Midterm exam GEO3-4301 Soil and Water Pollution
6 January 2009 9:00 – 11:00 h

General remarks:

- This exam contains five questions.
- Please answer concisely.
- Answers in English or in Dutch are allowed.
- Write down your name or student number on all answer sheets.
- At the end of the examination hand in all your answer sheets.
- Note that after this exam, there will be an introduction to the second assignment, so please be back at 11.00 h.

1. Define the following environmental terms:
   a. Diffuse source
   b. Biomagnification
   c. Partition coefficient
   d. Point of zero charge
   e. Nitrogen fixation
   f. Longitudinal dispersion
   g. Background radiation
   h. Retardation
   i. Pendular saturation
   j. Eutrophication

(20 points)

2. a. Explain why chloride is often used as a natural tracer in environmental studies.
   b. A wastewater treatment plant discharges its effluent in a river at a rate of 30 l s^{-1}. The river discharge is 0.25 m^3 s^{-1}. The chloride concentration in the stream just upstream the effluent outfall is 11 mg l^{-1} and the chloride concentration of the effluent water is 123 mg l^{-1}. Calculate the chloride concentration directly downstream from the effluent outfall.

(16 points)

3. Phosphorus is generally considered to be relatively immobile in soil and groundwater. The dissolved phosphorus concentration in soil water and groundwater depends on pH and redox potential.
   a. Explain in brief why the dissolved phosphorus concentration is relatively high in anaerobic groundwater.
   b. Explain in brief why the dissolved phosphorus concentration is relatively low in soils that are rich in calcium carbonate.

(16 points)

4. A spill of 1.5 m^3 of a DNAPL spreads slowly in a shallow aquifer with a porosity of 28 %. The residual concentration of the DNAPL in the aquifer material is 10 %. Calculate the maximum aquifer volume that will be contaminated by the DNAPL.

(10 points)

5. A shallow lake with the following dimensions: length 800 m, width 250 m, and depth 2 m, is fed by a stream with a water discharge of 4 $m^3\ s^{-1}$. The suspended sediment concentration in the stream at the mouth of the stream into the lake is 25 mg l^{-1}. In the lake the flow velocity is small and the actual bottom shear stress is lower than the critical shear stress for deposition. This causes the suspended sediment discharged into the lake to settle with an effective settling velocity of 1.6 10^{-5} m s^{-1}.

   a. Calculate the residence time of water in the lake.
   b. Calculate the sediment flux in g m^{-2} day^{-1} to the lake bottom *directly downstream* from the mouth of the river into the lake.
   c. Calculate the suspended sediment concentration *at the outflow* of the lake given $\frac{dC}{dt} = -\frac{J}{H}$. Disregard any inflow of water and sediment into lake other than the river.
   d. Calculate the sediment flux in g m^{-2} day^{-1} to the lake bottom *directly upstream* from the lake outflow.

   Wind action produces waves and currents in the lake, which affects the settling/resuspension and redistribution of bed sediments in the lake.
   e. Explain in brief the role of the wind direction for sediment settling and resuspension.
   f. Discuss in brief the effects of resuspension by wind action on the concentrations of dissolved nitrogen and phosphorus species in the lake water.

(28 points)