ENV 504: Remediation of soil and groundwater
Rizlan Bernier-Latmani
Problem set # 5: adsorption processes

Problem 1:
A groundwater aquifer in California has been contaminated with atrazine, an organic agricultural chemical, at a concentration of 300 µg/L. The State Health Department permits a maximum of 3 µg/L atrazine in drinking water. To meet the State's requirement, it is proposed to use activated carbon to treat the groundwater pumped from a group of wells that produce the groundwater at a rate of 2 m^3 per minute. The equilibrium isotherm for adsorption of atrazine on activated carbon is given by
$C_s = 250\ C^{0.003}$
where C_s =sorbed concentration (µg sorbed per g activated carbon) and C= equilibrium aqueous concentration (µg/L).
Granular activated carbon (GAC) is to be used to control this atrazine problem.
Total flow: Q= 2 m^3/min
C_{in}=300 µg/L
C_{out}=3 µg/L
Adsorbent bed length L=15m
Surficial velocity v_0=5 m/h
GAC grain diameter d_g=1.5 mm
GAC bulk density ρ_b=425 kg/m^3
ε_b= intragranular void fraction of bed=0.35

For simplicity, we will assume that the adsorption zone is S-shaped and symmetrical.

a- Calculate the empty bed contact time (minutes).
b- Assuming that the flow is treated in a single bed, what diameter is needed?
c- Approximately how long before the effluent concentration of the bed rises to 3 µg/L? How many bed volumes does this represent?
d- Calculate the average rate at which the GAC adsorbent must be reactivated (in gram of activated carbon per m^3 water treated).

Problem 2:
The goal is to remove metals from the following effluents using packed bed reactors containing either silica immobilized algae (SIA) or Actinomycetes.
Waste steam 1: 2 mg/L Cu^{2+}, 2 mg/L Cd^{2+}, 2 mg/L Zn^{2+}, pH 4. All concentrations must be below 600 µg/L.
Waste stream 2: 1.2 mg/L Cd^{2+}, 1.5 mg/L Zn^{2+}, pH 6. All concentrations must be below 600 µg/L.

Equilibrium isotherms for all three metals with SIA and actinomycetes are given in the next page. The beds contain each 50 kg of sorbent and the flow rate is 5 L/min.

Additivity is assumed for the sorption of these metals on these sorbents. Hence, the sorption behavior of single metal is expected to be the same as in the presence of other metals.

Which of the two sorbents would you use for each of the waste streams?