FINISH STRONG!

PYP Solution AY14-15 Sem 1

CV3015 Environmental Eng

1. (a) (i) pH range of around 7 must be maintained to ensure that the coagulant is insoluble in water & can be removed from water after use. Adding ~~cogu~~ coagulant into water will result in decrease of pH due to alkalinity being consumed. Consequently, soluble aluminium ions may form

(ii) pH will affect the amount of HOCl and OCl^- in water. At high pH, OCl^- amount is larger than HOCl. It's desirable to set the pH to 7 or less since at this pH, HOCl will be dominant (Remember that OCl^- is 100x less effective than HOCl)

(b) Natural Alkalinity = 100 mg/L

Final Alkalinity = 120 mg/L

Natural + Added = Consumed + Final.

$$Al_2(SO_4)_3 \cdot 14H_2O + 3Na_2CO_3 \rightarrow 2Al(OH)_3 + 3Na_2SO_4 + 11H_2O + 3CO_2$$

MW = 594   MW = 106

1 mg/L of alum will react with $\frac{3 \times 106}{594} \times \frac{\frac{100}{2} \rightarrow \text{EW of } CaCO_3}{\frac{106}{2} \} \text{EW of } Na_2CO_3} = 0.51 \frac{mg}{L}$ of Alk as $CaCO_3$

Alkalinity consumed = 0.51y where y is amount of alum in mg/L

Alkalinity added = $\frac{530\ kg/d}{10000\ m^3/d} = 53 \frac{mg}{L} \times \frac{50}{53} = 50 \frac{mg}{L}$ as $CaCO_3$

$$100 + 50 = 0.51y + 120 \rightarrow y = 58.82\ mg/L \text{ of alum}$$

Amount of alum used = $58.82 \frac{mg}{L} \times 10000 \frac{m^3}{d} \times \frac{10^{-6}}{10^{-3}} = \underline{\underline{588.2\ kg/d}}$

1 (c) Assumption: Particle exhibits type I behaviour in the sedimentation tank i.e discrete particle settling.

$Q = 10000\ m^3/d$ First, assume $Re < 1$,

$$V_s = \frac{(9.81)(2650 - 1000)(80\times10^{-6})^2}{18(0.89\times10^{-3})} = 6.47\times10^{-3}\ m/s$$

Check Re → $$Re = \frac{1000 \times 6.47\times10^{-3} \times 80\times10^{-6}}{0.89\times10^{-3}} = 0.582 < 1\ (ok)$$

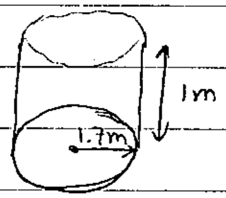
$$X_r = 50\% = \frac{V_s}{V_o} \rightarrow V_o = \frac{6.47\times10^{-3}}{0.5} = 0.01294\ m/s$$

$$V_o = \frac{Q}{A} \longrightarrow A = \frac{10000\ m^3/d}{0.01294\ m/s} \times \frac{1}{24\times60\times60} \approx 9\ m^2$$

If the sedimentation is circular, then:

$$9 = \pi r^2 \rightarrow r = 1.7\ m$$

The height of the tank → $X_r = \frac{h_c}{h_o} \Rightarrow 0.5 = \frac{0.5}{h_o} \rightarrow h_o = 1\ m$



(d) (i) When 1.8 mg/L of chlorine is added, chlorine breakpoint is reached. If chlorine is added beyond this point, HOCl will be formed with an amount proportional to the amount of chlorine added.

(ii) To know exactly the amount of chlorine necessary to be added into water to achieve a ~~dezitele~~ desired amount of HOCl as free chlorine.

(iii) To maintain 0.5 mg/L of free chlorine, 0.5 mg/L of chlorine must be added beyond the breakpoint. So, total dosage of chlorine needed is 1.8 + 0.5 = 2.3 mg/L

2. (a) (i) For Anthracite:

$V = 150 \frac{m}{d} = \frac{150}{86400} \frac{m}{s} = 1.74\times10^{-3} \frac{m}{s}$

$$Re = \frac{0.9(10^{-3})(1.74\times10^{-3})}{0.89\times10^{-6}} = 1.76$$

$$C_D = \frac{24}{1.76} + \frac{3}{\sqrt{1.76}} + 0.34 = 16.24$$

$$\frac{h}{L} = \frac{(1.067)(16.24)(1.74\times10^{-3})^2}{(0.9)(9.81)(10^{-3})(0.45)^4} = 0.145$$

$$h = 0.145(0.5) = 0.072 \text{ m}$$

For sand:

$$Re = \frac{0.75(0.5\times10^{-3})(1.74\times10^{-3})}{0.89\times10^{-6}} = 0.733 < 1$$

$$C_D = 24/0.733 = 32.74$$

$$\frac{h}{L} = \frac{1.067(32.74)(1.74\times10^{-3})^2}{0.75(9.81)(0.5\times10^{-3})(0.4)^4} = 1.123$$

$$h = 1.123(0.3) = 0.337 \text{ m}$$

Total head loss = 0.072 + 0.337 = 0.409 m

(ii) 1) When head loss is exceeded

2) When acceptable effluent standard is exceeded.

(iii) $V_b = 0.012$ m/s $\rightarrow$ $0.012 = 0.12(f_e)^{4.5}$

$V_s = 0.12$ m/s $f_e = 0.6$

$f_{initial}$ of the dual-media filter $= \frac{0.45(0.5) + 0.4(0.3)}{0.5 + 0.3} = 0.43125$

$$\frac{L_e}{L} = \frac{1-f}{1-f_e} = \frac{1-0.43125}{1-0.6} = 1.42$$

So, bed expansion = 42%

(iv) $d_2 = 0.5\left(\frac{2.65-1}{1.55-1}\right)^{2/3} = 1.04$ mm

It's unlikely that intermixing occurs.

2 (b) (i) In ultrafiltration, small viruses will be removed. However, dissolved solids can't be removed in this stage. Therefore, stream 2 has characteristics B.

(ii) Rejection rate $= 1 - \frac{50}{3500} = 98.6\%$ where 3500 is the TDS of the feed (stream) and 50 is TDS of drinking water.

(iii) $Q = 10000\ m^3/d$

For ultrafiltration,

$$J = \frac{Q_p}{A} \rightarrow 75\ \frac{L}{m^2 h} = \frac{10000\ m^3/d}{A}$$

$$A = \frac{10000}{75} \times \frac{10^3}{24} = 5555.56\ m^2$$

For reverse osmosis,

$$\frac{Q_p}{A} = \frac{\Delta P - \Delta \Pi}{\mu R_m} \rightarrow \frac{10000\ \frac{m^3}{d}}{A} = \frac{(15-10)\times 10^5\ \frac{kg\,m}{s^2}\frac{1}{m^2}}{0.89\times10^{-3}\times 10^{14}\ \frac{kg}{ms}\frac{1}{m}}$$

$$A = \frac{10000 \times (0.89\times10^{-3})(10^{14})}{5\times10^5} \times \frac{1}{86400}$$

$$A = 20{,}601.85\ m^2$$

3. (a)

	Aerobic	Anoxic	Anaerobic
Electron Acceptor	O_2	NO_3^-	CO_2 + organics
End Products	CO_2, H_2O, bacteria cells	N_2, CO_2, bacteria cells	$CH_4 + CO_2 + H_2O$ + bacterial
Odor Potensial	Low	Low	High
Ecosystems	Healthy systems	Upper Hypolimnion	Sediments

Anaerobic treatment has its own advantages & disadvantages:

Advantages: - No aeration required (energy saving)
- Low sludge production
- Energy recovery from biomass production

Disadvantages: - Smelly (due to CH_4) & slow (because no O_2)

3 (b) $C_7H_{14}O_2 + \frac{19}{2}O_2 \rightarrow 7CO_2 + 7H_2O$ (130) (304)

Assume there is y mg/L of $C_7H_{14}O_2$

$TOC = \frac{7 \times 12}{130} \times y = 120 \rightarrow y = 185.71$ mg/L $C_7H_{14}O_2$

(7×12 → C_7; 130 → $C_7H_{14}O_2$)

The COD is very close to ThOD, so

$$ThOD = \frac{19 \times 16}{130} \times 185.71 = 434.28 \text{ mg/L}$$

(c) $SVI = \frac{(350/2) \times 1000}{2500} = 70$ mL/g

{ Sludge volume after settling = 350 mL in a 2L cylinder so $\frac{350 \text{ mL}}{2L}$.

(d) (i) $W = Q \times S = 6500 \text{ m}^3/d \times 270 \text{ mg/L} \times \frac{10^{-6}}{10^{-3}} = 1755$ kg/d

$F = \frac{1+1.8}{(1+0.1(1.8))^2} = 2.01$

$E_{25} = E_{20} \times 1.035^{25-20}$

$E_{20} = \frac{75\%}{1.035^5} = 63.15\% = \frac{100\%}{1+0.448\sqrt{\frac{1755}{V(2.01)}}}$

$V = 520.93 \text{ m}^3$

(ii) Overall eff = $E = 100 - 100(1-E_1)(1-E_2)$

$90 = 100 - 100(1-\frac{63.15}{100})(1-E_2)$

$E_2 = 72.86\%$

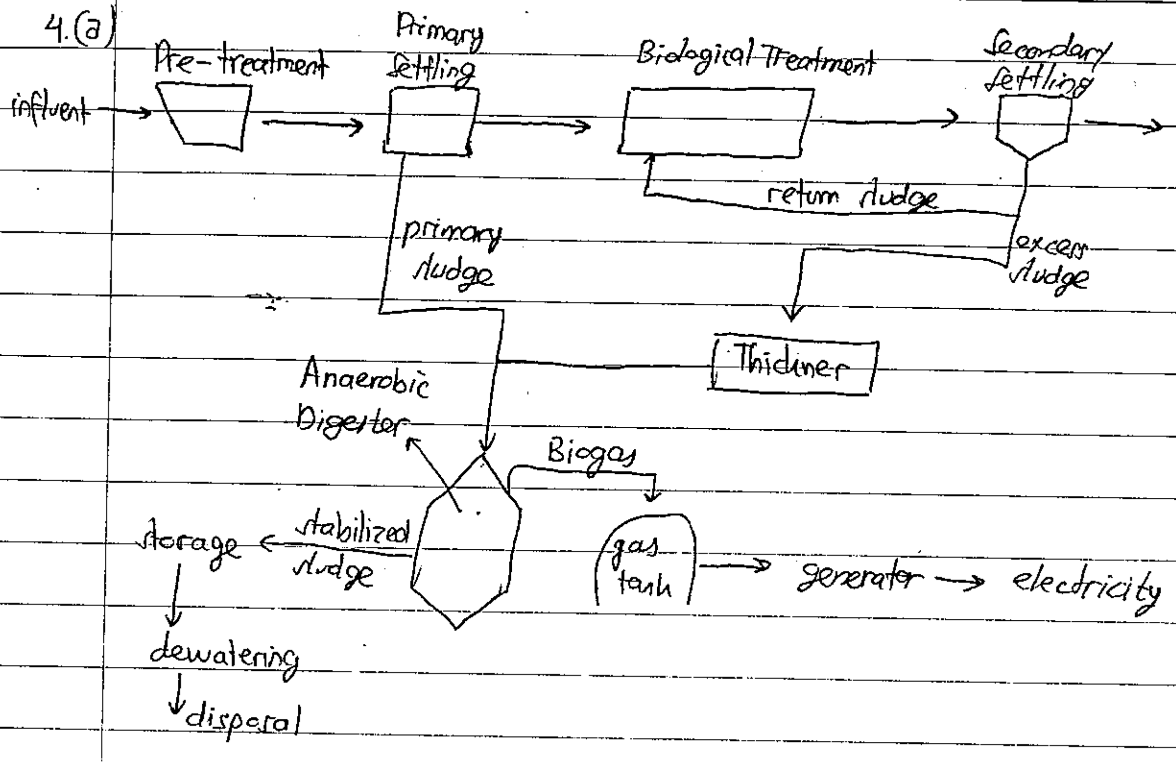
Treated effluent BOD_5 from the first trickling filter $= \frac{(100-63.15)}{100} \times 270$ mg/L

$= 99.5$ mg/L

So, the BOD loading to the second trickling filter is : $6500 \times 99.5 \times 10^{-3}$

$= 646.75$ mg/L

4.(a)



Pre Treatment (Screening, Grit Removal, FOG ~~Flotatic~~ Flotation, Equalisation)

Purpose : Protect wastewater treatment plant by removing big particles.

Primary Treatment: To remove settleable suspended solids by sedimentation.
The desired removal efficiency is : TSS → 50% to 70%, BOD 25% to 40%

Secondary Treatment : To remove mainly BOD. It also removes a low degree of TSS & nearly all pathogens.
The desired removal efficiency is TSS → 20-30%, BOD > 50%

Tertiary / Advanced Treatment : To further refine water quality so that stringent discharge limit is met.

4(b)

Components	% by weight	Bulk density	Volume (m^3)
Food Waste	15	360	0.0417
Mixed paper	30	80	0.375
Cardboard	10	50	0.2
Plastics	10	50	0.2
Glass	10	300	0.0333
Yard Waste	15	100	0.15
Metal cans	10 +	100	0.1 +
	100%		1.1 m^3

Consider 100 kg of solid waste

(i) average bulk density = $100/1.1 = 90.91\ kg/m^3$

(ii)

Components	% Recycled	Weight (before recycled)	Weight Reduced	Weight After Recycled	% Weight (New Composition)
Food Waste	0	15	0	15	15/68 = 22.06%
Mixed Paper	50	30	15 *	30 − 15 = 15	15/68 = 22.06%
Cardboard	0	10	0	10	10/68 = 14.71%
Plastics	0	10	0	10	10/68 = 14.71%
Glass	80	10	8	10 − 8 = 2	2/68 = 2.94%
Yard Waste	0	15	0	15	15/68 = 22.06%
Metal cans	90	10	9 +	10 − 9 = 1 +	1/68 = 1.47%
			32	68	

* Weight recycled/reduced = 50% × 30 = 15 kg. ~~Recycled we~~ After recycled, the solid waste weight will reduce.

(iii) Out of scope ?