Essential questions & proposed answers

**Questions posed on the first day of class**

**A.** What is the danger (from pollutants)?

**B.** Where will the pollutant go, how will it behave?

**C.** What can we do to reduce the danger?

**D.** When do things are relatively easy or difficult and why?

**What are my answers on the last day of class?**

Why do I give a particular answer? With which examples, which case studies can I support my answer?

**A.** **At a contaminated site, what is the danger (from pollutants)?**

• The danger is the impacts of toxic pollutants to the environment (example?) and to human health (example?)

- in environmental geotechnics, we mainly care about long-term impacts of low concentrations of contaminants

• But, we should not make decisions based on danger, but based on risk, which:

- takes into account different exposure pathways and different characteristics (e.g. children, adults) of the exposed population

 - quantifies the probability of occurrence of the impact

• **In this course we learned:**

- to find toxicity characteristics of contaminants

- to calculate risk of carcinogenic and non-carcinogenic impacts to human health

**B.** **At a contaminated site, where will the pollutant go, how will it behave?**

• The pollutant will go everywhere!

• From the release point, the pollutant will move through the unsaturated or/and the saturated zone, where it will partition to all soil phases (gas, water, solids)

• **In this course we learned** (see also detailed learning outcomes for unit 6, soil-contaminant interaction)**:**

- to calculate the distribution of contaminant mass in the three soil phases at equilibrium conditions

- to find the contaminant characteristics that determine this distribution

• The contaminant will be transported due to the mechanisms of advection, diffusion and dispersion through the air of the unsaturated zone and through the water of the saturated zone

• The mechanism of sorption will delay the spreading of the contaminant

• Meanwhile, the contaminant may change (e.g. change of valence for inorganic contaminants) or degrade, resulting in reduction of the contaminant mass

• **In this course we learned** (see also detailed learning outcomes for unit 4, subsurface flow)**:**

- to estimate the direction and the rate of spreading of the contaminant with the average (advection) velocity of groundwater

• **In this course we learned (see also detailed learning outcomes for unit 7, contaminant transport):**

- to calculate how concentrations change with time and with distance from the source, for 1-D groundwater flow

- for a number of initial and boundary conditions at the contaminant source

- taking into account the phenomena of sorption and degradation\* (using an educational software for 2D and 3D transport)

\* we did learn to search for degradation rates in the literature, but, with few exceptions, we did not study degradation pathways

**C. What can we do to reduce the danger?**

• It is always better to prevent/minimize contaminant releases with suitable designs (e.g. bottom liners of landfills) and selection of materials used in underground construction (e.g. grouts used during tunnel construction)

• For the remediation of a contaminated site, we can combine taking measures (to reduce risk) and applying remedial technologies (to reduce risk or hazard)

• In selecting remedial technologies, we use the following criteria:

- remedial goal (e.g. reducing or eliminating exposure, reducing contaminant mass)

- the performance of the remedial mechanism for the contaminants of concern

- access to the contaminants, which depends on site characteristics

• **In this course**

- we were introduced to a variety of remedial technologies and became familiar with the rationale for selecting a technology on the basis of the remedial goal, site characteristics and contaminant characteristics

- we studied in detail a few technologies and became familiar with some of the relevant design parameters

**D. At a contaminated site, when do things are relatively easy or difficult and why?**

• We can differentiate among difficult cases of pollutant release, difficult pollutants and difficult sites

• Difficult cases of pollutant release:

- long-term releases, large quantities of contaminants

• Difficult pollutants:

- persistent pollutants, non-aqueous phase liquids

• Difficult sites:

- heterogeneous soil, low-permeability soil + combinations with the above

• The course gave a taste of these difficulties and offered hints to address them