Final exam GEO3-4301 Soil and Water Pollution
2 February 2012 13:30 – 16:30 h

General remarks:

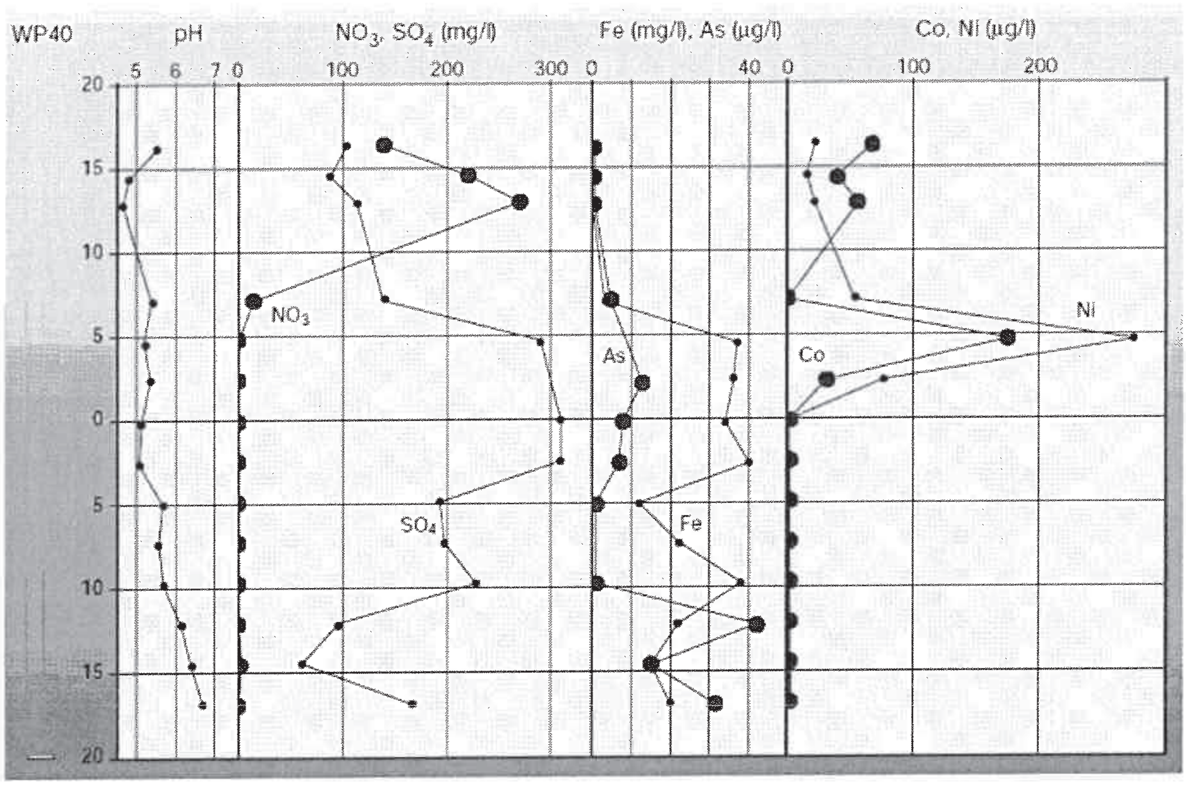
- This exam contains five questions.
- Please answer concisely.
- Answers in English or in Dutch are allowed.
- At the end of the examination hand in all your answer sheets.
- Write down your name or student number on all answer sheets.
- The answers will be available on Blackboard directly after this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

1. Explain in brief (max. 50 words per answer)
   a. Why the metal content in the top 5 cm of soils in the floodplains of many European rivers are lower than at 30 cm depth.
   b. Why ^{137}Cs inventories in soil are less on convex parts than on concave parts of a hillslope.
   c. Why the pH of lake water is generally higher during summer than during winter.
   d. Why chloride concentrations in shallow groundwater are generally larger near forest edges than in the centre of the forest.
   e. Why chloride concentrations in shallow groundwater are generally larger beneath forests than beneath natural grasslands.
   f. Why total suspended sediment concentrations in streamwater are higher during storm events than during baseflow conditions.
   g. Why metal concentrations in soil are positively correlated with the aluminium content of the soil.
   h. Why bicarbonate concentrations in stream water is often higher during baseflow than during periods of high discharge.
   i. Why ammonium concentrations are relatively high in pore water of peat soils.
   j. Why dissolved phosphate concentrations in shallow groundwater are larger in the marine areas than in the sandy areas of the Netherlands.

(20 points)

2. The figure below shows the concentration profiles in a multilevel well in a sandy aquifer underneath an area heavily influenced by agricultural emissions. Explain in brief (maximum 3 sentences per subquestion) the main features of, and the processes responsible for the concentration profiles of the following substances:

a. Nitrate
b. Sulphate
c. Iron
d. Nickel



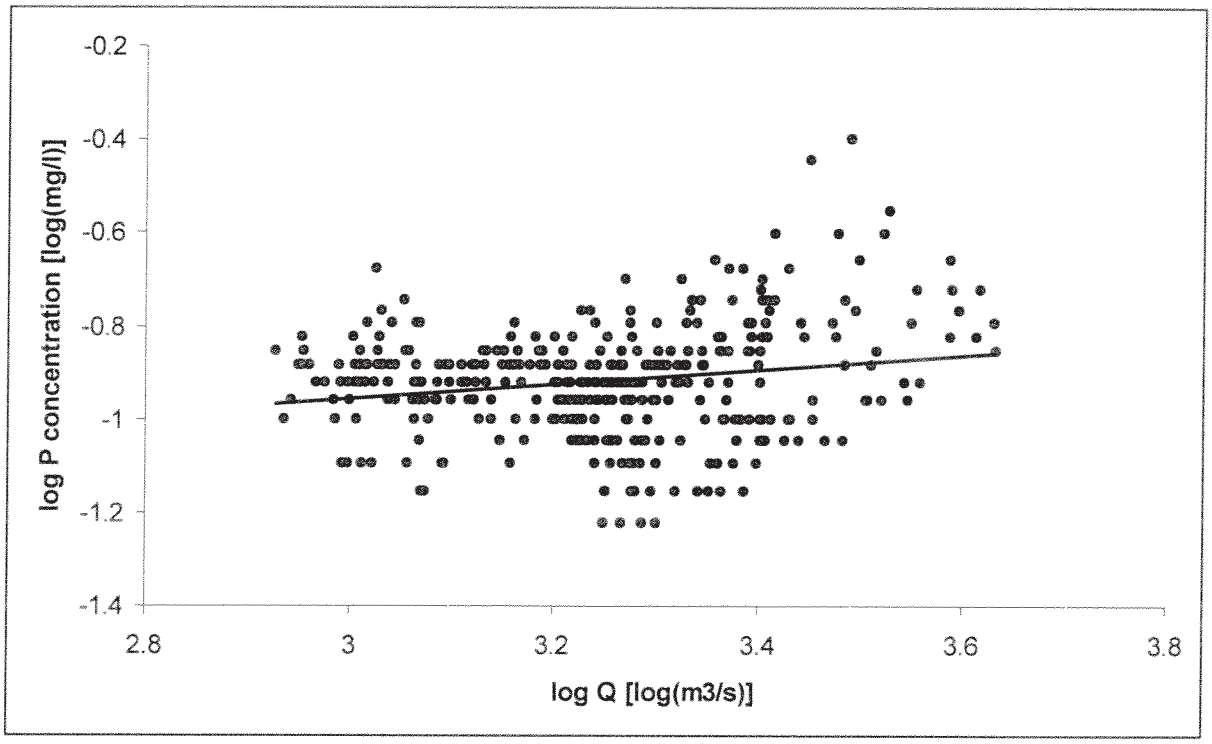
(16 points)

3. The figure below shows a so-called concentration rating curve for daily total phosphorus measurements in the River Rhine at Lobith, the Netherlands, for the year 2009. The rating curve depicts the relation between river discharge (Q; $m^3\ s^{-1}$) and the phosphorus concentration (P; $mg\ l^{-1}$) and usually has the form $P = a\ Q^{b}$.

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

The individual SSC measurements display a considerable variation around the rating curve.

b. Give two major reasons for the occurrence of this variation and describe in brief the processes responsible for this.



The change of the phosphorus concentrations as function of time can be described by a combination of a zero-order phosphorus release from the bed sediments and a first-order removal:

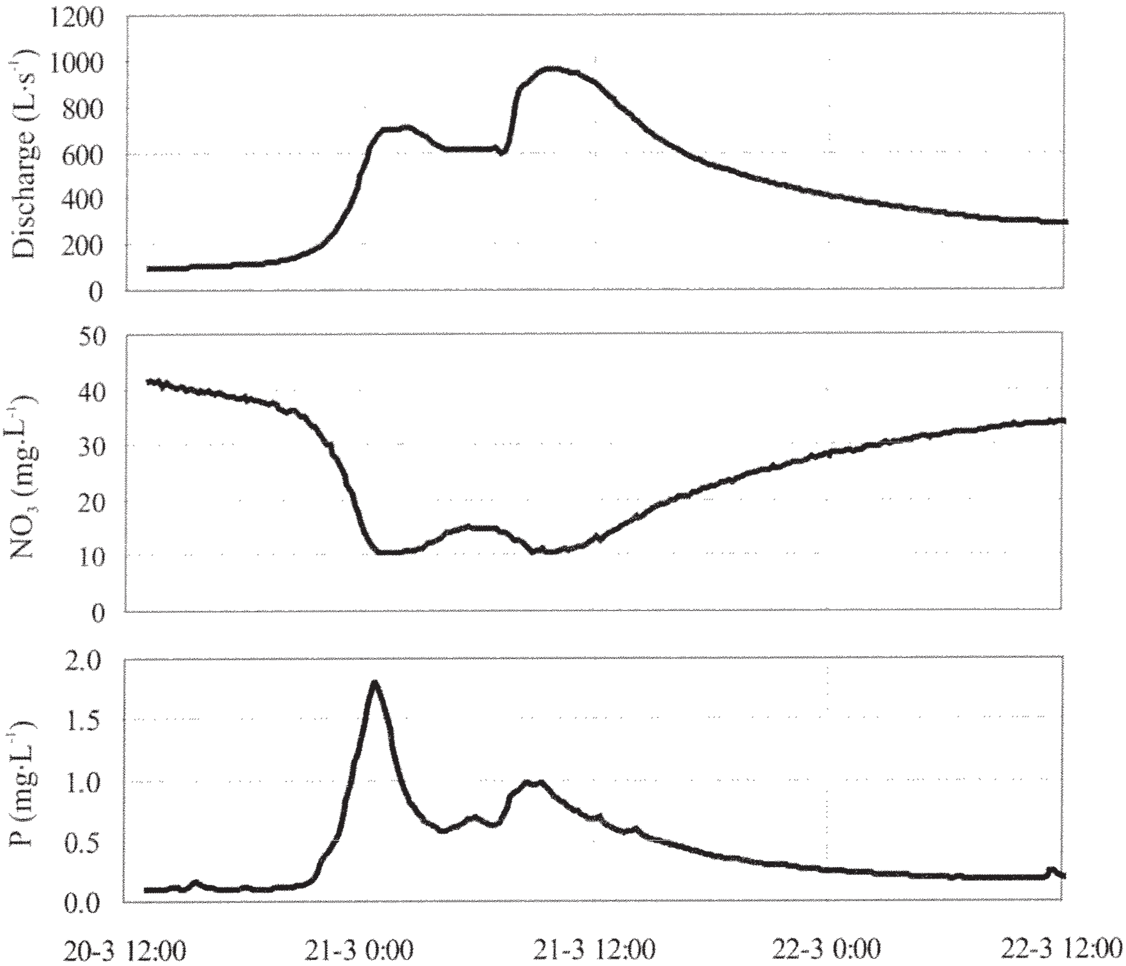
$$\frac{dC}{dt} = \frac{J}{H} - kC$$

During a period of high discharge a 10 ha large and 0.5 km long floodplain section is inundated. The water depth in the inundated floodplain section is 5 m. At the point of inflow the phosphorus concentration was measured to be 0.12 mg l^{-1}. The phosphorus concentration at the outlet remained unchanged at 0.12 mg l^{-1}. The phosphorus release flux rate from the floodplain soil was measured to be 360 mg $m^{-2}\ d^{-1}$.

c. Calculate the first-order phosphorus removal rate constant in d^{-1}.

(15 points)

4. The figure below shows the responses of the NO_3^- and P concentrations in the Hupselse Beek stream to a double storm event in March 2009 (data from Rozemeijer, 2010).



a. Describe the major process that explains the response of the NO_3^- concentration to the first storm event that had the peak discharge at 21 March around 1:00 AM.

b. Describe the major process that explains the response of the P concentration to the first storm event that had the peak discharge at 21 March around 1:00 AM.

The responses of the NO_3^- and P concentrations to the second storm event (with a peak discharge at 21 March around 9:00 AM) differ compared to the responses to the first event and cannot fully attributed to the processes described in answer to question a and b.

c. Describe the main difference in response of the NO_3^- concentration between the first and second storm event and describe the major process that explains this difference.

d. Describe the main difference in response of the P concentration between the first and second storm event and describe the major process that explains this difference.

(16 points)

5. A small village discharges domestic waste water into a small river with a cross-sectional area of 5 m^2. The discharge of the waste water outfall amounts to 50 l s^{-1}. Analysis of water samples from the waste water and from the river just upstream and 1 km downstream of the waste water discharge gave the following results for chloride ammonium, and nitrate concentrations:

Location	**Cl^- (mg l^{-1})**	**NH_4^+ (mg l^{-1})**	**NO_3^- (mg l^{-1})**
Waste water	400	20	<< detection limit
River water upstream of outfall	10	<< detection limit	0.4
River water 1 km downstream of outfall	88	3.0	0.5

Assume steady state conditions and no additional inflows of tributaries or groundwater in the 1 km long river section downstream of the outfall.

a. Calculate the discharge of the river downstream of the waste water outfall.
b. Sketch a schematic diagram of the concentration profiles of ammonium, nitrate, and chloride as function of distance from the waste water discharge to 1 km downstream from the discharge. Explain in brief which processes are responsible for the shape of the profiles.
c. Calculate the first-order nitrification constant expressed in d^{-1}.

(23 points)