S1 17/18 EN3002 WASTEWATER ENGINEERING.

YEO PEI Q1

Date No.

Q1 a (i) $TS = \frac{W_s}{V} \times 1000$ g/L

(ii) $TVS = \frac{(W_s - W_r)}{V} \times 1000$ g/L.

(iii) Cannot. To determine suspended solids, the sample should be filtered using 0.45 μm, dry the solids on the filter.

(iv)

sample
↓
0.45 μm filter → filtrate.
↓ Drying 103°c.
Total suspended solid (TSS)
↓
Ignition → VSS
↓
FSS

concentration of VSS = TSS − FSS.

b. (i) conc. of raw wastewater = $\frac{5\ ml}{300\ ml} = 0.0167$

$BOD_5 = DO_5 - DO_0$

$= 8mg/L - 3mg/L$.

$= 5mg/L$.

$BOD_5$ conc. $= \frac{5mg/L}{0.0167} = 300\ mg/L$.

(ii) Other than BOD of oxidized substrate, the BOD of new cells need to be took into consideration. Because activated sludge contains biomass which will uptake organic matters for biomass growth.

(iii) bCOD = 1.6 BOD.

COD is chemical oxygen demand which indicates the amount of organic matter can be oxidized by chemical. BOD, biochemical oxygen demand represent the amount of organic matters that can be degraded by biological organisms.

Hence, COD is always greater than BOD.

Q1 c. Bar screen: 1. remove coarse material
2. protect equipment
3. Improve treatment efficiency
4. Protect waterway

grit chamber 1. prevent abrasion on pump
2. prevent deposition in pipe.

primary clarifier – remove suspended solids and pollutants

Secondary clarifier – remove flocs of biological growth., biomass.

Q2 a $Q = 40000\ m^3/day$ $A = 60 \times 15 = 900\ m^2$

(i) Surface overflow rate.

$$SOR = \frac{Q}{2A} = \frac{40000\ m^3/day}{2(900)} = 22.22\ m/day.$$

2 tanks

(ii) $HRT = \frac{2V}{Q}$

$= \frac{2 \times (60 \times 15 \times 4)\ m^3}{40000\ m^3/day}$

$= 0.18$ days

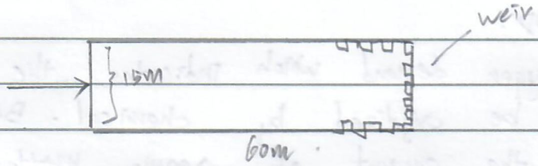
$= 4.32$ hrs.

(iii) $V = \frac{Q}{2A} = \frac{40000}{2(15 \times 4)} = 333\ m/day = 0.23\ m/min.$

(iv) weir loading rate $= \frac{Q}{L}$ ← consider 1 tank.

$250\ m^3/day\text{-}m = \frac{20000\ m^3/day}{L}$

$L = 80m$.




b. Sodium $\frac{11.5 \times 10^{-3}}{23} \times 1 = 5 \times 10^{-4}$

Calcium $\frac{40 \times 10^{-3}}{40} \times 2 = 2 \times 10^{-3}$.

Magnesium $\frac{12 \times 10^{-3}}{24} \times 2 = 1 \times 10^{-3}$

Potassium $\frac{7.8 \times 10^{-3}}{39} \times 1 = 2 \times 10^{-4}$

$3.7 \times 10^{-3}$

Bicarbonate $\frac{12.2 \times 10^{-3}}{1+12+3(16)} \times 1 = 2 \times 10^{-4}$

Sulfate $\frac{67.2 \times 10^{-3}}{32+4(16)} \times 2 = 14 \times 10^{-4}$

Chloride $\frac{74.55 \times 10^{-3}}{35.5} \times 1 = 2.1 \times 10^{-3}$.

$3.7 \times 10^{-3}$.

∵ cation & anion are balance, the analysis is complete.

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Q2 c. $K_{sp} = 4.18 \times 10^{-20} = [Cu^{2+}][OH^-]^2$     $[Cu^{2+}] = \frac{10\,mg}{L} \div \frac{64\,g}{mol}$

$4.18 \times 10^{-20} = (1.5625 \times 10^{-4})\,[OH^-]^2$     $= 1.5625 \times 10^{-4}\ \frac{mol}{L}$.

$[OH^-]^2 = 2.6752 \times 10^{-16}$

$[OH^-] = 1.6356 \times 10^{-8}\ mol/L \times (16+1)\ g/mol$

$= 2.78 \times 10^{-7}\ g/L$.

d) (i) overall reaction.

⇒ Balance electrons. (first equation times two).

$$4\,Br^-_{(aq)} \rightarrow 2\,Br_{2\,(l)} + \cancel{4e^-}$$

$$O_{2\,(g)} + 4H^+ + \cancel{4e^-} \rightarrow 2\,H_2O_{(l)}$$

$$4\,Br^-_{(aq)} + O_{2\,(g)} + 4H^+ \rightarrow 2\,Br_{2\,(l)} + 2\,H_2O_{(l)}$$

(ii) 4 electrons.

(iii) $E^\circ_{overall} = E^\circ_{ox} + E^\circ_{red}$.

(iv) $Q$, reaction quotient $= \frac{[product]}{[reactant]} = \frac{[Br_2]^2[H_2O]^2}{[H^+]^4[O_2][Br^-]^4} = 3921.57$.

$[O_2] = \frac{PV}{RT} = \frac{(2.5 \times 1L)}{0.08206\,(273+25)}$

$= 0.102\ mol/L$.

$[H^+] = 0.1\ mol/L$.

$[Br^-] = 0.25\ mol/L$.

$[Br_2] = \frac{0.25}{2}\ mol/L$

$= 0.125\ mol/L$.

$[H_2O] = 0.1\ mol/L$.

Nernst equation $E_{overall} = E^\circ - \frac{0.059}{n}\log Q$.

$= 0.152 - \frac{0.059}{4}\log 3921.57$.

$E_{overall} = 0.152 - 0.053$.

$= 0.097\ V$.

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Q3 a (i) $Y_{obs} = \frac{\text{production}}{\text{Substrate Utilised}}$.

in gVss/g BOD : $Y_{obs} = \frac{\text{generated biomass}}{SBOD_i - SBOD_e} = \frac{100\ mg\ Vss/L}{(200-2.5)\ mg/L} = 0.506$.

in gTSS/g BOD $Y_{obs} = \frac{100\ mg\ Vss/L \div 0.85\ g\ Vss/g\ TSS}{(200-2.5)\ mg/L} = 0.596$

(ii) $\frac{bCOD}{BOD} = 1.6 = \frac{sbCOD_e}{SBOD_e}$

Effluent. $1.6 = \frac{sbCOD_e}{2.5\ mg/L}$.

$sbCOD_e = 4\ mg/L$.

Total $sCOD_e = bsCOD_e + nbsCOD_e$
$= 4 + 130$
$= 134\ mg/L$.

Inflow. $1.6 = \frac{sbCOD_i}{SBOD_i}$.

$sbCOD_i = 1.6 \times 200$

$= 320\ mg/L$.

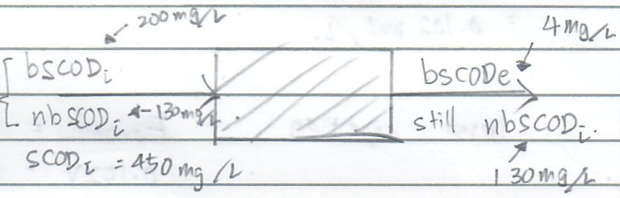
$SCOD_i = 450\ mg/L$.

$nbsCOD_i = 450\ mg/L - 320\ mg/L = 130\ mg/L = nbsCOD_e$ (no reaction).

Know that

① SCOD → bsCOD, nbsCOD.

② total = $SCOD_i$ = 450 mg/L




3b). (i) $P_{x,vss} = \frac{X_{vss} \cdot V}{SRT}$.

$SRT = \frac{X_{vss} \cdot V}{P_{x,vss}} = \frac{MLVSS \times V}{Q_e\ X_{vss\ e}}$.

$= \frac{3000\ g/L \times 1000\ m^3}{60\ m^3/day\ (9000\ g/m^3)}$.

$= 5.56$ days.

(ii) $R_o = Q(S_o - S) - 1.42\ P_{x,bio}$.

$= 5000\ m^3/d \cdot [(300\ g/m^3 - 5\ g/m^3) - (9000\ g/m^3 \times 60\ m^3/d) \times 1.42$.

$= 1475000 - 766800$ g COD/day.

$= 708200$ g COD/day

$= 708.2$ kg $O_2$/day.

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Q3 c (i) $HRT = \frac{V}{Q}$.

$24hr = 1 \text{ day} = \frac{V}{1000 m^3/d}$.

$V = 1000\ m^3$.

$P_{X,TSS} = \frac{X_{TSS} \cdot V}{SRT}$.

$(MLVSS_e + TSS_e) \cdot Q_e = \frac{MLVSS_i \cdot V}{SRT}$.

$SRT = \frac{2800\ g/m^3 (0.8) \cdot 1000}{[(10000 \times 0.8) + 20] \times 85.5}$

$= 3.26$ days.

(ii) $F/M \text{ ratio} = \frac{QS_o}{XV} = \frac{1000\ m^3/d \times 1875\ g/m^3\ BOD}{2800\ g/m^3\ MLVSS \times 1000 m^3} = 0.837$.

active biomass.

(iii) $L_{org} = \frac{QS_o}{V} = \frac{1000 m^3/d \times 1875\ g/m^3\ BOD}{1000 m^3}$.

$= 1875\ g\ BOD/m^3 \cdot day$.

$= 1.875\ kg\ BOD/m^3 \cdot day$.

Q4 a) (i) I. Longer SRT allows more biomass generation in the process, until it reaches the maximum when all substrate been fully utilized.

(ii) I More oxygen will be consumed for biomass generation.

(iii) D Longer SRT resulting in more biomass formed in aeration tank which will uptake more substrate in the tank.

(iv) I Aeration tank will be dominated by heterotrophs which will limit the growth of nitrifiers. Since the nitrifiers are not able to compete with heterotrophs, the amount of nitrifiers in tank will decrease, cause the effluent $NH_4$-N concentration to increase.

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Q4b (i) D. longer SRT allows longer reaction time, hence the effluent P concentration will decrease. No competition between PAO and nitrifier as they using different food source.

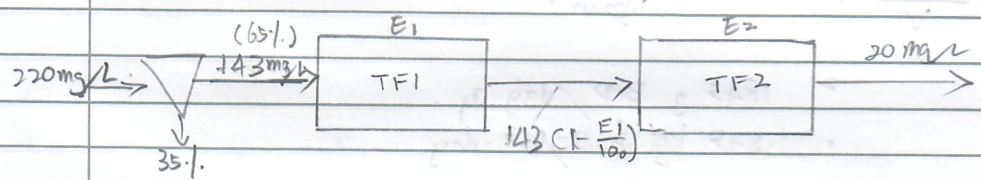
(ii) D. The food source for PAO, VFA is a type of rbCOD. Hence, the amount of rbCOD increase, encourage the growth of PAO.

(iii) I In A/O process, anaerobic condition is P-release, while P-uptake occurs under aerobic condition. In this case DO concentration decrease, the system become more anaerobic, which is better for P-release. Hence, effluent P concentration is expected to go up.

Inflow BOD.

4(c) $F = \frac{1+R}{(1+\frac{R}{10})^2} = \frac{1+2}{(1+\frac{2}{10})^2} = 2.083$.

$220 mg/L (1-0.35) = 143 mg/L$.




Effluent $20 mg/L = 143(1-\frac{E_1}{100}) \times (1-\frac{E_2}{100})$ — ①

$E_1 = E_2 = E$ — ②

Solve. $143(1-\frac{E}{100})(1-\frac{E}{100}) = 20$.

$(143 - 1.43E)(1-\frac{E}{100}) = 20$.

$143 - 1.43E - 1.43E + 0.0143E^2 = 20$

$0.0143E^2 - 2.86E + 123 = 0$.

$E = 137.4 (X)$ or $E = 62.6$ ✓.

$W_1 = 143 g/m^3 \times 5000 m^3/d = 715 kg/d$.

$E_1 = \frac{100}{1+0.4432\sqrt{\frac{W_1}{FV}}}$

$62.6 = \frac{100}{1+0.4432\sqrt{\frac{715}{2.083V_1}}}$

$1 + 0.4432\sqrt{\frac{343.25}{V_1}} = \frac{100}{62.6}$

$V_1 = 188.89 m^3$.

$W_2 = 143(1-\frac{E_1}{100}) \times 5000 m^3/d$.

$= 143(1-\frac{62.6}{100}) \times 5000$

$= 267.41 kg/d$.

$E_2 = \frac{100}{1+\frac{0.4432}{1-E_1}\sqrt{\frac{W_2}{FV_2}}}$

$1 + \frac{0.4432}{1-0.626}\sqrt{\frac{267.41}{2.083V_2}} = \frac{100}{62.6}$.

$1 + 1.185\sqrt{\frac{128.38}{V_2}} = 1.5974$.

$V_2 = 505.13 m^3$.

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Q4d.

$M_s = 8000\ m^3/d \times 250\ g/m^3 \times 0.8$

$= 16 \times 10^5\ g/d$

$= 1600\ kg/d.$

$\frac{M_s}{S_s} = \frac{M_v}{S_v} + \frac{M_f}{S_f}$

$\frac{1600}{S_s} = \frac{0.75(1600)}{1.3} + \frac{0.25(1600)}{2.6}.$

$1600 = 1076.92\ S_s$

$S_s = 1.4857.$

$M_{s1} = M_s + M_w.$

$= 1600 + \frac{96}{4}(1600)$

$= 40000\ kg/d.$

$\frac{M_{s1}}{S_{s1}} = \frac{M_s}{S_s} + \frac{M_w}{S_w}$

$\frac{40000}{S_{s1}} = \frac{1600}{1.4857} + \frac{\frac{96}{4}(1600)}{1}$

$\frac{40000}{S_{s1}} = 1076.93 + 38400$

$S_{s1} = 1.0133.$

$V_{s1} = \frac{M_s}{S_{s1} \rho_w P_s}.$

$= \frac{1600}{(1.0133)(1000)(0.04)}$

$= 39.476\ m^3/day.$

20 days $= 39.476 \times 20$

$= 789.52\ m^3.$