Fine-scale assessment of intrinsic contaminant degradation and responsible microbes in a tar-oil contaminated aquifer.

The microbial degradation of contaminants is a major mechanism that protects groundwater resources against anthropogenic pollution. A precise understanding of factors that trigger and control the degradation of contaminants and the responsible microbial populations in aquifers is an essential prerequisite for a sustainable management of groundwater resources.

A major objective of the IGOE’s research programme is to provide the scientific basis for a comprehensive understanding of the limitations of groundwater self-purification. One of our main hypotheses is that in most existing case studies, the spatial resolution of data acquisition in aquifers is inadequate for a precise mechanistic understanding of in-situ degradation. Therefore, we have recently installed a unique high-resolution multilevel monitoring well in Düsseldorf-Flingern, a well-characterised investigation site. With a spatial resolution of down to 3 cm, this well now allows us to monitor processes and responsible microbiota through a tar-oil contaminant plume with a spatial resolution unprecedented for aquifers to date. Already our first samplings have revealed fine-scale biogeochemical gradients of contaminants and electron acceptors, as well as locally specialised distribution patterns of hitherto unrecognized communities of contaminant degraders.

These results suggest that fine-scale heterogeneities in redox gradients and intrinsic aquifer microbiota, which were masked by insufficient sampling strategies to date, may be among the most important controls of pollutant degradation. The ongoing efforts of the IGOE to not only identify, but also quantitatively model these controls will provide decision makers with an urgently needed tool for the precise prediction and steering of groundwater self-purification.


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Contaminant degradation in groundwater ecosystems:
• Where does degradation occur?
  Depending on which electron acceptors?
• Who is responsible for degradation activities?
• Which metabolic pathways and enzymes are involved?
• How do intrinsic microbial populations react and adapt to drastic changes in environmental conditions (e.g. pollution)?
  ➔ What is limiting contaminant degradation?
  ➔ Understanding of groundwater self-purification by characterization of aquifer microbial communities and processes.
  ➔ Sustainable management of groundwater resources.
Installation of a unique multilevel monitoring well

Modules with diff. resolutions:
• 3 cm (high)
• 10 cm (middle)
• 33 cm (low)
Fine-scale analysis of biogeochemical gradients and contaminants and its temporal dynamics

GSF – National Research Center for Environment and Health
Institute of Groundwater Ecology
Localization and identification of microbial key-players

Results & Implications:

• Yet unidentified microbes carrying novel contaminant-degrading key-enzyme sequence types dominate the site.
• Relative abundance of degraders is highest in the gradient zone below the plume.

⇒ Highly specialised degrader assemblages establish at plume fringe and drive biodegradation!