Questions from Seminar 16th of November (answers inserted)

Give an example for a cable bacterium. What is special about it and why are they important?

Reduction and oxidation if different cells. Other cells are probably just electron conductors.

The marine cable bacteria oxidize sulfide in deeper sediment layers to sulfate, transfer the electrons along long filaments of bacteria, and reduce oxygen to water at the surface.

What applies for a given diffusion gradient at steady state?

If there are no processes between source and sink of a compound, the concentration gradient depicts a straight line. In case the gradient is bent, there is either consumption on the negative bent or production on the positive bent of the gradient. The slope of the gradient can be directly used to calculate the fluxes at that location.

Explain Fick's first law. What does it describe and what are the constituents?

Fick's law: $J_x=-DA(dc/dx)_t$

It describes the diffusive flux between two zones of different concentrations.

D= Diffusion coefficient [cm^2/s]

A= Area [cm^3]

J_x= Diffusive flux in direction x [mol/s]

dc= difference in concentration in given time

dx= length of diffusion in given time

What's wrong about the classical plume as shown in the textbook?

The redox zonation is based on the thermodynamic sequence of redox reactions. However, the classical redox zonation concept in contaminated aquifers is reverse to natural systems. The plume fringe concept much better explains the reality. The reaction takes place at the fringe of the plume, with a redox sequence from the outside to the inside of the plume.

Lake sediment with glucose (500 µM) was depleted to 200 µM after 5cm. Calculate the flux according to Fick's first law after 1 hour (diffusion flux) $D_{glucose}= 6{,}78*10^{-6}$ [cm^2/s].

$J_x=-DA(dc/dx)_t$

$J_x= -6{,}78*10^{-6}\ cm^2/s \cdot 5\ cm^2 \cdot (300\ \mu M/5\ cm)= -\ 0{,}002\ \mu M/s$

But it's 1 hour, thus $-0{,}002\ \mu M/s \cdot 3600\ s= -7{,}32\ \mu M$ per hour

- Why are highly contaminated systems usually electron acceptor limited and non-contaminated systems usually electron donor limited?

In contaminated systems there is usually a large excess of electron donors in form of the contaminant. Electron acceptors are usually not very prominent due to eg. Limited solubility of oxygen etc. As microorganisms need the electron acceptors in stoichiometric amounts for metabolic reaction they become limiting. Pristine systems have the same input of electron acceptors but much less input of organic carbon. The dissolved organic carbon (DOC) coming from the surface is poorly bioavailable and it needs a long time to degrade → poor kinetics. Thus, electron acceptors are sufficient for long time until the slow consumption of DOC or buried organics or oxidisable inorganics (e.g. pyrite) exceeds the amounts of electron acceptors present.

- What ist the special feature of cable bacteria? What would happen if you cut them?

They consists of a chain of linked microorganisms (filaments). One part does the oxidative reactions, the other part does the reductive reactions. The microorganisms in between have the function of an electron conductor. If you cut them, the reaction stops.

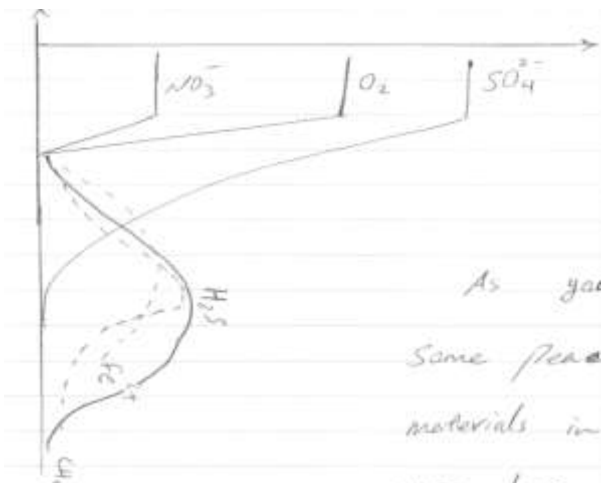
- Which information do you get from redox tower?

The redox tower provides information about the various redox potentials of different compounds and allows to predict if the reactions will take place.

- Why is there a significant $\delta^{13}C$ stable isotope fractionation at the plume fringe for toluene?

According to the plume fringe concept, the biodegradation takes place at the plume fringes. As isotope fractionation is indicative of degradation processes it is observed in the same location.

- The chart which is located below is the "consequence for redox sequences in lake sediment". As you can see there are some peaks for some of the substances from deeper places. Can you explain any reason for these peaks?



Answer: The reduced species H2S and methane are most abundant in deeper layers. This is because the other electron acceptors oxygen and nitrate are consumed before they reach those depths. H2S and methane decrease towards the surface because they are oxidized by nitrate-reducing and aerobic organisms.