CMAS Design Example

Example Problem:

Design a CMAS system for the following WW following primary treatment (with & w/o nitrification)

$Q = 0.15\ m^3/s$ (12,960 m^3/d) 3.4 MGD
0.25 m^3/s

$BOD_5 =$ 84 mg/L
120 mg/L

BOD_5 of TSS = 0.63 0.6

NH_4-N : 20 mg/L 25 (assume 90% nitrification efficiency)

Temp = 10 °C 10

Permit is 30 mg/L TSS & BOD_5
20 mg/L " "

$\mu_m = 2.5\ d^{-1}$ 2 d^{-1}

K_s : 100 mg/L 75

$k_d = 0.05\ d^{-1}$ 0.03

$Y = 0.5 \frac{mg\ VSS}{mg\ BOD_5}$ 0.55

run through same calc's w/ & w/o nitrification ?

1. Find $S = BOD_5$ allowed − BOD_5 of TSS

$= 30 - 0.63(30)$

$= 11.1$ mg/L BOD_5

use f = 0.6

next Thursday

2. Find θ_c set $\theta = 4h$

$$\theta_c = \frac{K_s + S}{S(\mu_m - k_d) - K_s k_d}$$

$$= \frac{100 + 11.1}{11.1(2.5 - 0.05) - 100(0.05)}$$

$= 5\ d$

3. find $\theta_{c_{min}}$ & S_{min}

$$\theta_{c_{min}} = \frac{K_s + S_o}{S_o(\mu_m - k_d) - K_s k_d} = \frac{100 + 84}{84(2.5 - 0.05) - 100(0.05)} = 0.92\ d$$

$\simeq 22h$

$$S_{min} = \frac{K_s k_d}{\mu_m - k_d} = \frac{100(0.05)}{2.5 - 0.05} = 2.04\ mg/L\ BOD_5$$

↓

$$\frac{4}{22} = .2$$

4. find $X = \dfrac{\theta_c Y(S_o - S)}{\theta(1 + k_d\theta_c)}$

$$X = \frac{5(0.5(84 - 11.1))}{.92(1 + 0.05(5))} = 158.5\ \frac{mg}{L}\ VSS$$ too low

ballpark θ 3-9 h conventional
12-24 h + extended aeration

assume $\theta = 4h = 0.166\ d$

$$X = \frac{5(0.5(84 - 11.1))}{.166(1 + 0.05(5))} = 875\ \frac{mg}{L}\ VSS$$

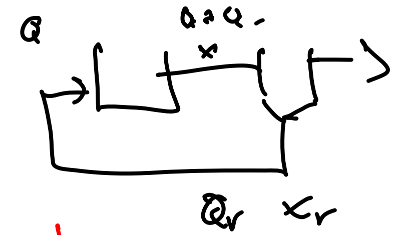
$X' = 1.2X = 1.2(875)$
$= 1050\ mg/L\ TSS$

Suppose we want to nitrify → assume 15d θ_c

$$X = \frac{15(0.5(84 - 11.1))}{.166(1 + 0.05(15))} = 1871\ \frac{mg}{L}\ VSS$$

$X' = 2245$

$\theta_r = ?$ $\quad Q_r X_r' = X(Q_r + Q)$



from graph SVI = 175 mg/L

$$X_r' = \frac{10^6}{175} = 5714 \quad (\tfrac{1}{2}\%\ \text{solids})$$

$$Q_r(5714) = 2245(Q_r + Q)$$

$$Q_r(5714 - 2245) = 2245\,Q$$

$$Q_r = \left(\frac{2245}{5714-2245}\right) Q = 0.65\,Q \quad \text{OK}$$

$$\left[Q_r \simeq (0.5 - 1.0)\,Q\right]$$

Sludge Production

$$P_x = Y_{obs}\,Q\,(S_o - S)\,\frac{kg}{1000\,g}$$

w/o $\quad Y_{obs} = \frac{Y}{1+k_d\theta_c} = \frac{0.5}{1+0.05(5)} = 0.4$

w/ $\quad = \frac{0.5}{1+15(0.05)} = 0.286$

$$S = \frac{K_s(1+k_d\theta_c)}{\theta_c(\mu_m - k_d) - 1} = 4.9\ mg/L$$

$$P_x = \frac{12,960}{1000}(0.4)(84-11.1) = 378\ kg/d$$

$$P_x = \frac{12,960}{1000}(.286)(84-4.9) = 293\ kg/d \quad (22\%\ \text{less})$$

$$\left[P_{NH_4} = \frac{12,960}{1000}(.1)(20-2) = 23.3\ kg/d\right]$$

Calc O_2 req. assume $f = 0.6$

$C_5H_7O_2N + 5O_2 \rightarrow 5CO_2 + 2H_2O$

$5(16)/113 = 1.42$

$$O_2\ req = \frac{Q(S_0 - S)}{f} \cdot \frac{1}{1000} - 1.42\ P_x$$

$$w/o = \frac{12960\,(84 - 11.1)}{0.6 \cdot 1000} - 1.42\,(378) = 1038\ kg/d$$

$NH_4\text{-}N + O_2 \rightarrow NO_3$

$$w/\ \frac{12960\,(84 - 4.9)}{0.6 \cdot 1000} - 1.42\,(293) + 4.57\,(20 - 2)\,\frac{12{,}960}{1000} = 2359\ kg/d$$

over 100% ↑

calc alkalinity req

$$\frac{12{,}960}{1000} \cdot (20 - 2)\,\frac{7.1\ mg\ alk}{mg\ NH_4\text{-}N} = 1656\ kg/d\ alk$$