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Degradation of organic contaminants in porous model aquifers – it is heterogeneity that matters

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In middle Europe aquifers constitute the most important drinking water resource. Thus, aquifers polluted with organic contaminants, such as aromatic hydrocarbons (BTEX, PAH), may pose a great risk to human health and the groundwater ecosystem. Consequent to contamination, generally a contaminant plume develops in the subsurface and microbial degradation is the most important process for a net reduction of the organic chemicals. Biodegradation mainly takes place at the plume's fringe where electron acceptor from pristine groundwater and electron donor from the plume mix driven by dispersion processes. However, understanding biotic degradation processes and their limitations in porous sediments of different degrees of heterogeneity is still a major challenge. We hypothesize that increasing heterogeneity in sediments enhance the mixing of pollutants, electron acceptors, nutrients, and additionally reduce toxic concentrations of contaminants and therefore improve the overall biodegradation capacity. By investigating basic principles of degradation under the impact of sediment heterogeneity in laboratory-based two-dimensional (2-D) model aquifers we expect to uncover key processes limiting biodegradation.

In 2-D microcosms, resembling a longitudinal section of a porous sediment system, we carried out experiments in homogeneous versus heterogeneous packed porous media to compare microbial biodegradation activity within a toluene/ethylbenzene plume. In an initial phase of the experiment we followed aerobic degradation of a "young" toluene plume which with time turned anoxic by the activity of the strain *Pseudomonas putida* F1. In a second phase we particularly addressed the competitive interaction of the established aerobic strain with the newly inoculated denitrifyer strain EbN1. In correspondence to a much higher contaminant removal in the het-

erogeneous microcosm at any time, the vertical distribution of oxygen, biomass, and microbial activity, as assessed by stable isotope fractionation, testified an increased mixing of nutrients and an enhanced biodegradation capacity compared to the homogeneous system. Furthermore, strain EbN1 outcompeted strain *P. putida* F1 due to the better availability of nitrate compared to dissolved oxygen.