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University of Baghdad
College of Eng.
Dept. of Civil Eng.

Final Exam. 1st Attempt
Environmental &Sanitary Eng.
Answer <u>Six</u> questions only

Date 8 /June/2013
Time 3 hrs.
Forth Year

Q1) The chemical analysis of the treated water (potable) from a WTP is given:

Ca (mg/l)	Mg (mg/l)	Al (mg/l)	Fe (mg/l)	Mn (mg/l)	K (mg/l)	Alkalinity mg/l as $CaCO_3$
55	23	0.11	0.05	20	5.5	136
HCO_3(mg/l)	CO_3(mg/l)	SO_4(mg/l)	Cl(mg/l)	PO_4(mg/l)	Na	Conductivity (μmohs/cm)
120	24	120	50	0.02	15.1	516

For the raw water total solids =395 mg/l, SS = 45 mg/l and conductivity = 510 μmohs/cm (assume f is the same for the treated and raw water). **FIND 1- TDS mg/l** in the treated water **2- Carbonate** and noncarbonated hardness mg/l as $CaCO_3$ for the treated water. **3- Volume** of a zeolite filter (m^3) to reduce the effluent hardness to 150 mg/l as $CaCO_3$ in a drinking water system. The zeolite capacity is 10 kg/m^3, influent flow 250 m^3/d.

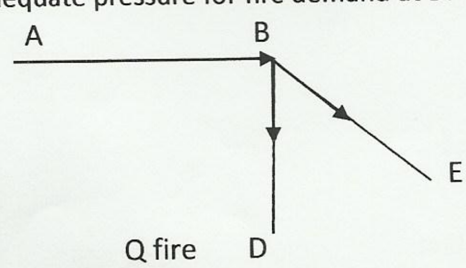
Equivalent weights

Ca 20	Mg 12	Na 23	K 39	Fe 26	Mn 27.5	Zn 33	Al 9
HCO_3 61	SO_4 48	Cl 45.5	CO_3 30	PO_4 31.7	NO_3 62	NO_2 46	F 19

Q2) A WTP is to treat 500 m^3/hr raw water of 150 mg/l SS concentration and 100 NTU turbidity, knowing that Gs = 1.2, $\rho w = 10^3$ kg/m^3 and $\mu w = 1.027 \times 10^{-3}$ kg/m.s.
The circular clarifier was designed according to the column analysis given below, at 40 min settling time. **FIND 1-Diameter** (mm) of the smallest particle to be 100% removed. **2-Volume** of the sludge hopper (m^3) if the tank is to be cleaned twice a day (assume solid content of the sludge is 5%).

Height (m)	0	0.5	1.0	1.5	2.0
% removal	100	88	73	69	64

Q3) For the water distribution system given below, the velocity in pipe BE is 0.8 m/sec. At D a 4 story ordinary type building was constructed, each floor is 100 m^2 and 3 m in height.
1- FIND Q fire demand (m^3/sec) at D. **2- WHAT** is the minimum pressure at A (KPa) to provide the adequate pressure for fire demand at D. (KPa= 0.102 m)



Line	Length (m)	Dia (mm)	C
AB	650	300	140
BE	300	200	120
BD	500	250	120

Q4) 1- State 4 main differences (operation parameters) between Trickling filters and Activated Sludge processes as biological units.
2-What are the main differences between the nephelometric and photometric methods in water testing.
3-What is the best type of residual chlorine in potable water. Why?
4-What are the objectives of: Skimming tanks, Digesters, Carbonation in RSFs, Catch basin in sewer systems.
5-Explain why it is hard to reach ideal settling in sedimentation tanks.

Q5) A waste water treatment plant is to receive 500 m^3/hr flow with BODu = 420 mg/l and 300 mg/l suspended solid concentration .In the primary treatment; removal of 70% for suspended solids and 30% of BOD is achieved. The secondary treatment is to achieve an effluent of 30/30.

1)-If an activated sludge process is used: MLSS=2300 mg/l, under flow SS concentration=15x10^3 mg/l, sludge age= 10 days, decay coefficient= 0.05 /day, yield coefficient= 0.6, BOD_5 of SS effluent is 65% of the effluent SS concentration and the solids are 80% volatile.

2)-If a single stage trickling filter is used: recirculation ratio=165% and depth of the filter= 3m.

Compare between the **sizes** (m^3) of these units and their **organic** loading rates (Kg/m^3/d).

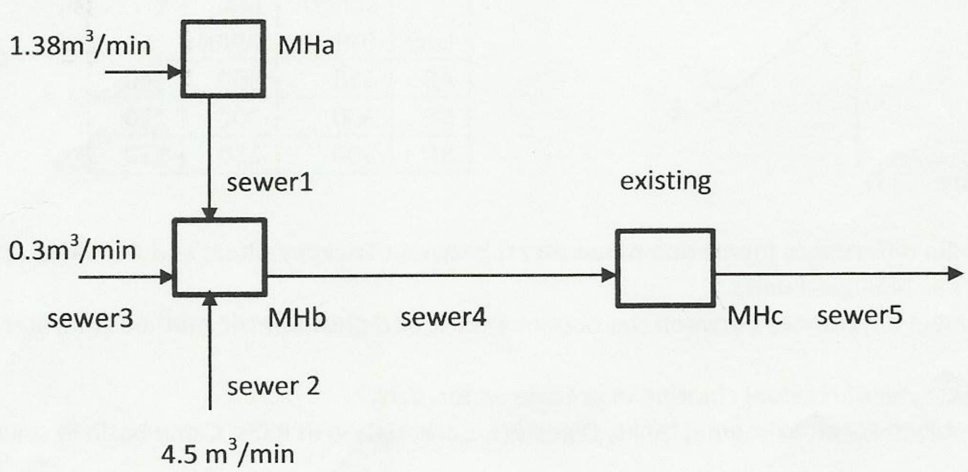
Q6) A river of 0.75 m^3/sec flow with BOD ultimate = 3.3 mg/l and DO = 9.17 mg/l at 20 °C receives a waste effluent of 0.25 m^3/sec with BOD $_{1/30}$ = 18.3 mg/l and DO = zero at 20 °C. The flowing velocity in the river is 0.2 m/sec with an aeration rate of 0.82/day and deoxygenating rate 0.43/day at 20 °C. A position 50 km downstream is to be chosen for an intake location, **FIND 1-DO** (mg/l). **2-Concentration** (mg/l) of the remaining organic matter.

Dissolved Oxygen Saturation Levels							
Temp. °C	0	5	10	15	20	25	30
DO mg/l	14.6	12.8	11.33	10.15	9.17	8.38	7.66

Q7) For the given sewer system, invert to invert at the manholes =25 mm, **V full** in sewer 1 =0.7 m/sec. Standard sizes (mm) 200, 250, 380, 460, 530, 610, 690, and 760 (assume n = 0.013).
1-FIND the standard size for sewer 4 (mm) laid on slope 0.006 and d/D=0.7. **2- WHAT** is the invert depth for sewer 4 at MHb & MHc?

Sewer	Length (m)	Dia. (mm)	Depth of invert (m)
1	40	250	at MHa 0.7 & MHb?
2	45	380	at MHb 0.713
3	50	250	at MHb 0.75
4	50	?	at MHb? & MHc?
5	50	760	at MHc 2.3

Partial Flow Elements					
d/D	q/Q	V/V	d/D	q/Q	V/V
0.3	0.2	0.77	0.6	0.67	1.05
0.4	0.33	0.9	0.7	0.82	1.10
0.5	0.5	1.0	0.8	0.89	1.14



$Pt=Po+K\Delta t$

$F=18\,C\,(A)^{0.5}$

$G=1020\,(\underline{P})^{0.5}\{1-(\underline{P})^{0.5}/100\}$

$P=C_D\,\rho w\,\sum A\,vd^3/2$

$G=(P/vol\,\mu)^{0.5}$

$y=1.73\,(\sqrt[3]{qt^2/(g\,b^2)})$

$BOD_5=L\,(1-e^{-kt})$

$K_{1(T)}=K_{1(20)}\,1.047^{T-20}$

$K_{2(T)}=K_{2(20)}\,1.025^{T-20}$

$(Ci-Ce)/Ci=1/\{1+0.532\,(Q\,Ci/VF)^{0.5}\}$

$F=(1+r)/(1+0.1\,r)^2$

$XV=YQ(So-S)\,\Theta c/(1+kd\,\Theta c)$

Qw = total solid producton /Xr

$Qr=Q\,X/(Xr-X)$

Organic loading= BODu Q)/Vol

$\ln(Pt)=\ln(Po)+K\Delta t$

$Vs=\{4\,g\,(Gs-1)\,d/(3C_D)\}^{0.5}$

$Vs=g\,\rho w\,(Gs-1)d^2/(18\,\mu)$

$Vh=\{8\,\beta\,g\,(Gs-1)\,d/f\}^{0.5}$

$V=0.85\,C\,R^{0.63}\,S^{0.54}$

$Q=0.278\,C\,D^{2.63}\,S^{0.54}$

$V=0.395\,D^{0.67}\,S^{0.5}/n$

$V=30.385\,D^{0.67}\,S^{0.5}$

$Q=0.31\,D^{2.67}\,S^{0.5}/n$

$Q=23.846\,D^{2.67}\,S^{0.5}$

$D=[(e^{-K1t}-e^{-K2t})\,K_1\,L/(K_2-K_1)]+Di\,e^{-K2t}$

$Dc=K_1\,(L\,e^{-K1tc})/K_2$

$tc=[1/(K_2-K_1)]\ln[(K_2/K_1)(1-\{Di\,(K_2-K_1)/L\,K_1\})]$

O_2 demand = 1.47 (So –S) Q – 1.14 Xr Qw

Hydraulic loading = (Q+ Qr)/As

التوفيق من الله

Q1 TDS in raw = 395 − 45 = 350 mg/l

F in raw = $\frac{TDS}{cond} = \frac{350}{510} = 0.686$

∴ TDS in the treated water = 0.686 * 516 = 353.98

= 354 mg/l

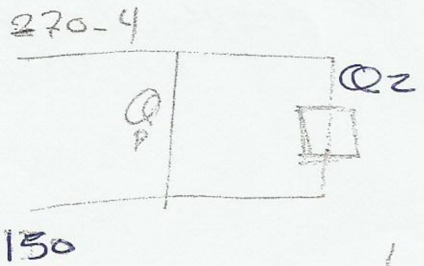
T. Hardness mg/l as $CaCO_3$ = $\frac{55*50}{20}$ (Ca) + $\frac{23*50}{12}$ (Mg) + $\frac{0.11*50}{9}$ (Al) + $\frac{0.05*50}{26}$ (Fe) + $\frac{20*50}{27.5}$ (Mn)

= 137.5 + 95.8 + 0.6 + 0.1 + 36.4

= 270.4

Alk = 136 mg/l as $CaCO_3$ T.H > T.Alk

∴ Carb Hardness = 136 mg/l as $CaCO_3$ non = 270.4 − 136 = 134.4 mg/l as $CaCO_3$



Qp * 270.4 = 250 $\frac{m^3}{d}$ * 150

∴ Qp = 138.68 m^3/d

Qz = 111.32 m^3/d

loading rate = 111.32 $\frac{m^3}{d}$ * 270.4 $\frac{mg}{l}$ * $\frac{10^3}{10^6}$

= 30.1 kg/d

Vol = $\frac{30.1}{10}$ = 3.0 m^3

$\frac{96 \times 61}{50}$ $\frac{40*30}{50}$

117 24

Q2 $v_s = \frac{g}{18\mu} \rho_w (G_s - 1) d^2 = SOR$

$SOR = \frac{H}{t*1.5} = \frac{2}{40*1.5} = 3.33*10^{-2}$ m/min $= 5.56*10^{-4}$ m/sec

$5.56*10^{-4} = \frac{9.81*10^{3}}{18*1.027}(1.2-1)\frac{d^2}{10^3*10^3}$

$d = 7.2*10^{-2}$ mm (0.072)

overall removal $= \frac{0.5}{2*2}(100 + 2*88 + 2*73 + 2*69 + 64)$

$= \frac{0.5}{2*2}(100 + 176 + 146 + 138 + 64)$

$= 77.9\% \approx 78\%$

Settled Solids $= 500\frac{m^3}{hr} * 150\frac{mg}{l} * \frac{0.78*10^3}{10^6} = 58.5$ kg/hr $= 1404$ kg/d

$0.05 = \frac{1404}{1404 + w_w}$

$0.05*1404 + 0.05 w_w = 1404$

$w_w = 26676$ Kg

Sludge vol $= \frac{1404}{1.2*10^3} + \frac{26676}{10^3} = 27.9\ m^3 \approx 28\ m^3$

Vol of hopper $= \frac{28}{2} = 14\ m^3$

Q5 To Sec. treatment

$\therefore 0.3 = \frac{420 - Ce}{420}$

$Ce = 420 * 0.7 = 294$ mg/l BOD_u

$BOD_5 = 294 * 0.58 = 199.92$ mg/l ≈ 200 mg/l

1) A.S.

$S = 30 - 0.65 * 30 = 10.5$ mg/l

$XV = \frac{0.6 * 500(200 - 10.5) * 10}{1 + 0.05 * 10} \quad \frac{m^3}{hr} * \frac{mg}{l} * 10^3 * 24$

$= 9096 * 10^6$ mg

$\therefore V = \frac{9096 * 10^6}{2300 * 10^3} mg * \frac{l}{mg}$

$= 3954.78 \approx 3955\ m^3$

org. loading $= \frac{294 * 500}{3955} \frac{mg}{l} * \frac{m^3}{hr} * \frac{10^3 * 24}{m^3 * 10^6}$

$= 0.89\ kg/m^3/d$

2) T.F.

$F = \frac{1 + r}{(1 + 0.1r)^2} = \frac{1 + 1.65}{(1 + 0.1 * 1.65)^2} = 1.953$

$Q = 500 \frac{m^3}{hr} * \frac{1}{60} = 8.33\ m^3/min$

$\frac{200 - 30}{200} = 0.85 = \frac{1}{1 + 0.532 \sqrt{\frac{8.33 * 200}{V * 1.953}}}$

$1 = 0.85 + \frac{13.207}{\sqrt{V}}$

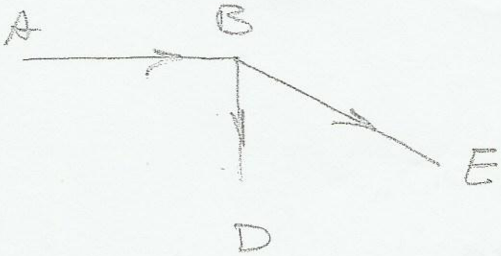
$0.15 = \frac{13.207}{\sqrt{V}}$

$\therefore V = 7752.2 \approx 7752\ m^3$

org. loading $= \frac{294 * 500}{7752} * \frac{24}{10^3} = 0.46\ kg/m^3/d$

$\therefore$ A.S is small in size and can recive twice the org. load

Q_3



1- at D Fire demand $= 18C\sqrt{A}$

$= 18 * 1 * \sqrt{4 * 100 * 10^{?6}}$

$= 1181 \text{ gpm} * \frac{3.78}{10^3}$

$= 4.46 \frac{m^3}{min} * \frac{1}{60}$

$= 7.4 * 10^{-2}\ m^3/sec$

2- $Q_{BE} = \frac{\pi D^2}{4} * V = \frac{\pi (0.2)^2}{4} * 0.8$

$= 2.5 * 10^{-2}\ m^3/sec$

$= 1.5\ m^3/min$

$Q_{AB} = Q_{BE} + Q_{BD}$

$= 2.5 * 10^{-2} + 7.4 * 10^{-2}$

$= 0.099\ m^3/sec$

$Q = 0.278\, C (D)^{2.63} (S)^{0.54}$

$Q_{AB} = 0.099 = 0.278 * 140 (0.3)^{2.63} (S)^{0.54}$

$S = 5.5 * 10^{-3} \quad \therefore h_l = 3.6\ m$

$Q_{BD} = 7.4 * 10^{-2} = 0.278 * 120 (0.25)^{2.63} (S)^{0.54}$

$S = 1.05 * 10^{-2} \quad \therefore h_l = 5.2\ m$

$h_{l\,ABD} = 3.6 + 5.2 = 8.8\ m$

Pressure at D $= 4 * 3 = 12\ m$

The min Pressure at A

$12 + 8.8 = 20.8\ m$

$\frac{20.8}{0.102} = 204\ kPa$

Q7

$\therefore q/3 = (1.38 + 0.3 + 4.5) * \frac{1}{60} = 0.103 \ m^3/sec$

sewer 4 $\frac{d}{D} = 0.7 \therefore \frac{q}{Q} = 0.82$

$\frac{1}{2.67} = 0.375$

$\therefore Q = 0.126 \ m^3/sec$

$0.126 = 23.846 (D)^{2.67} (0.006)^{0.5}$

D = 0.366 m = 366 mm

check 250, 380

$Q_{250} = 23.846 (0.25)^{2.67} (0.006)^{0.5}$

$= 0.046 \ m^3/sec$

$\frac{q}{Q} = \frac{0.103}{0.046} > 1$ over flow

$Q_{380} = 23.846 (0.38)^{2.67} (0.006)^{0.5}$

$= 0.139 \ m^3/sec$

$\frac{q}{Q} = \frac{0.103}{0.139} = 0.74 \quad \therefore D = 380 mm$

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sewer 1 invert at MHa = 0.7

$0.7 \ m/sec = 30.385 (0.25)^{0.67} (S)^{0.5}$

S = 0.0034

d = 0.0034 × 40 = 0.136 m

invert at MHb = 0.7 + 0.136 = <u>0.836 m</u>

sewer 2 at MHb = 0.713

sewer 3 at MHb = 0.75

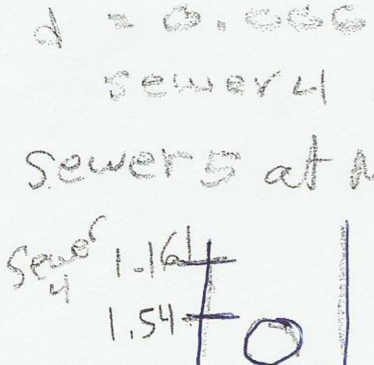
$\therefore$ sewer 4 at MHb = 0.836 + 0.025 = 0.861 m

d = 0.006 × 50 = 0.3 m

sewer 4 at MHc = 0.861 + 0.3 = 1.161 m

sewer 5 at MHC invert 2-3

crown 2 - 3 - 0.76 = 1.54



Q6 $Q_{mix} = 0.75 + 0.25 = 1 m^3/sec$

$DO_{mix} = 0.75 * 9.17 + 0.25 * zero$

$= 6.878 \ mg/l$

$BOD_{1/30} = BOD_u (1 - e^{-k_{1(30)} * 1})$

$k_{1(30)} = k_{1(20)} (1.047)^{30-20}$

$= 0.43 * 1.047^{10} = 0.68 \ /d$

$18.3 = BOD_u (1 - e^{-0.68 * 1})$

$BOD_u = 37.1 \ mg/l$

$\therefore BOD_{u/mix} = 0.75 * 3.3 + 0.25 * 37.1$

$= 11.75 \ mg/l$

$T_{mix} = 20°c \therefore DO_{sat} = 9.17 \ mg/l$

$D_i = 9.17 - 6.878 = 2.292 \ mg/l$

$t = \frac{dist}{V} = \frac{50 * 10^3}{0.2 * 24 * 360} = 2.894 \ day$

$D = \frac{0.43 * 11.75}{0.82 - 0.43} (e^{-0.43 * 2.894} - e^{-0.82 * 2.894}) + 2.292 \ e^{-0.82 * 2.8}$

$= 2.74 \ mg/l$

$\therefore DO$ at 50 km $= 9.17 - 2.74 = 6.43 \ mg/l$

y at 50 km $= L e^{-k_1 t} = 11.75 \ e^{-0.43 * 2.894}$

remaining organic matter $= 3.39 \ mg/l$