Questions from Seminar 30.11.2015 (lecture of 23.11.15)

Q: What are the main problems arising in the anaerobic degradation of hydrocarbons?

A: The main problem is to activate hydrocarbons without oxygen and to overcome the resonance energy of aromatic rings.

Q: A contaminated aquifer with PCE, observation->no degradation -> give possible reasons:

A: Cl_3C-CCl_3: -strong binding between Cl and C

-possible reasons are that the aquifer is oxic. As reductive dehalogenation (or dehalorespiration) does only take place under strictly anoxic conditions, the PCE cannot be reduced. Furthermore, although anoxic, there might not be enough electron donors around. The bacs would need hydrogen for the dehalorespiration. If the degradation stops at DCE or VC, Dehalococcoides might not be present in the aquifer, or the environmental conditions would be not as such that Dehalococcoides can perform.

Q: How do microorganisms overcome the activation energy for degradation of hydrocarbons in anaerobic conditions (name of enzymes)?

A: There are different pathways for activation of the substances a) methylated compounds such as toluene or methylnaphthalene are activated by fumarate addition through benzylsuccinate synthase and similar enzymes, a radical enzyme which can tackle rather unreactive molecules. B) Ethylbenzene can be activated either by fumarate addition or by direct hydroxylation at the benzyl-carbon atom (ethylbenzene dehydrogenase). C) phenol, benzene, and naphthalene are carboxylated to benzoic acid or naphthoic acid (naphthalene carboxylase).

Q: How can a methanogenic consortium of a methanogen and a fermenter survive if the total reaction allows only to conserve 1 ATP ≈ ΔG° = -48 kJ mol^{-1}?

A: It is enough energy to transport one proton over the membrane for each organism.

Q: Why might the use of radicals in anaerobic degradation of an aromatic hydrocarbons be a problem for the cell?

A: Radicals are very dangerous for biological systems because the react with other organics and can e.g. destroy proteins or nucleic acids. If molecular oxygen comes into contact with organic radicals reactive oxygen species form which are extremely reactive and lead to cell damage.

Q: What are the limitations of reductive dehalogenation and how can it be overcome?

A: Under anoxic conditions, reductive dehalogenation of polychlorinated hydrocarbon can take place at a contaminated site. However, sometimes the microbes do not really degrade the contamination completely, it ends sometimes at a more toxic metabolite (vinyl chloride). To overcome this, vinyl

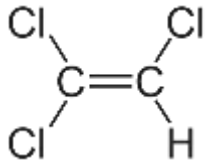
chloride is further degraded by providing e.g. Dehalococcoides cultures or electron donors in the form of lactate or molasses (sugar).

Q: Naphthalene and benzene are regarded to be important aromatic compounds. Why?

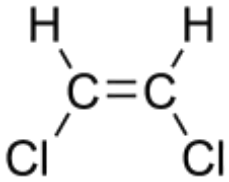
A: As they are toxic and as they are in the environment it is important to take care of them. They are produced if e.g. waste is burned. They are also very well water soluble and thus transported with the groundwater flow.

Q: What problem does occur in aquifers close to dry-cleaning facilities?

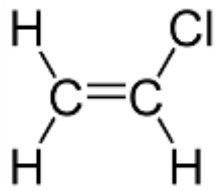
A: Dry-cleaning facilities release a lot of PCE and TCE into the nature and therefore into aquifers. This TCE,



is further reduced to DCE, e.g.



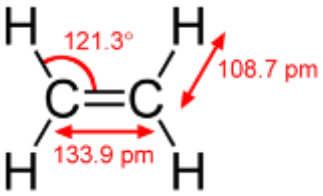
and finally to VC



, by MOs.

VC (vinyl chloride) is a very toxic compound. In most cases there is no further reaction happening that would lead to ethene (non toxic).

Ethene:



Q: What is the name of the infection that takes place in the hospitals? How much time it has to wait considering this?

A: *Pseudomonas aeroginosa* causes this in the hospitals. It's called a nosocomial infection, defined as an infection that occurs within 48h after the stay in the hospital.

Q: What is the problem with PCB degradation?

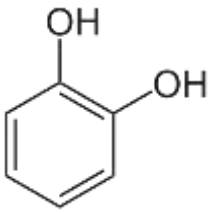
A: 1. PCBs can only be degraded by reductive dehalogenation or dehalorespiration. Unfortunately, the reduction gets slower with every released chlorine atome rendering metabolites untouched.

Q: What are NAPLs and what is the problematic thing about them concerning remediation of a contaminated site?

A: “non aquous phase liquids” do not mix with water. Thus, the dissolution is very slow. Aquifers have only laminar flow → fast saturated of the water close to the NAPL → because of no mixture → no degradation

Q: What is the main intermediate for anaerobic and for aerobic degradation of aromatics?

A: benzoate for anaerobic degradation of aromatics, catechol for aerobic:



Q: *Dehalococcoides ethenogenes* differs from other bacteria with respect to its cell wall. How does it differ and what are the consequences (culture growth?)?

A: The cell wall is different from “typical” bacteria, it is more complex, related to the ones of archeae. So antibiotics that have an effect on the cell wall, do not work.

Q: Describe one typical problem that arises in the degradation of PCE in aquifer systems.

A: DNAPL phase. There is only very little solution of DNAPL phases in the water phase. So it stays in the medium for a long time. DNAPLs cannot be dissolved in the water and there is no mixing. As DNAPLs are denser than water, they migrate to the bottom of the aquifer, until they reach an aquitard.

Q: Name four strategies for remediation and estimate the effect on a hydrocarbon contaminated site.

A: 1. Excavation and Isolation

→ Always some leftover

2. Pump and treat

→ contaminant is pumped out to a certain concentration

→ problem is not solved, usually the concentrations go up, when the pumping is stopped as the NAPLs have not been removed.

3. funnel and gate system

→ reductive elimination of chlorinated hydrocarbons. Works well, but the stand times are not long enough as the iron corrodes quickly. Strong pH changes as well!

4. Iron particles

→ Problem: mobility in the aquifer