Resit exam GEO3-4301 Soil and Water Pollution

28 February 2012 17:00 – 20:00 h

1. Define in brief the following environmental terms:
   a. 1:1 clay mineral
   b. Biomagnification
   c. Gamma radiation
   d. Nitrogen fixation
   e. Chelate

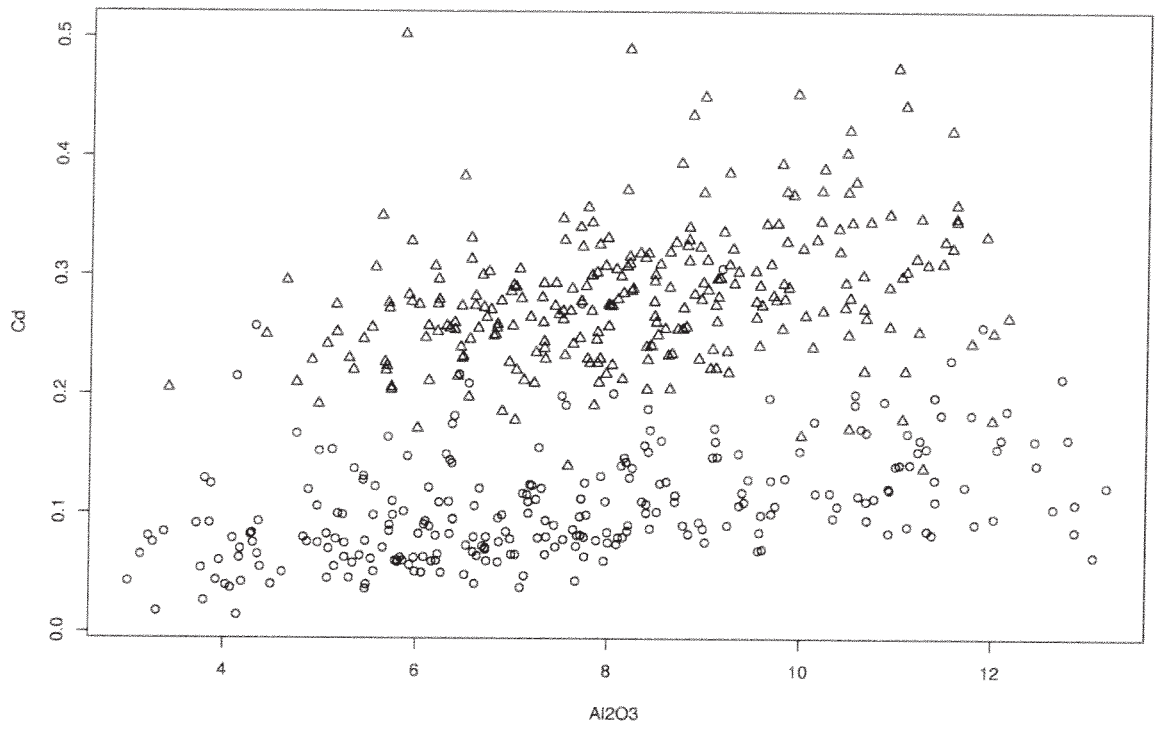
   Explain in brief (max. 30 words per answer)
   f. why the iron concentration increases sharply at a certain depth in groundwater in a sandy aquifer.
   g. why the phosphorus concentration in river water decreases downstream of a waste water discharge;
   h. why heavy metal concentrations in soil correlate positively with soil clay content.
   i. why the Q-C relationship for chloride in rivers is negative.
   j. why dissolved iron disappears in the sulphate reduction zone in groundwater.

(20 points)

2. The decomposition of organic matter in bed sediments or aquifer sediments causes a lowering of the redox potential in a number of consecutive steps. In soil and groundwater these different steps are reflected in different layers or zones characterised by a predominant redox reaction. Describe five of these layers in terms of the predominant oxidant and the reaction products.

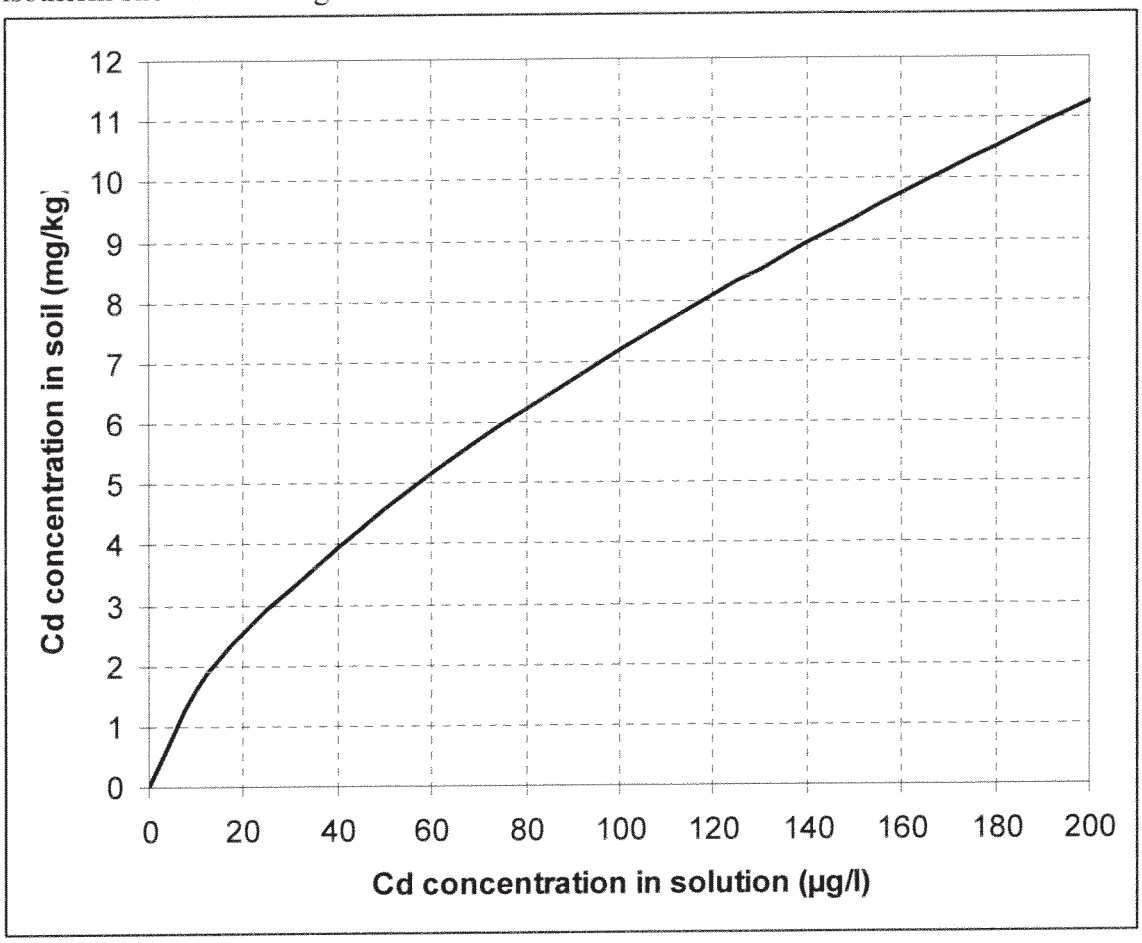
(15 points)

3. For a study to diffuse soil contamination in the Province of Zeeland, soil samples were collected from both the subsoil (about 1 m below soil surface) and the top soil. These samples were analysed for a number of parameters, amongst which Cd and Al_2O_3. In the graph below the Cd concentration (in mg kg^{-1}) are plotted against the Al_2O_3 concentration (also in mg kg^{-1}) for both the subsoil samples (○) and topsoil samples (Δ).
   a. Explain the relation between the Cd and Al_2O_3 concentrations
   b. What is probably the reason why the topsoil samples contain more Cd than the subsoil samples
   c. In a topsoil sample the Cd concentration amounts to 0.43 mg/kg and the Al_2O_3 concentration amounts to 11 mg kg^{-1}. Estimate the anthropogenic enrichment of Cd in this topsoil sample using the information from the graph below.
   d. Name two critical assumptions in this calculation method of the anthropogenic enrichment of Cd.



(20 points)

4. A pipe leakage underneath an industrial facility has discharged cadmium contaminated wastewater in small volumes into groundwater. The cadmium concentration in the waste water was 130 µg l^{-1}. Ten years after the beginning of the leakage, the leakage is discovered and repaired. To assess the dispersal of cadmium in the shallow sandy aquifer, the local hydrologic situation and the adsorption characteristics of the aquifer material are determined. The porosity of the aquifer material amounts to 0.34 and the dry bulk density amounts to 1700 kg m^{-3}. The horizontal groundwater flow velocity was determined to be 50 m per year. To determine the cadmium distribution coefficient a batch-experiment with the aquifer material was carried out, from which the cadmium isotherm shown in the figure below was derived.



a. Derive the cadmium distribution coefficient expressed in l kg^{-1} for the situation described above from the cadmium isotherm.
b. Estimate the maximum horizontal displacement of cadmium 10 years after the beginning of the leakage, given the retardation factor R_f (=1+ $K_d * \rho_b / n$) (neglect dispersion).

(10 points)

5. In an 80 cm deep river, ammonium release from the bed sediment occurs at a rate of 16 mg m^{-2} d^{-1}. The nitrification rate constant is 0.4 d^{-1} and the denitrification rate constant is 0.8 d^{-1}. If internal and external sources and sinks other than release from bed sediments, nitrification, and denitrification can be ignored, and the above rate parameters remain constant, the system tends to equilibrium. See for basic equations/information below.

   a. Calculate the ammonium concentration in mg l^{-1} at equilibrium
   b. Calculate the nitrate concentration in mg l^{-1} at equilibrium.
   c. Name three sources or sinks apart from direct anthropogenic sources (e.g. effluent discharges, agriculture) which may have been overlooked.

(25 points)

First-order decay:	Atomic weights
$\frac{dC}{dt} = -kC$	H = 1
	N = 14
	O = 16
Zero-order release:	
$\frac{dC}{dt} = \frac{J}{H}$	