Examination in Environmental Risk Assessment in Engineering, BOM060

Use separate sheets to answer questions. The only accepted support is pen, dictionary, eraser and calculator.

Q1. Sensitivity analysis (5 p)

The GREAT-ER model is a model that can be used to calculate the risk of chemical emissions to rivers. One part of the model is the calculation of the (dimensionless) removal of chemicals from the river (R_{river}). It can be calculated according to the following equation:

$$R_{\text{river}} = 1 - e^{-\frac{Lk}{v}}$$

In this equation, L is the length of the river [m], v is the flow velocity [m/s], and k is the removal rate constant [s^{-1}]. The parameter e is a mathematical constant (the base of the natural logarithm), and has an approximate value of 2.7. Often in environmental risk assessments of rivers, the river is divided into many stretches which each has the length L, but here we will assume that the whole river is one single stretch. Assume a 1 km long river, with a water flow velocity of 0.01 m/s. For the chemical paracetamol, which is common in painkillers, the removal rate constant is approximately 0.0032 h^{-1}.

a. First, calculate R_{river}. Then, calculate the sensitivities of the input parameters L, v, and k given a 50% increase. Which of the parameters is most sensitive? (3 p)

b. As an alternative to this type of sensitivity analysis, scenarios can be used. Suggest and motivate a scenario analysis strategy for evaluating the sensitivity of the three parameters. (1 p)

c. As yet another alternative, Monte Carlo simulation can be used for evaluating the sensitivity of R_{river} to variations in L, v, and k. What would be the main difference for the parameters L, v, and k when analysed by Monte Carlo simulations and when analysed with the other sensitivity analysis strategies mentioned above? (1 p)

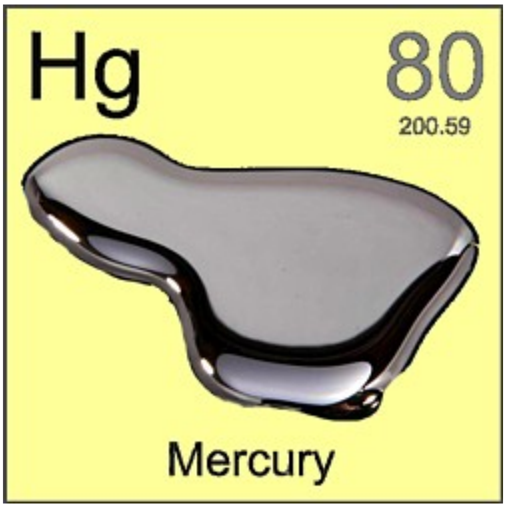
Q2. Exposure assessment (5 p)

In section 7.5.6 of the course book, Burgman writes about the toxic substance mercury in the South African u'Mgeni River.

a. Draw a graphical single compartment mass balance fate model for mercury in the river. In addition to emissions/inflow of mercury, include three fate processes that you think are relevant. (2 p)

b. Based on your graphical single compartment mass balance fate model, draw a schematic equation by which you would be able to calculate the predicted environmental concentration (PEC) of mercury in the water. Do not forget to include all the fate processes that you have included in the model. (2 p)

c. Water (such as that of the u'Mgeni River) is an example of a general environmental compartment often seen in mass balance fate models for exposure assessment. Name two other such general compartments. (1 p)



Q3. Chemical risk assessment framework (5 p)

a. Draw and explain the chemical risk assessment framework. Do not include risk management. (4 p)

b. State the equations used for calculating ecological/environmental and human health risks in chemical risk assessment, and briefly explain the terms in the equations. (1 p)

Q4. Hazard identification and risk estimation (5 p)

Hazard identification and risk estimation are two important steps of the overall risk management work.

a. Give two examples of aspects that should be considered when performing hazard identification (i.e. what characterize good hazard identification?) and shortly explain one type of method that can be used when identifying hazards. (3p)

b. Explain shortly a typical qualitative risk estimation method (sometimes also referred to as a risk classification/ranking method), what results are obtained and how this information can be used. (2p)

Q5. Contaminant migration (5 p)

You are contracted to perform an environmental risk assessment at a former industrial site. Of special interest is an adjacent stream with high protection value because of its high importance as a reproduction stream for salmon. As a part of your risk assessment you need to perform a calculation of the contaminant mass flux to the stream. The mass flux, F_{tot}, to the river is given by the following model:

$$F_{tot} = Q \cdot C = K \cdot \frac{dh}{dl} \cdot A \cdot C$$

Where: Q = the groundwater flow [m^3/s]

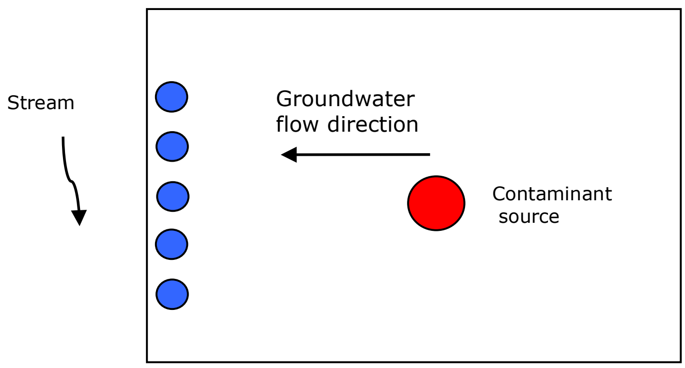
C = the contaminant concentration reaching the river [g/m^3]

K = the hydraulic conductivity [m/s] = $5x10^{-4}$ m/s

dh/dl = the hydraulic gradient [m/m] = 0.005

A = the cross-sectional flow area of the groundwater flow [m^2] = 1000

The area is conceptually shown below:



You have taken 5 samples of the groundwater contaminant concentration near the stream, represented by the five filled circles on the map. You got the following results: 9.33, 12.55, 45.21, 13.63 and 3.36 g/m^3. You expect the hydrogeological conditions to be rather uniform over the area and at steady-state, i.e. concentrations are not expected to change over time. The flow in the small stream, Q_s = 0.03 m^3/s.

a. Why did you take the samples at the marked locations? (1p)
b. What is the mass flux of contaminants to the stream? (2p)
c. Motivate how you handled the contaminant concentration data in your calculations. (1 p)
d. What is the concentration in the stream downstream the site and after full dispersion of the contaminant? (1 p)

Q6. Effects assessment (5 p)

To construct a relationship between exposure to chemicals and observed effects on a specific endpoint, experiments can be performed. What are the requirements for such an experiment? How are they constructed? How are the results mostly represented? (Illustrate with a graph.) (5 p)

Q7. Risk perception and professional duties of risk assessors (10 p)

An old - but still valid - conceptualisation of the social construction of environmental problems (and risks) by Parlour and Schatzow (1978) indicates that media has an important role to play. Who are the other important actors (and actants) involved? How can their connections be conceived (draw a simple model of the influences)? Where do you as educated specialists of risk assessment place yourself in the influence diagram? What does this mean in terms of responsibilities and professional duties? (10 p)

Q8. Risk assessment at contaminated sites (6 p)

a. Risk assessment at contaminated sites is based on the concept of "source-pathway-receptor". However, the risk assessment can be made in two essentially different ways: (1) with the use of guideline values and (2) with the use of risk levels. Describe these two principles. (3p)

b. Describe the difference between generic soil guideline values and site-specific guideline values. (2p)

c. What would be the soil guideline value given the following data? (1p)

Human health toxicological values:
Reference value for soil intake: 16 700 mg/kg dry soil
Reference value for dermal contact: 2 000 mg/kg dry soil
Reference value for inhalation of dust: 1 800 mg/kg dry soil

Ecotoxicological value:
Dutch C-value: 200 mg/kg dry soil

Q9. Soil sampling and data evaluation (4p)

a. What is the statistical definition of a sample and what is a common field definition of a sample? (1 p)

b. You are about to plan a sampling campaign at a contaminated site and one of your sampling objectives is to be able to calculate an unbiased estimation of the mean concentration of the most important contaminants at the site. Describe the most important considerations when developing your sampling plan. (3 p)