Nutrient and e$^-$ acceptor consumption – Ex 3.4

1) N and P

The N and P consumption rates,

$$r_N = (0.124\ g\ N/g\ VSS) \cdot (0.42\ g\ VSS/g\ \ BOD_L) \cdot (-249\ mg\ BOD_L/L-d) \cdot \frac{1+(1-0.8)\cdot 0.15 \cdot 2}{1+0.15\cdot 2}$$

$$=-10.6\ mg\ N/L-d$$

$$r_P = r_N \cdot 0.2\ g\,P/g\ N = -10.6 \cdot 0.2 = -2.1\ mg\ \ P/L-d$$

The effluent N and P concentrations

$$C_N = C_N^0 + r_N\theta = 50\ mg\ N/L - (10.6\ mg\ N/L-d)\cdot 2\ d = 28.8\ mg\ NH_4^+ - N/L$$

$$C_P = C_P^0 + r_P\theta = 10\ mg\ P/L - (2.1\ mg\ P/L-d)\cdot 2\ d = 5.8\ mg\ PO_4^{3-} - P/L$$

(the amount of nutrients did not limit the biological activity in the reactor)

2) O_2

The acceptor consumption in the reactor,

$$\frac{\Delta S_a}{\Delta t} = (1\ g\ O_2/g\ COD)\cdot(1000\ m^3/d)$$

$$\cdot\ [500-1.7-31.8+1.42(50-221)]\,mg\ COD/L \cdot 10^3\ L/m^3 \cdot 10^{-3} g/mg$$

$$= 2.24\times 10^5\ g\ O_2/d$$

To support the acceptor consumption, O2 should be supplied to the reactor with a rate of:

$$R_{O_2} = 2.24\times 10^5\ g\ O_2/d - (1000\ m^3/d)\cdot(6-2)\ mg/L \cdot 10^3\ L/m^3 \cdot 10^{-3}\ g/mg$$

$$= 2.20\times 10^5\ g\ O_2/d$$

(O_2 supplied by the influent DO is very small compared to the O_2 requirement – aeration is essential)

Effect of hydrolysis – Ex 3.6

i) effluent particulate BOD, S_p

$$S_p = \frac{S_p^0}{1+k_{hyd}\theta} = \frac{100\ mg\ COD/L}{1+(0.2/d)(2\ d)} = 71\ mg\ COD/L$$

ii) effluent soluble BOD, S: no change, 1.7 mg BOD_L/L

iii) effective S^0 considering S_p, $S^{0'}$:

$$S^{0\prime} = S^0 + k_{hyd} S_p \theta = 500\ mg\ COD/L + (0.2/d)(71\ mg\ COD/L)(2\ d) = 528\ mg\ BOD_L/L$$

(error in the textbook!)

iv) Effluent VSS

$$X_a = Y(S^0 - S)\frac{1}{1+b\theta_x} = 0.42 \cdot (528-1.7)\frac{1}{1+0.15 \cdot 2} = 170\ mg\ VSS/L$$

(slight increase from 161 mg VSS/L without particulate BOD)

$$X_i = X_i^0 + X_a(1-f_d)b\theta_x = 50\ mg\ VSS/L + (170\ mg\ VSS/L) \cdot (1-0.8) \cdot (0.15/d) \cdot (2\ d)$$

$$= 60\ mg\ VSS/L$$

(didn't change much – slight increase happened, but not enough to have increase in significant numbers)

$$X_v = X_a + X_i + S_p = (170+60)\ mg\ VSS/L + \frac{71\ mg\ COD/L}{1.42\ mg\ COD/mg\ VSS} = 280\ mg\ VSS/L$$

(Assumed that the particulate COD has the same formula, $C_5H_7O_2N$, as the biomass)

v) SMP: let's skip the calculation and obtain value from the text:

SMP = 32.6 mg BOD_L/L

(slight increase from 31.8 mg BOD_L/L because of increased biomass – BAP increases)

vi) Effluent COD & BOD_L

$$Effluent\ COD = S + SMP + 1.42 \cdot X_v = 1.7 + 32.6 + 1.42 \cdot 280 = 432\ mg\ COD/L$$

$$Effluent\ BOD_L = S + SMP + 1.42 \cdot f_d \cdot X_a + S_p = 1.7 + 32.7 + 1.42 \cdot 0.8 \cdot 170 + 71 =$$

$$= 299\ mg\ BOD_L/L$$