Seoul National University

457.621.001

Biological Processes in Environmental Engineering

MIDTERM EXAMINATION (Take-home)

Due: November 05, 2014 (Wed), 9:30 am

November 03, 2014

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1. If needed, you can use any tools such as Excel spreadsheet or programming language (e.g., MATLAB, C++) to solve the problems. The Excel spreadsheet or the programmed code should be made by your own effort. If you use a spreadsheet or programming code made by anybody else, it is regarded as cheating. Submit the spreadsheet or the programming code you used to the instructor by email (ychoi81@snu.ac.kr) by November 05, 2014 (Wed), 12:00 pm (noon).

2. Be aware that the cheated student will get 80% of the lowest score in class! There is no tolerance at all.

3. Make sure your answers include units if appropriate. Watch your units! Prepare your answers in a logical, easy-to-follow format.

4. This exam contains 2 questions. Total points = 100.

Use following values for physical constants and properties, if needed:

Atomic weights: C, 12; Cl, 35.5; H, 1; N, 14; O, 16; P, 31; S, 32.1; Ca, 40

Density of water at 4°C: 1 g/cm^3

1. A laboratory chemostat (i.e., a CSTR without sludge recycling) having a volume of 10 m^3 receives a flow rate of 2 m^3/hr of wastewater containing an initial substrate concentration of 200 mg BOD_L/L. The wastewater also contains the inert biomass of 30 mg VSS/L. The following parameters are found for aerobic biodegradation:

$\hat{q} = 15\ g\ BOD_L/g\ VSS/d$ $k_2 = 0.08\ g\ COD/g\ VSS/d$

$Y = 0.5\ g\ VSS/g\ BOD_L$ $\hat{q}_{UAP} = 1.5\ g\ COD/g\ VSS/d$

$K = 20\ mg\ BOD_L/L$ $K_{UAP} = 100\ mg\ COD/L$

$b = 0.10\ /d$ $\hat{q}_{BAP} = 0.1\ g\ COD/g\ VSS/d$

$f_d = 0.8$ $K_{BAP} = 50\ mg\ COD/L$

$k_1 = 0.12\ g\ COD/g\ BOD_L$

i) Calculate the effluent COD and BOD_L. Include SMPs in the calculation. Assume that the biomass has a COD value of 1.42 g COD/g VSS. (30 points)

ii) The influent contains a nitrogen concentration of 40 mg NH_4^+-N/L. What is the effluent nitrogen concentration? Use $C_5H_7O_2N$ as the cell formula. (15 points)

iii) The influent DO is 8 mg/L. To maintain the DO in the reactor as 3 mg/L, how much oxygen (in g O_2/hr) should be supplied to the chemostat? (15 points)

2. You ran a sand-packed column in the laboratory to remove nitrate from groundwater. In the influent, you added ethanol at a concentration of 100 mg BOD_L/L to serve as a substrate. For the ethanol degradation by denitrifying bacteria, you found following values from the literature:

$Y = 0.2\ g\ VSS/g\ BOD_L$ $\hat{q} = 15\ g\ BOD_L/g\ VSS/d$

$K = 20\ mg\ BOD_L/L$ $b = 0.1\ /d$

$D = 1.2 \times 10^{-5}\ cm/s$

You ran the column until you were sure that the steady state is achieved throughout the column. The effluent concentration was measured to be 20 mg/L at steady state. You further worked on the biofilm to achieve following parameters, applicable to biofilm in the entire column:

$L = 0.05\ cm$ $X_f = 50\ mg/cm^3$

$b_{\text{det}} = 0.1\ /d$ $D_f = 0.8D$

Calculate the ethanol flux, J, in mg $BOD_L/cm^2/d$ for the biofilm formed on the sand particle right at i) the inlet and ii) the outlet of the column. Assume that, right at the inlet, the ethanol concentration in the bulk liquid is the same as the influent concentration, and right at the outlet, the ethanol concentration in the bulk liquid is the same as the effluent concentration. (40 points)