# Final exam GEO3-4301 Soil and Water Pollution
## 3 February 2011 13:30 – 16:30 h

**General remarks:**
- This exam contains five questions.
- Please answer concisely.
- Answers in English or in Dutch are allowed.
- At the end of the examination hand in all your answer sheets.
- Write down your name or student number on all answer sheets.
- The answers will be available on Blackboard directly after this exam.

1. Explain in brief (max. 50 words per answer)
   a. Why chloride concentrations in groundwater are generally larger near the coast than further away from the coast
   b. Why chloride concentrations in groundwater are generally larger below forests than below natural grasslands
   c. Why chloride concentrations in shallow groundwater are generally larger near forest edges than in the centre of the forest.
   d. Why sulphate concentrations in runoff water from forested ecosystems have decreased between 1975 and 2000.
   e. Why $^{137}Cs$ deposition densities in soil are less on convex parts than on concave parts of a hillslope.
   f. Why the pH of lake water is generally higher during summer than during winter.
   g. Why the metal content in the top 5 cm of soils in the floodplains of many European rivers are lower than at 30 cm depth.
   h. Why the nitrification rate is larger at the edge of an ammonium plume than in the centre of the plume.
   i. Why metal concentrations in soil are positively correlated with the aluminium content of the soil..
   j. Why drainage water from mine sites contains high levels of dissolved metals.

(20 points)

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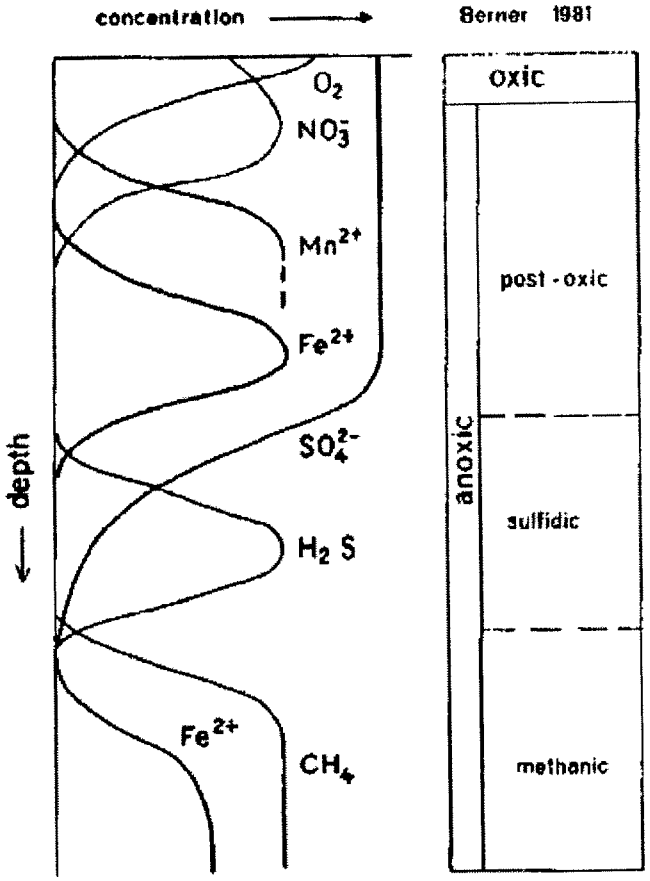
2. In sediments and groundwater, a clear vertical zonation with respect to the chemical composition as depicted in the figure below can often be found.
   a. What is the main driving process controlling this zonation?
   b. Give for each of the four zones (oxic, post-oxic, sulphidic, and methanic) the most important reactions in terms of reactants and reaction products (note that it is not necessary to give a closed reaction equation).
   c. Why does the $Fe^{2+}$ concentration decrease in the sulphidic zone?




(10 points)

3. The figure below shows a so-called rating curve for the river Meuse at Keizersveer, the Netherlands, for the 2000-2006 period. The rating curve depicts the long-term relation between river discharge ($Q$; $m^3\ s^{-1}$) and the suspended sediment concentration ($SSC$; $mg\ l^{-1}$) and usually has the form $SSC = a\ Q^{\ b}$.

a. Give the most important reason why there is a positive relation between discharge and the suspended sediment concentration.

The individual SSC measurements display a considerable variation around the rating curve. This is mainly due to the fact that the Q-SSC relation for individual hydrologic events displays hysteresis

b. Give the major reason for the occurrence of the hysteresis effect.

c. Is the hysteresis most-often clockwise or anti-clockwise?

A floodplain section along the river Meuse near Keizersveer is inundated at a discharge of 375 $m^3\ s^{-1}$. The water flow velocity in the floodplain is 0.8 $m\ s^{-1}$ and the water depth is 2 m.

d. Calculate the distance needed to reduce the SSC in the floodplain to 5 $mg\ l^{-1}$ given the parameters of the rating curve $a = 0.22$ and $b = 0.675$, the effective settling velocity of the sediment (i.e. including the effect of shear stress) = $1.5\ 10^{-5}$ $m\ s^{-1}$, and:

$$\frac{d\,SSC}{dt} = -\frac{J}{H} \text{ and } J = w_s\ SSC$$

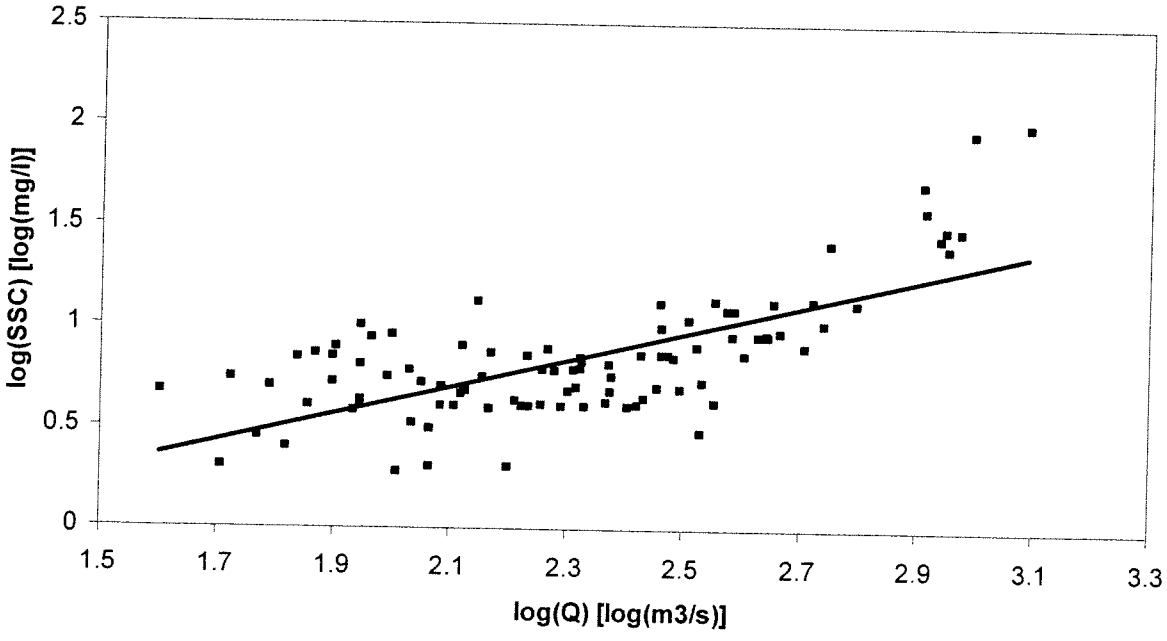
Assume the SSC at the point of inflow is equal to the SSC according to the rating curve and neglect dispersion.

In this calculation the effect of hysteresis has not been taken into account.

e. Would this have caused an underestimation or an overestimation of the distance as calculated in exercise d? Explain your answer.

Wind action produces waves and currents in the inundated floodplain, which affects the settling and redistribution of bed sediments in the lake.

f. Explain in brief the role of the wind *direction* for the settling suspended sediments.




(22 points)

4. A flow reactor with a cross-sectional area of 0.8 $m^2$ is filled with sandy sediment with a dispersivity $\alpha$ of 0.012 m. The sediment is fully saturated with water with a $Cl^-$ concentration of 0 mg $l^{-1}$. The flow velocity is set to 0.75 m $d^{-1}$, a mass of 1 g of $Cl^-$ is released instantaneously.

a. Calculate the dispersion coefficient
b. Does this coefficient refer to longitudinal or to transverse dispersion? Give reasons for your answer.
c. Explain the major mechanisms that cause dispersion in the flow reactor.
d. Calculate the maximum concentration after 1 day given

$$C(x,t) = \frac{M}{2A\sqrt{\pi D_x t}} e^{-(x-u_x t)^2 / 4 D_x t}$$

e. Calculate the maximum concentration at x = 1.0 m.

(23 points)

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5. For a stream, the following parameters are given:

Discharge = 0.02 $m^3$ $s^{-1}$
Stream width = 1.2 m
Water depth = 0.2 m
Water temperature = 15 °C
Zero-order ammonium release rate = 18 mg $m^{-2}$ $d^{-1}$.
First-order nitrification rate constant at 20 °C = 0.5 $d^{-1}$.
First-order denitrification rate constant at 20 °C = 0.8 $d^{-1}$.
Temperature coefficient nitrification = 1.04
Temperature coefficient nitrification = 1.08

Furthermore, the following atomic weights are given:
Atomic weight of nitrogen = 14
Atomic weight of oxygen = 16
Atomic weight of hydrogen = 1

a. Calculate the ammonium concentration in mg $l^{-1}$ in the stream assuming equilibrium.
b. Calculate the nitrate concentration in mg $l^{-1}$ in the stream assuming equilibrium.

(15 points)

± 50