

Anaerobic degradation of aromatic hydrocarbons in contaminated groundwater and oil reservoirs

Aromatic hydrocarbons are among the most frequent and hazardous contaminants of aquatic ecosystems. Although well degradable by aerobic microorganisms, they are quite stable in the absence of molecular oxygen. Therefore, such anaerobic degradation processes are of utmost importance for the production of clean drinking water as well as our most important energy source, crude oil.

Our research focusses on the generic principles of the anaerobic, microbial degradation of aromatic hydrocarbons and the biotic and abiotic factors limiting such processes in the environment.

We studied the biodegradation of naphthalene as a model compound for polycyclic aromatic hydrocarbons with sulfate and iron-reducing microorganisms. The biochemical pathway was elucidated to large extent with biochemical and genomic studies and several novel enzyme reactions were described on enzymatic level including a novel activation of aromatic rings by direct carboxylation. This knowledge could be used to identify specific metabolites and prove anaerobic degradation in field studies as demonstrated at the example of a contaminated aquifer. Here, also limitations of biodegradation were identified such as the spatial separation of electron acceptors and donors.

For oil reservoirs, previous work suggests that biodegradation mostly occurs at the interfaces of oil and water compartments. However, we showed at the example of the world's largest asphalt lake in Trinidad & Tobago that microorganisms thrive in minuscule water droplets (1-3 μ l) entrapped in oil. Pyrotag sequencing of individual droplets revealed complex methanogenic microbial communities actively degrading the oil as shown by metabolite analysis with NMR and FTICR/MS. High salinity and water stable isotopes of the inclusions indicated a deep subsurface origin suggesting entrapment of the droplets in the oil reservoir itself. This reveals a currently underestimated potential for biodegradation of oil reservoirs and a new, extreme habitat for microbial life.