Problem 1

A 10,000-gal bioreactor operates at a biomass concentration of 2,500 mg/L (as MLVSS) and treats 13,000 gal/day liquid waste that contains an organic contaminant. The suspended solids are separated in a clarifier following the bioreactor with recycle of separated sludge (i.e. your system looks like the one shown in Figure 10-13 of your textbook). We know that at least 25 days of solids retention time is required for effective treatment of this waste stream. What is the recycle flow rate if 100 gal/day of the recycled biomass is wasted and the biomass concentration in the clarifier effluent is 20 mg/L MLVSS?

Problem 2

An industrial facility generates three process wastewaters with the following characteristics:

Waste Stream	Flow (gal/min)	COD (mg/L)
Wastewater 1	300	5,100
Wastewater 2	120	3,700
Wastewater 3	140	2,450

The plan is to combine the three wastewater streams and treat the combined stream in a completely mixed, suspended growth system with solids recycle. The cleanup goal is 100 mg/L COD based on requirements set by a regulatory agency. Treatability tests of the combined wastewater indicate the following: 1) BOD: COD ratio of 1:2, 2) a biomass production rate of 0.8 mg/mg BOD removed, and 3) an endogenous decay rate of 0.06 day^{-1}. Based on the above information, what will be the concentration of biomass in the bioreactor? Is this biomass concentration within the typical range for effective treatment using this technology?

Problem 3

The feasibility of land treatment of an oily sludge waste is evaluated. The test involved five waste applications to the same land treatment unit over time. The amount of waste applied and the oil content of the waste for each of these additions is shown in Table 3.1. Table 3.2 shows results of a sampling event that was conducted at 450 days from the time of the initial waste application. The volume of soil in the land treatment unit is 2,550 ft^3. Assuming a soil density of 96 lbs/ft^3, determine the first order biodegradation rate constant and the half-life of this contaminant. Is land treatment of this waste a viable option? Explain why or why not. (Hint: Be careful with the way you use variables that have units of % in your calculations.)

Table 3.1 Waste applications

Waste application	Time of application	Amount of waste applied	Oil concentration of applied waste
#	days after initial application	tons	%
1	0	15.7	17.5
2	90	26.1	14.1
3	180	18.5	17.2
4	270	22.3	18.3
5	360	25.4	15.7

Table 3.2 Sampling results

Sample	Oil	Sample	Oil	Sample	Oil
#	%	#	%	#	%
1	15.3	13	12.8	25	6.4
2	18.7	14	10.6	26	13.9
3	16.2	15	17.5	27	11.2
4	6.2	16	5.8	28	7.8
5	18.6	17	6.5	29	8.3
6	8.8	18	6.6	30	9.2
7	9.5	19	7.5	31	4.5
8	4.7	20	10.2	32	15.7
9	13.2	21	12.8	33	18.9
10	8.9	22	18.1	34	5.3
11	13.5	23	15.3	35	8.7
12	14.7	24	8.3	36	6.6

Problem 4

Monitored natural attenuation is considered as a treatment alternative for the remediation of a groundwater plume contaminated with an organic contaminant. The natural attenuation rate of this contaminant is 0.0076 day^{-1}. The contaminant concentration at the source is 13 mg/L and the nearest receptor is 400 m away from the source. The groundwater flow velocity, and the velocity of the contaminant in the groundwater, is 0.3 m/day. Is MNA a viable treatment alternative for this site if the maximum contaminant concentration at the nearest receptor is 0.005 mg/L? What is the closest possible distance from the source to a receptor for MNA to still be effective?