Midterm for 3502

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1. Given the information from the question

$Q = 1000\ m^3/d$ $\quad S^0 = 300\ mg\ BOD/L$ $\quad X_v^0 = 0$

$X_v^R = 9000\ \frac{mg\ VSS}{L}$ $\quad X_v^e = 8\ mg\ VSS/L$ $\quad \theta_x = 6$

$Y = 0.5\ g\ VSSa/g\ BOD$ $\quad f_d = 0.8$ $\quad \hat{q} = 18\ \frac{g\ BOD}{g\ VSSa\ d}$ $\quad K = 9\ mg\ \frac{BOD}{L}$

$b = 0.1\ d^{-1}$ $\quad V = 300\ m^3$

a. $[\theta_x^{min}]_{lim} = \frac{1}{Y\hat{q} - b} = 0.11\ day$

b. $SF = \frac{\theta_x}{[\theta_x^{min}]_{lim}} = 53.4$

c. $S = K\frac{1 + b\theta_x}{Y\hat{q}\theta_x - (1 + b\theta_x)} = 9\ \frac{mg\ BOD}{L} \times \frac{1 + 0.6}{0.5\ \frac{g\ \cancel{VSSa}}{g\ BOD} \times 18\ \frac{g\ BOD}{g\ \cancel{VSSa}\cdot d} \times 6d - 1.6} = 0.27\ \frac{mg\ BOD}{L}$

$S_{min} = K\frac{b}{Y\hat{q} - b} = 9\ \frac{mg\ BOD}{L} \times \frac{0.1\ d^{-1}}{0.5\ \frac{g\ VSSa}{g\ BOD} \times 18\ \frac{g\ BOD}{g\ VSSa\cdot d} - 0.1\ d^{-1}} = 0.10\ \frac{mg\ BOD}{L}$

d. $\theta = \frac{V}{Q} = \frac{300\ m^3}{1000\ m^3/d} = 0.3d$

e. $M\ (BOD\ loading) = Q(S^0 - S) = 1000\ \frac{m^3}{d} \times 299.73\ \frac{mg}{L} \times \frac{1000\ L}{1\ m^3} \times \frac{1g}{1000mg} \times \frac{1kg}{1000g} = 299.73\ \frac{kg}{d}$

f. $U = \frac{\hat{q}S}{K + S} = \frac{18\ \frac{g\ BOD}{g\ VSSa\cdot d} \times 0.27\ \frac{mg\ BOD}{L}}{9\ \frac{mg\ BOD}{L} + 0.27\ \frac{mg\ BOD}{L}} = 0.52\ \frac{kg}{kg\ VSS\cdot d}$

g: $X_a = \frac{\theta_x}{\theta} \times \frac{Y(S^0 - S)}{1 + b\theta_x} = \frac{6\ day}{0.3\ day} \times \frac{0.5\ \frac{g\ VSSa}{g\ BOD} \times (300 - 0.27)\ \frac{mg}{L}}{1 + 0.1d^{-1} \times 6d} = 1873.3\ \frac{mg\ VSSa}{L}$

$X_i = \frac{\theta_x}{\theta} \times [X_i^0 + X_a(1 - f_d)b\theta_x] = \frac{6\ day}{0.3\ day} \times [0 + 185.8\ \frac{mg\ VSSa}{L} \times 0.2 \times 0.1d^{-1} \times 6day]$

$$X_i = 224.80 \ \frac{mg\ VSS_i}{L}$$

$$X_v = X_a + X_i = 2098.11 \ \frac{mg\ VSS_v}{L}$$

h. $r = \frac{X_a}{X_v} = \frac{1873.3}{2098.11} = 0.893$

i. $M_{t,total} = X_v \cdot V = 2098.11 \ \frac{mg\ VSS_v}{L} \times \frac{1000\,L}{1\,m^3} \times \frac{1\,kg\ VSS_v}{10^6\,mg\ VSS_v} \times 300\,m^3 = 629.4\ kg$

j. $F/M = \frac{Q^0 \cdot S^0}{V \cdot X_v} = \frac{1000\ \frac{\cancel{m^3}}{d} \times 300\ \frac{\cancel{mg}\ BOD}{\cancel{L}} \times \frac{1000\cancel{L}}{\cancel{m^3}} \times \frac{1\,kg}{10^6\cancel{mg}}}{\frac{1000\cancel{L}}{\cancel{m^3}} \times 300\,\cancel{m^3} \times 2098.11\ \frac{\cancel{mg}}{\cancel{L}} \times \frac{1\,kg}{10^6\cancel{mg}}} = 0.48\ kg/kg \cdot d$

k. $\frac{\Delta X_v}{\Delta t} = \frac{\Delta X_a}{\Delta t} + \frac{\Delta X_i}{\Delta t} = \frac{\Delta X_a}{\Delta t}(1 + (1-f_d) b\theta_x)$

$$= \frac{Q(S^0 - S) \cdot Y}{1 + b\theta_x} \times (1 + (1-f_d) b\theta_x)$$

$$= \frac{1000\ \frac{\cancel{m^3}}{d} \times \frac{1000\cancel{L}}{\cancel{m^3}} \times 299.73\ \frac{\cancel{mg}}{\cancel{L}} \times \frac{1\,kg}{10^6\cancel{mg}} \times 0.5}{1 + 0.6} \times (1 + 0.2 \times 0.6)$$

$= 104.9\ \frac{kg\ VSS_v}{d}$

l. $Q^w = \frac{\frac{\Delta X_v}{\Delta t} - Q \cdot X_v^e}{X_v^R - X_v^e} = \frac{104.9\ \frac{kg}{d} - 1000\cancel{m^3}/d \times 8\ \frac{\cancel{mg}}{\cancel{L}} \times \frac{1\,kg}{10^6\cancel{mg}} \times \frac{1000\cancel{L}}{1\,m^3}}{(9000 - 8)\ \frac{\cancel{mg}}{L} \times \frac{1\,kg}{10^6\cancel{mg}}}$

$$= 10776\ \frac{L}{d} = 10.8\ \frac{m^3}{d}$$

m. $R = \frac{Q^R}{Q} = \frac{X_v(1 - \frac{\theta}{\theta_x})}{X_v^R - X_v} = \frac{2098.11\ \frac{mg\ VSS_v}{L} \times (1 - \frac{0.3\,d}{6\,d})}{(9000 - 2098.11)\ \frac{mg\ VSS_v}{L}} = 0.289$

n. $Q^R = Q \cdot R = 289\ m^3/d$

$$0.\ V.L. = \frac{QS^{\circ}}{V} = \frac{1000\ \frac{m^3}{d} \times \frac{1kg}{\cancel{10^6 mg}} \times 300\ \frac{mg}{L} \times \frac{\cancel{1000L}}{1m^3}}{300m^3}$$

$$= 1\ kg/m^3 \cdot d$$

$$P.\ X_a^e(BOD_L) = X_a^e \cdot 1.42\ \frac{mg\ BOD}{mg\ VSS} \times f_d$$

$$= X_v^e \times r \times 1.42\ \frac{mg\ BOD}{mg\ VSS} \times 0.8$$

$$= 8\ \frac{mg}{L} \times 0.893 \times 1.42\ \frac{mg\ BOD}{mg\ VSS} \times 0.8 = 8.12\ \frac{mg}{L}$$

$q.\ \hat{q}_{UAP} = 1.8$ mg COD_P/mg VSS$\cdot$d

$\hat{q}_{BAP} = 0.1$ mg COD/mg VSS d

$K_{UAP} = 100$ mg COD_P/L

$K_{BAP} = 85$ mg COD_P/L

$k_1 = 0.12$ g COD_P/g COD_S

$k_2 = 0.09$ g COD_P/g VSS$\cdot$d

$$UAP = \frac{-(\hat{q}_{UAP} X_a \theta + K_{UAP} + k_1 r_{ut} \theta) + \sqrt{(\hat{q}_{UAP} X_a \theta + K_{UAP} + k_1 r_{ut} \theta_2)^2 - 4 K_{UAP} k_1 r_{ut} \theta_1}}{2}$$

$$= 3.33\ \frac{mg}{L}$$

$$BAP = \frac{-(K_{BAP} + (\hat{q}_{BAP} - k_2) X_a \theta) + \sqrt{(K_{BAP} + (\hat{q}_{BAP} - k_2) X_a \theta)^2 + 4 K_{BAP} k_2 X_a \theta}}{2}$$

$$= 34.39\ \frac{mg}{L}$$

* Calculate process by python programming.

where $r_{ut} = -\frac{S^0 - S}{\theta} = -999.1\ \frac{mg}{L \cdot d}$

$$SMP = UAP + BAP = 37.72\ \frac{mg}{L}$$

$r_{O_2, demand} = r_{substrate} + r_{SMP} + r_{VSS}$

$= Q \times S + Q \times SMP + 1.42 \times \frac{\Delta X_v}{\Delta t}$

$= 1000 \frac{m^3}{d} \times \frac{1000L}{1 m^3} \times \frac{1 kg}{10^6 mg} \times (0.27 \frac{mg}{L} + 37.72 \frac{mg}{L}) + 104.9 \frac{kg}{d} \times 1.42$

$= 142.9 \frac{kg\ O_2}{d}$

r.

$r_{O_2, supply} = r_{substrate} + r_{VSS}$

$= Q \cdot S^0 + \underbrace{1.42 \times Q \times X_i^0}_{\rightarrow 0}$

$= 1000 \frac{m^3}{d} \times \frac{1000L}{1 m^3} \times \frac{1 kg}{10^6 mg} \times 300 \frac{mg}{L} + 0$

$= 300 \frac{kg\ O_2}{d}$

s. O_2 uptake rate, $\frac{\Delta O_2}{\Delta t} = r_{O_2, supply} - r_{O_2, demand} = 157.1 \frac{kg\ O_2}{d}$

$\therefore$ Power $= \frac{\Delta O_2}{\Delta t} \div$ efficiency

$= 157.1 \frac{\cancel{kg}\ O_2}{d} \div \frac{1.3 \cancel{kg}\ O_2}{kWh} = 120.1 \frac{kWh}{d}$

t. $\frac{\Delta N}{\Delta t} = \left(\frac{\Delta X_v}{\Delta t}\right) \times 0.124 \frac{kg\ N}{kg\ VSS} = 13.0 \frac{kg\ N}{d}$

$\frac{\Delta P}{\Delta t} = \left(\frac{\Delta X_v}{\Delta t}\right) \times 0.025 \frac{kg\ P}{kg\ VSS} = 2.6 \frac{kg\ P}{d}$

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