Examination Environmental Risk Assessment in Engineering, BOM060, 2014-03-11, 14.00-18.00
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Student ID no. ……..........................

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. Chemical risk assessment framework (5 p)

There exist several environmentally-related risk assessment frameworks. One specific that has been presented to you is the chemical risk assessment framework.

a. What is the first major step in the chemical risk assessment framework? What does it involve? (1 p)

b. What are the two following, parallel steps of the chemical risk assessment framework? What is the aim of each of these steps? What are the results or outputs of these two steps? (2 p)

c. What is the final step of a chemical risk assessment? What is conducted in that step? What is the result or output of that step? (1 p)

d. The fourth and final step of a chemical risk assessment implies a certain definition of risk which is applied in chemical risk assessment. Which definition of risk, that is in line with the final step in the chemical risk assessment framework, is that? (1 p)

Q2. Exposure assessment (5 p)

"*The overuse of pesticides has already resulted in severe environmental deterioration, such as contamination in aquatic ecosystems and groundwater. In addition, pesticide residues in agricultural products can threaten human health through the food web. Inadequate protection from the exposure to pesticides also put the peasants and workers into danger, especially in developing countries*."

(Liu *et al*. 2012, Environmental Science & Technology, 46, 5658−5659)

Consider a lake situated close to an agricultural land. Further assume that pesticides are continuously applied to the soil. From the land, it reaches the lake in two ways. The first is leaching from the soil to the water in the lake. The second is via something called "spray drift", which means that a share of the sprayed pesticides travels with the wind to the lake, before it lands on the soil.

a. Draw a graphical multimedia mass balance fate model for the water compartment that the lake constitutes. In addition to the two mentioned emission pathways, also include at least two additional fate processes for the pesticides in the water. (2 p)

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

c. Name two chemical properties of the pesticides that you think will affect the fate processes that you have included in your model. Also name which fate process they affect, respectively. (1 p)

Soybean spraying in Goiás, Brazil, November 2011. Photo by Christel Cederberg.

Q3. Sensitivity analysis (5 p)

At the division of Environmental Systems Analysis, there is currently an ongoing master thesis project about assessing the risks of pharmaceuticals to fish in the Göta älv river. One specific pharmaceutical studied is the painkiller diclofenac. Part of that project is to estimate emissions to the river. This can be done by the following simple equation:

$$E = P \times A \times x$$

where E is the emissions to Göta älv [kg/year], P is the population that are connected to waste water treatment plants along Göta älv [capita], A is the per capita consumption of diclofenac [kg/capita and year], and x is the removal rate of diclofenac at the waste water treatment plant [dimensionless]. As you can probably imagine, the input parameters to this equation are uncertain.

a. One potential method for sensitivity analysis is the s_p equation described in the course book by Mark Burgman. However, this method would not be very interesting to apply in this case. Explain why. (1 p)

b. Another, in this case more suitable method would be scenario analysis. Describe two general types of scenarios that could be useful for the parameter A in the equation above, and why they would be interesting. (1 p)

c. Another method that could be useful is Monte Carlo simulations. Describe shortly how a Monte Carlo simulations of the equation above would be conducted. Also, based on the experience you have received during the course, suggest probability density functions for the three input parameters (P, A and x) and motivate. (3 p)

Q4. Hazard identification and risk ranking (5 p)

Hazard identification is an important step when assessing risks, irrespectively of what kind of further analysis that is performed.

a. Give <u>two</u> examples of aspects that should be considered when performing hazard identification (i.e. what characterise good hazard identification?). (2p)

b. Give <u>two</u> examples of tools/means and explain shortly how they can be used for identifying hazards. (1p)

c. Explain shortly the principles of risk ranking – what results are obtained and how can this information be used? (2p)

Q5. Contaminant transport (5 p)

You have mapped the geological boundaries of an unconfined aquifer and based on average groundwater recharge in this type of aquifer you estimate that the aquifer discharges 20 l/s to a nearby stream. The hydraulic conductivity is approximately 10^{-4} m/s (sand) and the porosity 20%. You have measured the hydraulic gradient in observation wells near the stream and found that the average gradient is 0.01. You expect the aquifer to be contaminated by pesticides due to an old manufacturing facility located on top of the aquifer. The stream flow is 200 l/s on average.

a. How big is the cross-sectional area between the aquifer and the stream? (3p)

b. You have measured a pesticide concentration of 0.01 mg/l in the stream. What is the mass flux of the solvent into the stream from the aquifer? (2p)

Q6. Effects assessment (8 p)

Give a description of a typical ecotoxicological test system set up for the measurement of strictly controlled arsenic exposure effects on earth worms, including the principles for data handling and interpretation in relation to their use in an ecological risk assessment of a contaminated site.

Q7. Conceptual model (2 p)

What is a conceptual model? Sketch a conceptual model linking all human causes of stress to all significant effects that put stress on all organisms on Earth.

Q8. Environmental risk assessment (5 p)

In your future possible role as consultant, and as you already have understood, you will work in a very complex environmental risk assessment reality, consisting of technical (e.g. software, sampling equipment, remediation techniques), ecological (many different species interacting in a complicated way) and social (many actors, many interests and values) aspects. Give examples and discuss what can go wrong when performing an ecological risk assessment of a contaminated site.

Q9. Contaminated sites and risk assessment (4 p)

a. How are generic soil guideline values for contaminated sites derived? (2 p)

b. Explain the difference between generic soil guideline values and site-specific soil guideline values for contaminated sites. (2 p)

Q10. Soil sampling (2 p)

A soil sampling program was carried out at a former metal industry. The field personnel followed your prescribed map of the soil sample locations, which you had placed randomly within the site – you used a stratified random sampling design to ensure a good coverage of the whole site. A drilling auger was used as a sampling device and was used to drill down to the rock, which at this site was 1-1.5 meters below the surface. In the field, the personnel choose samples depth wise to send to the laboratory for chemical analysis according to whether they looked contaminated or not. You have now received the results of the analyses and you want to make a calculation of UCLM95 to base your risk assessment on. What should be your largest concern regarding the soil sampling procedure?

Q11. Uncertainties and decisions (4 p)

Consider "*Figure 3.6 The decision space…*" below.

a. If you use UCLM95 as the representative value of the site to compare with the guideline value, which error type (or type of wrong decision) do you aim to avoid? Motivate your answer. (2 p)

b. How can you reduce the probability for making any of the two types of wrong decisions? (2 p)

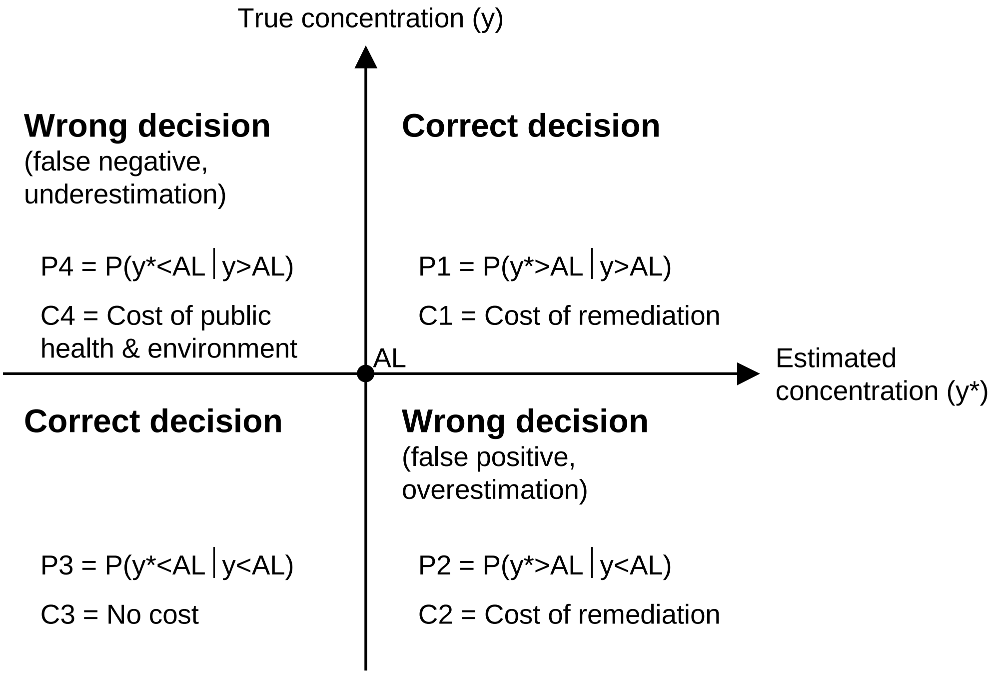

Figure 3.6 The decision space for classification of contaminated land (after Flatman and Englund, 1991). The two axis intersect at the action level AL. The probability of occurrence (P) and the cost (C) is described for each type of classification.