentially relevant waste water bound organic compounds from column experiments with natural aquifer sediment. Once redox-dependencies have been established for different compounds, organic trace compound mixtures present in groundwater may actually be useful to determine upstream redox conditions where information is missing.