EXAMINATION GEO4-1440 Microbes and Biogeochemistry
Monday April 15, 2013: 9-12 h.

To optimize marking the examination, you are kindly asked to use separate sheets for questions 1-5 and 6-10. In total 100 credits can be obtained.

1. Microbes: 12 points (3,3,3,3)

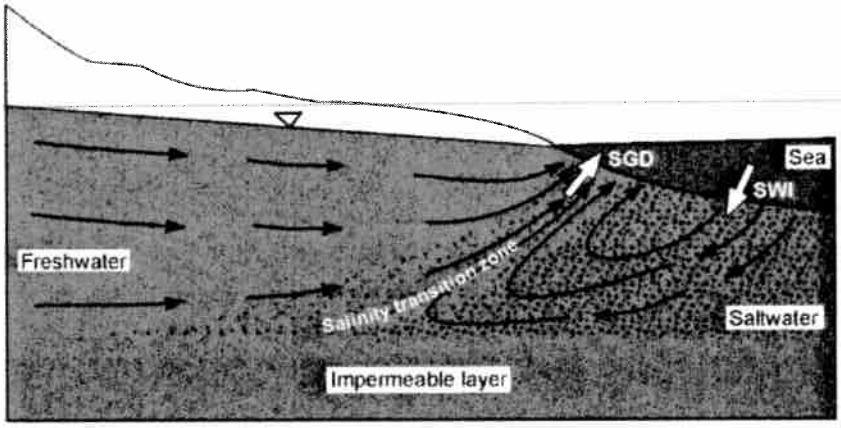
1.1. Identify the VALID answer: The current classification system of life has the following groups
   a) Monera, Protista, Fungi, Plants and Animals
   b) Eubacteria, Archaebacteria, Fungi, Plants and Animals
   c) Bacteria, Archaea, Eukarya
   d) None of the above

1.2. Check the INVALID statement
   a) Cyanobacteria are photosynthetic organisms using CO_2 as a carbon source
   b) Purple and green sulfur bacteria have different bacteriochlorophylls which allows them to occupy different niches and avoid competition for light
   c) Archaea are always extremophiles (live in extreme temperature and salt conditions)
   d) Sulfur oxidizers are chemolithoautotrophs

1.3. Check the INVALID statement
   a) Thaumarchaeota are ammonia oxidizing archaea living in high temperature ecosystems
   b) Stromatolites are fossilized remains of microbial life and are believed to represent the first microbial ecosystem on Earth
   c) An association of Anaerobic methanotrophic archaea (ANMEs) and sulfate reducers can mediate the Anaerobic oxidation of Methane
   d) All the statements are true

1.4. Which of the following options would you choose to estimate the ACTIVITY of a microbial group
   a) Count the bacterial numbers under the microscope
   b) Estimate the diversity with a fingerprinting method like DGGE
   c) Stain bacteria and count under the microscope
   d) Quantify gene expression (RNA) of a metabolic or 16S rRNA gene

2. Coastal Biogeochemistry; 12 points (3,3,3,3)
The figure below shows a schematic representation of a so-called "subterranean estuary".



2.1 Explain the (potential) sources and likely fate of dissolved inorganic phosphate in anoxic fresh groundwater that is flowing towards the coastline

2.2. By what other pathways can phosphorus be transported from land to the ocean and in what form does this transfer mostly occur?

2.3. How have humans impacted this transfer?

2.4. Explain the consequences of the increased input of phosphorus to the Baltic Sea over the past century

3. Sediment oxygen consumption: 12 points (4,4,4)

3.1 Give three ways how sediment oxygen consumption rates can be measured

3.2 Which method would you use in sandy, permeable sediments and which one in muddy deep-sea sediments.

3.3 Why are rates of aerobic mineralization in coastal sediments only a fraction of total oxygen consumption rates?

4. Primary production in ocean: 12 points (4,4,4)

4.1 What are the main factors governing deep chlorophyll maxima?

4.2 What is the rationale underlying the use of remote sensing in estimating primary production in the ocean.

4.3 Give four reasons why primary production may decrease and/or increase with global change.

5. Redfield deviations in ocean: 12 points (4,4,4)

5.1 What is the rationale underlying the N* concept.

5.2 Where do you find positive and negative N* values and why is this so?

5.3 Why is there is no 1:1 relationship between oxygen used and carbon respired?

6. Bacteria are involved in the turnover of nitrogen species in soils: 8 points (4,2,2).

6.1 Describe which bacterial functions are relevant for nitrogen cycling in soils.

6.2 Why are these functions important for plants?

6.3 Some plants have root nodules. What are these nodules and which is the benefit for the plants?

7. Bioavailability: 8 Points (4,2,2)

7.1. Describe the meaning of "bioavailability" (in the context of microbial processes) and why it needs to be considered in terrestrial systems (soil, groundwater).

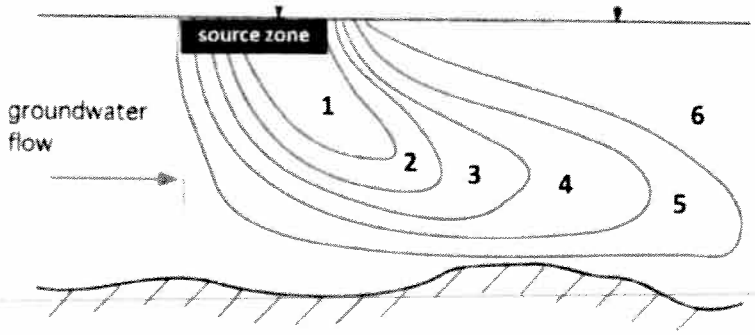
7.2. How can fungi change the bioavailability of a compound?

7.3. How do fungi support plant growth?

8. Biodegradation: 6 Points (3,3)
Many groundwater contaminants can be degraded by microorganisms.

8.1 What is the main reason for the occurrence of different redox zones in contaminated aquifers with biodegradation?

8.2 Below you can see the outline of different redox zones within an aquifer contaminated by a biodegradable organic carbon contaminant. The source zone of the contamination marked black and the contaminant is degraded in the aquifer via the following pathways: A – nitrate reduction; B- sulfate reduction; C – aerobic degradation; D - iron reduction; E – methanogenesis; F – manganese reduction. Which of the shown redox zone belongs to which pathway (link numbers and capital letters)?



9. Stable isotopes: 8 points (4,2,2)
Stable isotope signatures can be used to determine if biodegradation takes place at a site:

9.1 Describe the basic principles of stable isotope fractionation and how it can be used to detect biodegradation qualitatively.

9.2 How can the Rayleigh fractionation model be used to quantify biodegradation using stable isotope signatures?

9.3 What additional information could be obtained if the stable isotope signatures of two elements (e.g., C and H) are measured at the same site?

10. Microbial dynamics: 10 points (2,3,3,2)
Consider a batch experiment where microorganisms are oxidizing DOC to gain the energy needed for their growth. The system is closed without any exchange with its surrounding.

10.1 Draw schematically the concentration plots for DOC and microbial biomass vs. time.

10.2 What is the growth rate of the microorganisms in case DOC is the only rate limiting species and no other processes limit the growth of the microorganisms? Give the equation.

10.3 Give three examples for processes besides DOC limitation, which can limit the buildup of microbial biomass in subsurface environments.

10.4 Consider oxygen and sulfate being the only terminal electron acceptors present in the system. Give an example on how such as system can be described by microbial growth kinetics.