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1/ a) $Q = 10\ m^3/d$

$sCOD_0 = 500\ mg/L$

$VSS_0 \approx 0$

$sCOD_e = 20\ mg/L$

$VSS_e = 200\ mg/L$

(i) $C_5H_7NO_2 + 5O_2 \rightarrow NH_3 + 5CO_2 + H_2O$

113 → 5 × 32

200 → ?

O_2 needed $= 200 \times 5 \times 32 / 113 \approx 283.186\ mg/L$

→ Th COD = O_2 needed / VSS_e

$= 283.186 / 200$

$\approx 1.416\ gO_2/g\,VSS$

(ii) sCOD utilized = $(500 - 20)\ mg/L \times 10\ m^3/d = 4800\ g/d$

COD cells = $(VSS_e - VSS_0) \times$ Th COD $\times Q$

$= (200 - 0) \times 1.416 \times 10\ m^3/d = 2832\ g/d$

O_2 consumed = sCOD utilized − COD cells

$= 4800 - 2832 = 1968\ g/d$

→ Th O_2 needed $= (1968\ g/d) / 4800\ g/d$

$= 0.41\ gO_2/g\,sCOD$ removed

b) $Q = 3500\ m^3/d$

$Q/(2WL) = 32$ (1)

$D = 3m$

Weir loading $= 150\ m^3/m.d$

$L/W = 4$ (2)

(i)

(1) ⇒ $WL = 54.6875$

(2) ⇒ $L = 4W$

⇒ $W = 3.7\ m$, $L = 14.8\ m$

Volume $= L \times W \times D = 3.7 \times 14.8 \times 3 = 164.28\ m^3$

(ii) $HRT = \frac{Volume}{Q'} = \frac{Volume}{Q/2} = \frac{164.28}{3500/2} = 0.094\ d$

(2 tanks in parallel)

(iii) Weir loading $= \frac{Q}{\Sigma \text{Weir length}}$ ⇒ Σ Weir length $= \frac{Q}{\text{Weir loading}}$

$= \frac{3500}{150} \approx 23.33\ m$

⇒ Weir length (1 tank) $= \frac{23.33}{2} = 11.67\ m$

(c) $Q = 100{,}000\ m^3/d = 1.1574\ m^3/s$

$h_L = 0.2 \Leftrightarrow 30\%$ clogged

$D = 1.5\ m$

$W = 2\ m$

~~Velocity~~ Upstream velocity, $v = \frac{Q}{D \times W} = \frac{1.1574}{1.5 \times 2}$

$= 0.3858$

$h_L = \frac{1}{C}\left(\frac{V^2 - v^2}{2g}\right)$

$\Leftrightarrow 0.2 = \frac{1}{0.6}\left(\frac{V^2 - 0.3858^2}{2 \times 9.81}\right)$

$\Leftrightarrow V = 1.582\ m/s$

~~V_{clean}~~ ⇒ Flow area (clogged bar), $A =$

$= \frac{Q}{V} = \frac{1.1574}{1.582} = 0.7316\ m^2$

⇒ Flow area (clean bar), $A_{clean} = \frac{A}{70\%} = \frac{0.7316}{70\%}$

$= 1.045\ m^2$

2/ a) (i) $Fe(s) \rightarrow Fe^{2+} + 2e$

$O_2 + 4e + 4H^+ \rightarrow 2H_2O$

(ii) $2Fe + O_2 + 4H^+ \rightarrow 2Fe^{2+} + 2H_2O$

$K_{eq} = \frac{[Fe^{2+}]^2}{[O_2][H^+]^4} = 5 \times 10^{115}$

$pH = 8.5 \Rightarrow [H^+] = 10^{-8.5}\ M$

$[Fe^{2+}] = 10^{-6}\ M$

⇒ $[O_2] = 0.2 \times 10^{-93}\ M$

(b)

Ions	EW	Conc (meq/L)
Ca^{2+}	20	2.4
Mg^{2+}	12	1.5
Na^+	23	1
K^+	39	0.5
HCO_3^-	61	2
SO_4^{2-}	48	1.5
Cl^-	35.5	1.2

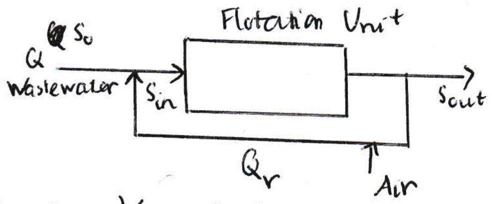
Σ cation $= 2.4 + 1.5 + 1 + 0.5 = 5.4\ meq/L$

Σ anion $= 2 + 1.5 + 1.2 = 4.7\ meq/L$

⇒ M is anion

⇒ $[M] = 5.4 - 4.7 = 0.7\ meq/L$

(c)



3/(a) (i) $HRT = \frac{V}{Q} = \frac{1000 L}{500 L/d} = 2 days$

(ii) O_2 used per day $= 10\ mg/L \cdot h \times 24h \times 1000\ L$

$= 240 g/d$

(iii) COD removed $= sCOD_0 - sCOD_e$

$= 1000 - 10$

$= 990\ mg/L$

COD removed in 1 day $= 990\ mg/L \times 500\ L/d$

$= 495\ g/d$

O_2 consumed = COD removed − COD cells

⇔ $240\ g/d = 495 g/d$ − COD cells

⇔ COD cells $= 255\ g/d$

~~VSS produced in 1 day = COD cells × 255 1.4~~

COD cells = VSS produced in 1 day × $1.42 g\ O_2/gVSS$

⇒ VSS produced in 1 day $= \frac{COD cells}{1.42 g O_2/gVSS}$

$= \frac{255 g/d}{1.42 g O_2/gVSS} = 179.577 g VSS/d$

⇒ VSS conc $= \frac{179.577 g/d}{500 L/d} = 0.359\ g/L \approx 359\ mg/L$

(iv) Observe yield $= \frac{VSS\ conc}{COD\ removed} = \frac{359}{990} = 0.3626$

(b) (i) $P_x = \frac{MLSS \times V}{SRT} = \frac{3000 mg/L \times 8000 m^3 \times 1000 m^3/L}{8d}$

$= 3 \times 10^9 mg/d$

$= 3000\ Kg/d$

(ii) When wasting from reactor:

Sludge production rate = Wasting rate × sludge conc

⇔ $3000\ kg/d = Q \times 3000\ mg/L \times 10^{-6} kg/mg \times 10^{3} L/m^3$

⇔ $Q = 1000\ m^3/d$

(iii) Sludge production rate = rate × sludge conc

⇔ $3000\ kg/d = Q \times 10\,000 mg/L \times 10^{-6} \times 10^{3}$

⇔ $Q = 300 m^3/d$

(c) + Presence of more organic carbon → nitrifiers outcompeted by heterotrophs

+ Accumulation of heterotrophic waste inhibits the activities of nitrifiers

4/(a) Depends on your opinion

My opinion is not agree. Cos composting produces less GHG than anaerobic digestion (can search google for this info). Besides, using methane for fuel → contributes a lot to green house gas effect (worse than CO_2)

(b) $Q = 1000 m^3/d$

$sCOD_0 = 2000\ mg/L$

$Y_{net} = 0.04 g\ VSS/g\ bCOD_{removed}$

95% removal of sCOD

CH_4 = 65% gas, at 0°C, $0.35\ L CH_4/gCOD$

* At 0°C, $0.35\ L\ CH_4/gCOD$

At 30°C, CH_4 volume $= 0.35 \times \left(\frac{273.15 + 30}{273.15 + 0}\right)$

$= 0.3884\ L\ CH_4/g\ COD$

* COD degraded $= 2000 mg/L \times 95\%$

$= 1900\ mg/L$

→ COD degraded $= 1900 mg/L \times 1000 m^3/d$

$= 1900\ kg/d$

$COD_{VSS} = (1.42 gCOD/gVSS)(0.04 g\ VSS/g bCOD removed)(1900\ kg/d)$

$= 107.92\ kg/d$

→ COD_{CH_4} = COD degraded − COD_{VSS} $= 1900 - 107.92 = 1792.08\ kg/d$

CH_4 production: $1792.08\ kg/d \times 0.3884\ L CH_4/gCOD$

$= 696 m^3/d$

⇒ Gas flow: $696/65\% = 1071\ m^3/d$

(c)

(i) Sulfate reduced $= 500 g/m^3 \times 98\% = 490 g/m^3$

→ Sulfate reduced $= 490 g/m^3 \times 2000 m^3/d$

$= 980\ kg/d$

$COD_{sulfate} = 0.89 g\ COD/g$ Sulfate × $980\ kg/d$

$= 872.2\ kg/d$

$COD_{removed} = 4000\ g/m^3 \times 2000\ m^3/d \times 95\%$

$= 7600\ kg/d$

⇒ $COD_{CH_4} = 7600 - 872.2 = 6727.8\ kg/d$

* At 0°C, $0.35 L\ CH_4/gCOD$

→ At 35°C, CH_4 volume $= 0.35 \times \frac{273.15 + 35}{273.15 + 0}$

$= 0.395\ L CH_4/gCOD$

⇒ CH_4 production $= 6727.8\ kg/d \times 0.395\ L CH_4/gCOD$

$\approx 2657\ m^3/d$

(ii) $COD'_{CH_4} = COD_{removed} = 7600\ kg/d$

CH_4 production: $7600 \times 0.395\ L\ CH_4/g\ COD$

$= 3002\ m^3/d$

(d) $Q = 1000\ m^3/d$

$COD_0 = 3000\ g/m^3$

$sCOD_0 = 2500\ g/m^3$

$VSS_e = 150\ g/m^3$

$Q_w = 0$

$L_{org} = 10\ kg\ sCOD/m^3 d$

$E = 0.85$

$SRT = 32\ d$

(i) $V_n = \frac{Q S_0}{L_{org}} = \frac{(1000\ m^3/d)(2500\ g/m^3)}{10\ kg/m^3 d} \times 10^{-3}\ kg/g$

$= 250\ m^3$

$\Rightarrow V_L = \frac{V_n}{E} = \frac{250}{0.85} = 294.12\ m^3$

(ii) $HRT = \frac{V_L}{Q} = \frac{294.12\ m^3}{1000\ m^3/d} = 0.29412\ d \approx 7h$

(iii) $SRT = \frac{V(X_{VSS})}{(Q - Q_w)X_e + Q_w X_R}$

$Q_w = 0 \Rightarrow SRT = \frac{V(X_{VSS})}{Q X_e}$

$\Rightarrow X_{VSS} = \frac{Q X_e\, SRT}{V} = \frac{1000\ m^3/d \times 150\ g/m^3 \times 32 d}{250\ m^3}$

$= 19\,200\ g/m^3$

$= 19.2\ kg/m^3$