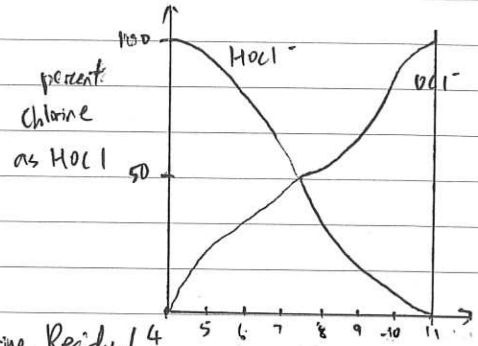
CV3015 Envi engineering Sem 1 exam 2016-2017

1. (a) (i) At high pH, HOCl dissociates to OCl^-, but OCl is 20-100X less effective as disinfectant. Desirable pH 7 or less for disinfection (to get HOCl)



(ii) Chlorine Added = Chlorine Demand + Chlorine Residual
2.0 = Chlorine demand + 1.2 + 0.3
Chlorine Demand = 0.5 mg/L

(b) (i) - Included four zones : Inlet, Outlet, Settling, Sludge
- Uniform horizontal velocity in settling zone
- No interference from other particles.

(ii) The height of the tank is not a factor in determining the size of particle that can be removed completely in the settling tank.

Critical settling velocity is the factor, $V_0 = \frac{h_0}{t} = \frac{h_0}{V/Q} = \frac{h_0}{\frac{h_0 A}{Q}} = \frac{Q}{A}$

from the equation show that h_0 is not related to critical settling velocity.

(c) Dense and fine material at the bottom, less dense and course material at the top. Media are stratified during backwashing. To minimise intermixing of media grains during backwashing, different media type should be about the same settling velocity.

$$d_2 = d_1 \left(\frac{S_{s1}-1}{S_{s2}-1}\right)^{2/3}$$

where d_i = diameter of media i with specific gravity S_{si}

- Large porosity (course) to collect large quantities of flocs, particulates
- Fine enough to prevent passing of flocs, solids
- sufficiently deep to increase filter run time.

(d) (i) Nanofiltration membrane is use to remove hardness (Ca^{2+}, Mg^{2+}). So Nanofiltration is not the main process to be used in desalination process. The main process is reverse osmosis which can remove monovalent species (Na^+, Cl^-)

(ii) Advantages
- MF is effective for removing protozoa. eg. Cryptosporidium; better than granular filtration which requires coagulation - flocculation step
- Removal of virus by UF eg. 7-log removal of MS2 bacteriophage with 100000 Dalton UF
- High packing density, smaller footprint

(iii) Dead end filtration have higher filtration rate than cross flow. But required back wash.

2. (a) TON = 7mg/L

$C_6H_{14}N_2O_2 + 7O_2 \rightarrow 6CO_2 + 2NH_3 + 4H_2O$

146   224 $6\times12=72$ $2\times14=28$

x y z 7 mg/L

$x = \frac{146\times7}{28}$

$= 36.5$ mg/L

$y = \frac{224\times36.5}{146}$

$= 56$ mg/L

$z = \frac{36.5\times72}{146}$

$= 18$ mg/L

$C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$

342   384   144

a $\frac{384}{342}a$ $\frac{8}{19}a$

$C_{18}H_{36}O_2 + 26O_2 \rightarrow 18CO_2 + 18H_2O$

284   832   216

b $\frac{208}{71}b$ $\frac{54}{71}b$

TOC = 150

$18 + \frac{8}{19}a + \frac{54}{71}b = 150$ — ①

ThOD = 500

$56 + \frac{384}{342}a + \frac{208}{71}b = 500$ — ②

$\begin{cases} 568a + 1026b = 178068 \\ 27264a + 71136b = 10781208 \end{cases}$

$a = 129.14$ $b = 102.06$

$\therefore$ $C_{12}H_{22}O_{11} = 129.14$ mg/L

$C_{18}H_{36}O_2 = 102.06$ mg/L

$C_6H_{14}N_2O_2 = 36.5$ mg/L

2 (b)(i) for Material A

$Re = \frac{\phi d v}{\nu}$ assume $\nu = 1\times10^{-6}$

$= \frac{0.8\times0.001\times V/(3600\times24)}{1\times10^{-6}}$

$= 9.26\times10^{-3} \cdot V$

assume $Re < 1$

$C_D = \frac{24}{Re}$

$= 2592/V$

$h = L \cdot \frac{1.067 C_D v^2}{\phi g d f^4}$

$= 0.5 \times \frac{1.067\times2592\times V/(3600\times24)^2}{0.8\times9.81\times0.001\times0.5^4}$

$= 3.78\times10^{-4}\ V$

for Material B

$Re = \frac{\phi d v}{\nu}$

$= \frac{0.8\times0.0005\times V/(3600/24)}{1\times10^{-6}}$

$= 4.63\times10^{-3} \cdot V$

assume $Re < 1$

$C_D = \frac{24}{Re}$

$= 5184/V$

$h = 0.5\times\frac{1.067\times5184\times V/(3600\times24)^2}{0.8\times9.81\times0.0005\times0.4^4}$

$= 3.69\times10^{-3}\ V$

total head loss $= 0.2m$

$3.78\times10^{-4}V + 3.69\times10^{-3}V = 0.2m$

$4.068\times10^{-3}V = 0.2m$

$V = 49.2\ m^3/m^2.d$

check Material A

$Re = 9.26\times10^{-3}\times49.2 = 0.45 < 1$

material B

$Re = 4.63\times10^{-3}\times49.2 = 0.23 < 1$

$\therefore$ ok

(ii) material A

$V_s = \sqrt{\frac{4\times9.81\times(1.5-1)1000\times0.001}{3\times2592/49.2\times1000}}$

$= 0.011\ m/s$

material B

$V_s = \sqrt{\frac{4\times9.81\times(2.4-1)1000\times0.0005}{3\times5184/49.2\times1000}}$

$= 0.009\ m/s$

choose the biggest $V_s = 0.011\ ms^{-1}$

$V_b = V_s (f_e)^{4.5}$

$f_e = 0.587$

$f = 0.5\times0.5 + 0.4\times0.5 = 0.45$

bed expansion $= \frac{(1-0.45)}{(1-0.587)} = 1.33 = 33\%$

3(a)(i) $V = \pi(\frac{6}{2})^2 \times 5 = 141.37\ m^3$

$HRT = \frac{V}{Q}$

$= 141.37 / 1500 \times 24$

$= 2.26$ hours

(ii) $A = \pi(\frac{6}{2})^2$

$= 28.27\ m^2$

$SOR = \frac{Q}{A}$

$= \frac{1500}{28.27}$

$= 53.06\ m^3/m^2 \cdot d$

(iii) Recirculation rate $= 1.8 = \frac{Q_R}{Q}$

$Q_R = 2700 m^3/d$

$A = \pi(\frac{15}{2})^2 = 176.71\ m^2$

Hydraulic loading $= \frac{1500 + 2700}{176.71}$

$= 23.77\ m^3/m^2 \cdot d$

(iv) $S_0 = 300 \times 0.75$

$= 225\ mg/L$

$V = \pi(\frac{15}{2})^2 \times 1.8 = 318.09\ m^3$

Organic loading $= \frac{1500 \times 225}{318.09}$

$= 1.06\ kg/m^3 \cdot d$

(v) $F = \frac{1+R}{(1+0.1R)^2}$

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

$= 2.01$

$E = \frac{100}{1+0.4432\left(\sqrt{\frac{1500 \times 225 \times 10^{-3}}{318.09 \times 2.01}}\right)}$

$= 75.4\%$

BOD_5 of the trickling effluent

$= 225 \times (1 - 0.754) = 55.35\ mg/L$

(b) $E_{26} = E_{20} \times 1.03^{(T-20)}$

$= 75.4 \times 1.03^{26-20}$

$= 90$

BOD_5 of the trickling effluent

$= 225\ (1 - 0.9)$

$= 22.5\ mg/L \not< 20 mg/L$

$E_{27} = 75.4 \times 1.03^{27-20}$

$= 92.7$

BOD_5 of the trickling effluent $= 225\ (1 - 0.927)$

$= 16.35\ mg/L < 20 mg/L$

∴ cannot meet the treatment goal throughout a year but sometimes can meet when have higher temperature.

3(c) 1. Nutrient load up: excessive nutrients from fertilisers are flushed from the land into rivers or lakes by rainwater.

2. Plants flourish: these pollutants cause aquatic plant growth of algae, duckweed and other plants.

3. Algae blooms, oxygen is depleted: algae blooms, preventing sunlight reaching other plants. The plants die and oxygen in the water is depleted.

4. Decomposition further depletes oxygen: dead plants are broken down by bacteria decomposers, using up even more oxygen in the water.

5. Death of the ecosystem: oxygen levels reach a point where no life is possible. Fish and other organism die.

4(a) (i) sulfur $= 250\ kg/d \times 2.5\%$

$= 6.25\ kg/d$

$S + O_2 \rightarrow SO_2$

32 — 64

6.25kg/d — x

$x = \frac{6.25 \times 64}{32}$

$= 12.5\ kg/d$

(ii) $CaO \rightarrow SO_2 + CaSO_3$

56 — 64

y — 12.5kg/d

$y = \frac{56 \times 12.5}{64}$

$= 10.94\ kg/d$

$CaCO_3 \rightarrow CaO + CO_2$

100 — 56

z — 10.94kg/d

$z = \frac{10.94 \times 100}{56}$

$= 19.54\ kg/d$

∴ 19.54 kg/d is required for the complete removal of sulfur dioxide in the scrubbing process.

(iii) Environmental Impacts

- Acid rain formation
  - $2SO_2 + O_2 \rightarrow 2SO_3$
  - $SO_3 + H_2O \rightarrow H_2SO_4$
- Reduction in visibility (sulfurous smog)
- Injury to vegetation
- Metal corrosion
- Attack on building material
  - $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$

(b) $PM_{2.5}$ and PM_{10} are different in sizes. PM2.5 is combastion particles < 2.5 microns while PM_{10} is dust, pollen, mold those are < 10 microns. PM effets on human healts and $PM_{2.5}$ are relative importance compared to PM_{10}, because perticle diameter less than 10μm with deposit in our respiratory system and effects on control device's collection efficiency.

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