ENV 4417: WATER QUALITY & TREATMENT

Fall 2015 — University of South Florida
Problem set #1 — Civil & Environmental Eng.
Due Tuesday, Sept. 8 — Prof. J. A. Cunningham

1. (50 pts) In the grocery store, you can buy bottled Evian water. Evian water is imported from the French Alps. To me, the idea of importing bottled water across an ocean does not make a lot of sense, but one thing that I do like about Evian water is that they report the mineral composition of their water. The numbers in the table below are from the Wikipedia entry for Evian water (https://en.wikipedia.org/wiki/Evian); these numbers differ slightly from the values that used to be reported on the bottles, but the differences are not large. For this assignment, we'll use the values from the Wikipedia page, not from the old labels.

   Ion concentrations, in mg/L:

Calcium, Ca^{2+}	80.
Chloride, Cl^{-}	6.8
Bicarbonate, HCO_3^{-}	360.
Magnesium, Mg^{2+}	26.
Nitrate, NO_3^{-}	3.7
Potassium, K^{+}	1.
Silica, SiO_2	15.
Sodium, Na^{+}	6.5
Sulfate, SO_4^{2-}	12.6

   pH: 7.2

   (By the way, the old labels used to claim that Evian water is "sodium-free", a claim about which I was always a bit skeptical; the concentration of 6.5 mg/L sounds more realistic.)

   a. (5 pts) Calculate the concentrations of H^{+} and OH^{-} in mg/L and in meq/L. Are these concentrations significant compared to the concentrations of the other ions reported? Decide whether you have to include those ions when you do part (b), next.
   b. (10 pts) Calculate the concentrations of the major ions in meq/L, and summarize the results in a table. In your table, put the cations and the anions in separate sections. Do the cations and anions appear to be in charge balance (say, within 5%)? If not, what ion(s) do you think might be missing from the above analysis, and what concentrations of those ions would result in a suitable charge balance?
   c. (7 pts) The old Evian bottles also said that the total dissolved solids at 180 °C is 309 ppm. Is this information consistent with the values given in the table above? Explain.

problem 1 continues →

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   d. (7 pts) If you wanted a quick estimate of the total dissolved solids, but did not want to run the full TDS test, you might measure specific conductance instead, because it can be measured quickly with a probe. Then you could estimate the TDS from the conductance. Here let's do it the other way; since we think we know the TDS of Evian water, what would you expect the specific conductance to be if you measured it? *Document how you make your estimate*.
   e. (7 pts) Estimate the ionic strength of Evian water.
   f. (7 pts) Estimate/calculate the hardness of Evian water. Report your answer as mg/L $CaCO_3$. Is all of the hardness due to carbonate hardness, or is any of it non-carbonate hardness?
   g. (7 pts) Estimate/calculate the alkalinity of Evian water. Report your answer as mg/L $CaCO_3$. How does your alkalinity value compare to the hardness?

2. (20 pts) The following problem comes from *Environmental Engineering: Principles and Practice*, by R.O. Mines, Jr. (whose nephew, by the way, graduated from USF with a degree in Civil Engineering – he was a student of mine in ENV 4001!).
   A solids analysis is performed on a wastewater sample. The abbreviated procedure is outlined as follows:
   a. A Gooch crucible and filter pad are dried at 105 °C to a constant mass of 25.439 g.
   b. 200 mL of a well-mixed sample of the wastewater is passed through the filter pad.
   c. The crucible, filter pad, and solids collected on the pad are dried at 105 °C to a constant mass of 25.645 g.
   d. 100 mL of the filtrate that passes through the filter pad in step (b) is placed in an evaporation dish that has been pre-weighed at 275.410 g.
   e. The sample in step (d) is evaporated to dryness at 105 °C and the dish and the residue are weighed at 276.227 g.
   f. Both the crucible from step (c) and the evaporation dish from step (e) are placed in a muffle furnace at 550 °C for an hour. After cooling in a dessicator, the mass of the crucible is 25.501 g and the mass of the dish is 275.944 g.

   Determine the following: suspended solids (mg/L), dissolved solids (mg/L), total solids (mg/L), organic or volatile fraction of the suspended solids (mg/L), and the organic or volatile fraction of the dissolved solids (mg/L).

3. (15 pts) Answer problem 8.29 in the text book. As part of the problem, complete the table, and prepare a graph of BOD versus time. Turn in the completed table and the graph as part of your solution. Also estimate the apparent BOD rate coefficient, *k*, including proper units. Show your work for how you estimated *k*. Finally, estimate the ultimate BOD of the wastewater.

4. (15 pts) A wastewater contains 110 mg/L of organic matter that has an approximate molecular formula of $C_5H_7O_2N$. The wastewater also contains 36 mg/L of NH_4^+. The pH is 7.3 which means that there is very little NH_3 present. (It is all NH_4^+ because pH << pK_A. If you don't follow that, it is OK – the important part for right now is that there is no NH_3.)
   a. (5 pts) Estimate the total Kjeldahl nitrogen (TKN) of the wastewater in units of mg-N/L.
   b. (10 pts) Estimate the theoretical oxygen demand of the wastewater if all carbon is oxidized to CO_2 and all nitrogen is oxidized to NO_3^-. You can use the following balanced equations:

      $C_5H_7O_2N + 7\ O_2 \rightarrow 5\ CO_2 + NO_3^- + H^+ + 3\ H_2O$

      $NH_4^+ + 2\ O_2 \rightarrow NO_3^- + 2\ H^+ + 2\ H_2O$

      What fraction of the theoretical oxygen demand is carbonaceous and what fraction is nitrogenous?

I would really like to add a problem about estimating MPN for coliform bacteria in a drinking-water source (like a river), but it will take me some time to come up with that. Maybe if we do a unit on disinfection this semester I can come up with something.