ENVE 445
Homework Set 6

Instructions: *Clearly show your steps when solving problems and if you feel additional information is needed, state clearly any assumptions you are making. Lack of clarity and failure to include assumptions will result in loss of points. Homework must be done individually, you may discuss the problems with classmates, but do not copy solutions; the solutions must be written up independently. Copying other students work, sharing solutions with others, or copying from solutions manuals or homework solution sets from prior years will result in zero grades for the homework for both parties and the incident will be reported to the SDSU Center for Student Rights and Responsibilities, where further action may be taken.*

Problems:

1. The LifeStraw Membrane Microfilter (https://www.lifestraw.com/) claims to remove 99.999% of parasites (Giardia, Cryptosporidium) from water.
   a. What is the equivalent $\log_{10}$ reduction value for 99.999%?

$$\boldsymbol{LRV = \log_{10}\left(\frac{100}{100 - 99.999}\right) = \boxed{5\ \log_{10}}}$$

   b. If a source water contains 3.4E+2 oocysts/L of *Cryptosporidium*, then what is the concentration of water treated with the LifeStraw Membrane Microfilter, if the device removes 99.999% as they claim? Express your answer in oocysts/L.

$$\boldsymbol{C = 340(1 - 0.99999) = \boxed{0.0034\ \text{oocysts/L}}}$$

2. Consider a 6 MGD water treatment system with conventional filtration (e.g., coagulation/flocculation and sedimentation followed by filtration) serving a population of >10,000 with 15°C source water containing 13 oocysts/L *Cryptosporidium*.
   a. What is the additional *Cryptosporidium* $\log_{10}$ reduction requirement for disinfection of the filtered water?

2.5-$\log_{10}$

Bin Classification For Filtered Systems

Cryptosporidium Concentration (oocysts/L)	Bin Classification	Additional *Cryptosporidium* Treatment Required			Alternative Filtration
		Conventional Filtration	Direct Filtration	Slow Sand or Diatomaceous Earth Filtration	
< 0.075	Bin 1††	No additional treatment required			
0.075 to < 1.0	Bin 2	1 log	1.5 log	1 log	(1)
1.0 to < 3.0	Bin 3	2 log	2.5 log	2 log	(2)
≥ 3.0	Bin 4	2.5 log	3 log	2.5 log	(3)

†† Systems serving < 10,000 people that are not required to monitor for *Cryptosporidium* are placed in Bin 1.
(1) As determined by the state (or other primacy agency) such that the total removal/inactivation > 4.0-log.
(2) As determined by the state (or other primacy agency) such that the total removal/inactivation > 5.0-log.
(3) As determined by the state (or other primacy agency) such that the total removal/inactivation > 5.5-log.

b. If chlorine dioxide is applied to a contact chamber with a T_{10} value of 360 min, what residual chlorine concentration is needed at the effluent of the contact tank in order to comply with the $\log_{10}$ reduction requirement?

$$\boldsymbol{LRV = 0.001506\left(1.09116^{\mathrm{Temp}}\right) \times CT}$$

$$\boldsymbol{C = \frac{2.5}{0.001506(1.09116^{15}) \times 360} = \boxed{1.2\ \mathrm{mg/L}}}$$

Exhibit 10.1 CT Values (mg-min/L) for *Cryptosporidium* Inactivation by Chlorine Dioxide [1]

Log credit	Water Temperature, °C										
	<=0.5	1	2	3	5	7	10	15	20	25	30
0.25	159	153	140	128	107	90	69	45	29	19	12
0.5	319	305	279	256	214	180	138	89	58	38	24
1.0	637	610	558	511	429	360	277	179	116	75	49
1.5	956	915	838	767	643	539	415	268	174	113	73
2.0	1275	1220	1117	1023	858	719	553	357	232	150	98
2.5	1594	1525	1396	1278	1072	899	691	447	289	188	122
3.0	1912	1830	1675	1534	1286	1079	830	536	347	226	147

[1] Systems may use this equation to determine log credit between the indicated values:
Log credit=$(0.001506 \times (1.09116)^{\mathrm{Temp}}) \times$ CT

c. Suppose the chlorine dioxide decays at a first order rate of -0.1 per hour in the disinfection contact chamber. Assuming plug flow conditions, what concentration would have to be added to the water at the influent of the contact chamber?

Under plug flow assumption, T_{10} = mean HRT.

$$\boldsymbol{C = C_o e^{-kt}}$$

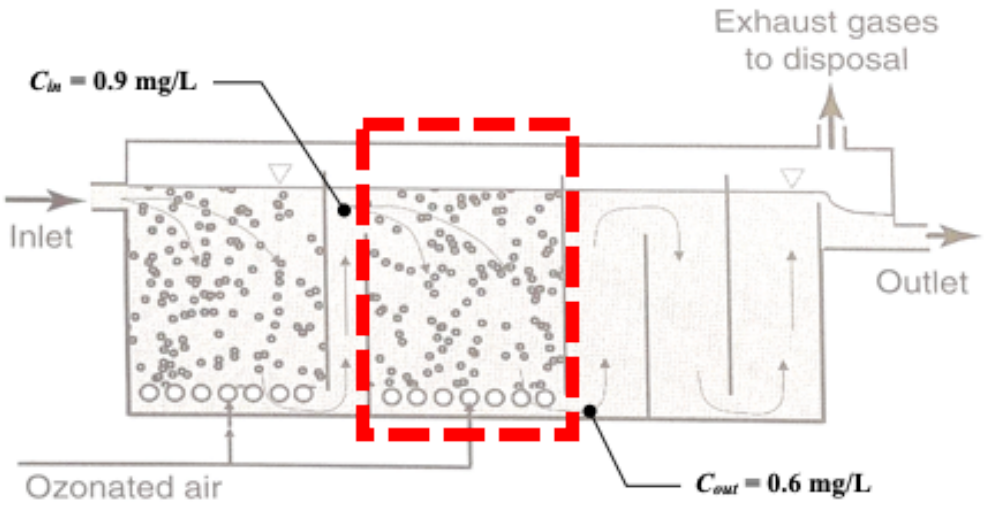
$$\boldsymbol{C_o = Ce^{kt} = 1.2e^{0.1 \times 6} = \boxed{2.2\ \mathrm{mg/L}}}$$

d. Given the concentration calculated in part (c), what is the approximate dosing rate of chlorine dioxide? Express your answer in kg/day.

6 MGD * 3785 m³/mil. gal. = 22,710 m³/day

Dosing Rate = 2.2 g/m³ * 22,710 m³/day = ~50 kg/day

3. What CT value can be claimed for the second counter-current dissolution chamber in series of an ozone reactor (as indicated below) with C_{in} = 0.9 mg/L and C_{out} = 0.6 mg/L? Assume a tracer test showed that the T_{10} value for this chamber was found to be 8 min. Express your answer in mg-min/L.



$$CT = \frac{0.6\,\frac{\text{mg}}{\text{L}}}{2} \times 8\ \text{min} = \boxed{2.4\,\frac{\text{mg}\cdot\text{min}}{\text{L}}}$$