ENV 4001: ENVIRONMENTAL SYSTEMS ENGINEERING

Fall 2021 University of South Florida
Problem Set #4 Civil & Environmental Eng.
Complete by Wednesday, October 6 Prof. J.A. Cunningham

This problem set will not be collected or graded. Your reward for completing this problem set is that it is essential for learning the course material and passing the quizzes and final exam.

1. Answer the following problems in your text book: 6.25, 6.26, 6.27, and 6.31.

2. Suppose a toxicologist ran some tests to determine the acute toxicity of Chemical Z on zebrafish. Groups of zebrafish (100 zebrafish in each group) were given different doses of Chemical Z, and the toxicologist monitored how many zebrafish died under each dose. The results are given in the following table.

Dose of Chemical Z (mg of Chemical Z per kg of zebrafish body mass)	Number of zebrafish that died (out of 100 fish in each group)
5.4	1
7.1	12
8.2	34
10.1	81
11.9	98

   a. Do these data appear to follow a Gaussian model for dose-response? Use Gaussian graph paper to decide.
   b. Explain in words what the term "LD50" means in the context of acute toxicity. Estimate the LD50 for Chemical Z on zebrafish. Hint: use your graph from part a.
   c. Explain in words what the term "NOAEL" means in the context of acute toxicity. Why can't we tell the NOAEL for Chemical Z on zebrafish from the data given? Can you come up with a decent estimate for the NOAEL?
   d. How well do the data match the equation given in problem 6.22 of the text book?

3. Suppose you are asked to make a recommendation to the U.S. Environmental Protection Agency on how much Chemical X should be allowed in our drinking water. Some toxicologists ran tests to see how exposure to Chemical X affected laboratory animals. The toxicologists then used their animal tests to estimate how Chemical X might affect humans. Based on their lab tests and their estimates, they gave you the following data.

Concentration of Chemical X in Drinking Water (μg/L)	Lifetime Risk of Contracting Cancer Caused by Exposure to Chemical X
100	1×10^{-7} to 1×10^{-2}
50	1×10^{-8} to 1×10^{-3}
10	1×10^{-9} to 1×10^{-4}
2	1×10^{-10} to 1×10^{-5}

Now consider a city in which 500,000 people reside. Suppose that, currently, the drinking water contains around 100 μg/L of Chemical X.

a. How many cancer cases would you avoid if the concentration of Chemical X in drinking water is reduced to 50 μg/L? How many cancer cases would you avoid if it reduced to 10 μg/L? to 2 μg/L? Hint: your answers must be reported as *ranges* of numbers, because the input data are given as ranges of numbers.
b. For Chemical X, what should be the Maximum Contaminant Level Goal (MCLG) for our drinking water? Hint: look up how MCLGs are set for suspected carcinogens under the Safe Drinking Water Act.
c. Do you have enough information to recommend to EPA what the drinking water Maximum Contaminant Level (MCL) should be? If yes, then what level do you recommend for the MCL? If no, then what additional information would you need to make your recommendation? Hint: look up how MCLs are set under the Safe Drinking Water Act.

Note: Problem 3 is pretty similar to how EPA actually sets its drinking water standards. For more information, you can read the following article:

Cothern, C.R., W.A. Coniglio, and W.L. Marcus, 1986. "Estimating risk to human health: Trichloroethylene in drinking water is used as the example." *Environmental Science & Technology*, vol 20, no 2, pp 111–116.

4. When we disinfect our water with chlorine, we produce disinfection by-products called trihalomethanes (THMs). In 2004, the City of Tampa reported THM concentrations around 27 μg/L in drinking water, and the City of Temple Terrace (where I live) reported concentrations around 43 μg/L. (We have more recent data, but let's just use the 2004 value of 43 μg/L.) Exposure to THMs is known to increase the risk of health problems, including cancer. Although the term "THM" includes many different chemicals, the most prevalent chemical in this group is chloroform. For the purposes of this problem, assume that all THMs are in the form of chloroform, i.e., Tampa water contains 27 μg/L chloroform, and Temple Terrace contains 43 μg/L chloroform.

   a. Estimate the chronic daily intake (CDI) of chloroform from exposure to City of Tampa water. Consider both ingestion of water and inhalation from bathing; we will ignore dermal absorption from bathing. Assume that the person under consideration is a 65-kg woman who takes an average-length shower every day. Clearly state whatever assumptions you make in estimating the CDI. Report your answer in units of mg chloroform per kg body mass per day.

      Hint: Assume that the concentration of chloroform in the air during a shower is 5% of the concentration in the water. That is just a ballpark estimate (based on Henry's constant and a guess of how close we are to equilibrium), but it might be pretty close.

   b. Now estimate the CDI of chloroform for a similar woman who lives in Temple Terrace. Report your answer in the same units.
   c. For these two women, estimate the lifetime risk of their contracting cancer due to chloroform in the drinking water.
   d. Consider that the average cancer death rate in the U.S. is 193 deaths per 100,000 people per year. Does it appear that a significant number of these deaths are caused by exposure to chloroform in our drinking water? Based on this, do you think that disinfection of drinking water leads to a significantly higher risk of contracting cancer?

5. Imagine that at the Slow Suicide Bar, they still allow patrons to smoke cigarettes inside the bar. Because of this, the concentration of benzene in the air of the Slow Suicide Bar is around 100 $\mu g/m^3$. Benzene is a known carcinogen.
   a. A waitress who works at Slow Suicide is worried about her risk of contracting cancer from breathing second-hand smoke. The waitress is 26 years old, she weighs 55 kg, and she works 5 shifts per week with an average shift length of 7 hours per shift. If this waitress works at Slow Suicide for the next 10 years, what is her risk of contracting cancer from breathing the benzene in second-hand smoke? Hint: you will need to find a "slope factor" for the inhalation of benzene – you should indicate what source you used to find this value.
   b. Imagine that a city has 100,000 people in it, and that of these people, 500 work full time (or close to full time) as waiters or waitresses in bars and restaurants. If all 500 of them are exposed to benzene concentrations similar to that in the Slow Suicide Bar, how many are expected to contract cancer *this year*? Hint: estimate the *lifetime* risk, then divide by the average lifetime to find the risk for *this year*.
   c. Consider that the average cancer death rate in the U.S. is 193 deaths per 100,000 people per year. Do you think breathing second-hand smoke in restaurants contributes significantly to the cancer death rate? Explain.
   d. One of the arguments for banning smoking in bars and restaurants is that it is necessary to protect the health of the employees. Based on your calculations above, do you believe this argument has validity? Explain why or why not. There is no "right" answer here, but your conclusion must be supported by your calculations in parts (a)–(c).

6. Pick your favorite of the UN Sustainable Development Goals (SDGs). Look up the *targets* for that SDG. Note that the word "target" has a specific meaning in the context of the SDGs. Write down three of the targets associated with your goal.