

CVEN 5534, Wastewater Treatment
Spring 2005
Assignment 3
Due Thursday, Feb. 17

A stoichiometric expression for heterotrophic cell growth (with cell-COD as the reference component) is:

$$\frac{-1}{Y_H} S_S - \frac{(1 - Y_H)}{Y_H} S_O + X_{BH} - i_{NXB} S_{NH} = 0$$

where:

S_S = substrate COD

S_O = oxygen

S_{NH} = ammonia nitrogen

X_{BH} = heterotrophic bacteria cell-COD

Y_H = heterotrophic growth yield (g cell-COD grown/g-substrate COD consumed)

A similar expression for autotrophic nitrifying bacteria, including cell synthesis requirements is:

$$-\left(\frac{1}{Y_A} + i_{NXB}\right) S_{NH} - \frac{(4.57 - Y_A)}{Y_A} S_O + X_{BA} = 0$$

where:

S_O = oxygen

S_{NH} = ammonia nitrogen

X_{BA} = autotrophic bacteria cell-COD

Y_A = autotrophic growth yield (g cell-COD grown/g-substrate NH_4 -N consumed)

1. Develop expressions for the total rate of consumption of ammonia nitrogen and oxygen assuming that COD consumption and nitrification, with associated growth of heterotrophs and autotrophs, respectively, occur simultaneously.

2. If the rate of growth of heterotrophic bacteria is 30 mg-COD/L-hr and the rate for autotrophic bacteria growth is 5 mg-COD/L-hr, calculate the overall rate of consumption of ammonia nitrogen and oxygen, given that

$Y_H = 0.60$ g cell-COD grown/g-substrate COD consumed, and

$Y_A = 0.10$ g cell-COD grown/g- NH_4 -N oxidized, and

$i_{NXB} = 0.08$ g NH_4 -N/g cell-COD

3. Show the effect of heterotrophic yield, Y_H , on the rates of consumption of ammonia nitrogen and oxygen, holding all other values to those given previously, and $0.4 \leq Y_H \leq 0.75$

(use a graph)

4. A wastewater contains 200 mg/L COD and 40 mg/L NH₄-N. Using the stoichiometric coefficients from question 2, above, determine the oxygen consumption and nitrite-nitrogen formed if the COD and NH₄-N are completely consumed.

5. Experiments to determine the growth rate of a culture of heterotrophic bacteria were done with the following results.

S (mg/L COD)	specific growth rate, μ (hr ⁻¹)
0.01	0.003
0.05	0.015
0.1	0.030
1	0.300
2	0.550
5	1.200
10	2.000
20	3.000
50	4.300
100	5.000
200	5.500
500	5.800
1000	5.900
2000	5.950
5000	5.980

Find the maximum specific growth rate, $\mu_{\max}$, and the half-saturation constant, K_S , given that growth kinetics follow the Monod expression:

$$\mu = \frac{\mu_{\max} * S}{(K_S + S)}$$

(hint: invert both sides of the Monod equation to linearize and solve for $\mu_{\max}$ and K_S .)