Environmental Geotechnics (mp4760) Examination

Date: April 14th 1999
Time: 9.00-12.00 hour

Question 1:
An industrial site is located next to a river. At the site production, handling and storage of petrochemical products take place. This industrial activity already is present since about 1965.

a) Give any suggestions for techniques with which information about the soil structure can be obtained?
b) Mention the advantages and drawbacks of at least three techniques.
c) What type of contamination probably can be found in the subsoil?
d) Which mechanisms are directly responsible for the migration of dissolved contaminants?
e) Which mechanisms retard the migration of a dissolved contaminant and therefore effect the rate of migration?
f) Which mechanisms are responsible for the process of natural attenuation of a dissolved contaminant?
g) Which circumstances stimulate the process of natural attenuation?
h) Which techniques can be applied for the determination of the groundwater quality?
i) Mention the advantages and drawbacks of at least three techniques.
j) When a floating layer is present and groundwater samples are taken from a groundwater standpipe, which mechanisms can disturb your sample?

Question 2:
The site can be characterised as follows. At the beginning of the sixties the land is developed for building purposes. Therefore, the soil surface was raised with a sandy layer. The thickness of this embankment is about 5-m. The current thickness of the former top layer is about 10-m. Underneath this layer the first regional aquifer is present. It has a thickness of about 10-m. The clay layer between the first and second aquifer is a fluvial sediment with a restricted thickness. The second aquifer has a thickness of 20-m. A thick consolidated clay layer borders the second aquifer and is nearly impermeable. A quay is created along the river. At the border of the industrial site with the polder area a former clay dike is present. The dimensions of the site, properties and circumstances are given below:

- Length (kade) 2000 m
- Width 100 m
- Level soil surface 3 m
- Net rate of infiltration 0.3 m^3/m^2/year
- Hydraulic resistance quay 1000 days
- Hydraulic resistance clay dike 1000 days
- Hydraulic resistance former top layer 1000 days
- Average hydraulic head embankment 1 m
- Level surface water 0 m
- Hydraulic head first aquifer 0 m
- Level surface water polder -1 m

At the industrial site contamination is present. A floating layer of pure product is detected. The embankment as well as the first aquifer is contaminated with dissolved hydrocarbons. A polder area is located adjacent to the industrial site. Farmers located in the polder extract groundwater for drinking purposes for their cattle. The owner of the industrial site wants to apply Flexible Emission Control (FEC) as concept for controlling the contamination of the subsoil.

a) Mention the different pathways by which dissolved contaminants might migrate?
b) Give a drawing with the different boundaries of FEC?
c) Give the main principles of FEC?
d) Mention the differences between FEC and ICM (Isolate Control and Monitor)?

e) How do local circumstances fit into the concept of FEC?
f) How can we take uncertainties in soil properties into account?
g) Give a water balance for the embankment at the site?
h) What is width of the area that drains towards the river?
i) What is width of the area that drains towards the polder?
j) When hydraulic containment is necessary for controlling the contaminated plume in the first aquifer give the relevant aspects which have to be taken into account in the designing stage?

Question 3:
The industrial site can be characterised as follows. At the beginning of the sixties the land is developed for building purposes. Therefore, the soil surface was raised with a sandy layer (embankment). In the embankment organic material is present. The hydraulic situation at the site can be characterised as vertical infiltration through the embankment. Advection and adsorption only govern the migration of dissolved contaminants. The adsorption is linear and the coefficient of adsorption can be described as:

$k_a = 10^{4,45} f_{oc} S^{-0,67}$

with:

k_a	: linear coefficient of adsorption	(dm^3/kg)
f_{oc}	: fraction organic carbon	(-)
S	: maximum solubility in water	(mg/dm^3)

The following properties are relevant for the embankment:

• Porosity	0.33 m^3/m^3	• Net rate of infiltration	0.3 m^3/m^2/year
• Hydraulic permeability	10^{-5} m/day	• Fraction organic carbon	0.01
• Thickness embankment	5 m	• Bulkdensity	1650 kg/m^3
• Surface	10 m * 10 m	• Solubility of benzene	1780 mg/litre

a) Give a definition of 'the pore water velocity'?
b) Give the equation with which you can calculate the pore water velocity for the current problem?
c) Calculate the value for the pore water velocity for the current problem?
d) Give a definition of 'the retardation factor'?
e) Give the equations with which you can calculate the retardation factor for the current problem?
f) Calculate the retardation factor for benzene in the current problem?
g) How long does it takes before the sand layer is flushed once?
h) Which mechanisms are responsible for the removal of benzene when we carry out a remediation by flushing?
i) How long does it takes before benzene is removed from the sand layer?
j) Motivate your answer?

Question 4:
At the industrial site contamination is present. A floating layer of pure product is detected as well as a plume of dissolved hydrocarbons. The plume of dissolved hydrocarbons is stationary. The decision is made to remove the LNAPL by 'pump & treat' and by 'venting'.
a) What might be the reasons for carrying out those specific remedial measures?
b) Why is it that the plume can be stationary when pure product (LNAPL) still is available?
c) How will the plume change when we increase the local groundwater velocity as well as the rate of degradation with a factor of two?
d) In which order the remediation techniques 'pump & treat' and 'venting' will be carried out?
e) Which mechanisms govern the process of venting?
f) Which interactions between the different phases are taking place?
g) Which mechanism is responsible for retention of LNAPL within the porous medium?
h) How can we determine whether biological degradation takes place in the subsoil?
i) When biological degradation of per and tri is completed, which chemical compounds will be the end result?
j) How can we stimulate the rate of biodegradation?