UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2016

Module Number: CE4305 **Module Name: Water and Wastewater Engineering**

[Three Hours]

[Answer **all questions**, each question carries **ten marks**]

[Use **separate books** to answer **Section-A** and **Section-B**]

SECTION – A

Q1. a) Followings are several water related issues in a particular area of the Hambantota district. Name possible reason/s for these issues.

Water related issues:

i. Newly born babies in this area having Blue-baby syndrome
ii. White color scaling in the water supply pipelines
iii. Children having teeth problems such as decaying enamel
iv. Some well waters near the coastal area having extremely high conductivity
v. One irrigation tank undergoing high eutrophication
vi. Well water samples having high concentrations of Fecal Coliform

[3.0 Marks]

b) In order to address the above water related issues, the government has decided to construct a new water supply scheme in this area to provide safe drinking water to the community. As there is no suitable surface water source, ground water seems to be the most potential source of water for this project. Table Q1 shows the typical groundwater characteristics of the area. Draw the schematic diagram of a possible treatment train to produce drinking water out of this groundwater, and explain briefly the reasons for selecting each unit operation/process in this treatment train. The selection of unit operations/processes should be based on engineering, economic and energy factors.

Table Q1 Typical groundwater characteristics of the area

DO, *mg/L*	Turbidity, *NTU*	Hardness, *mg/L as* $CaCO_3$	Fe, *mg/L*	Mn, *mg/L*	Total Coliform, *MPN/100 mL*	Fecal Coliform, *MPN/100 mL*
5.5	5	80	12	7	8	0

[4.0 Marks]

c) Dissolved Oxygen (DO) is an important chemical water quality parameter. Name **four** factors that may affect the DO concentration in water.

[2.0 Marks]

d) What is meant by the biological water quality parameter called '**Indicator Organism**'?

[1.0 Marks]

Q2. a) Why is the 'Coagulation Process' important in water treatment? Name three types of typical inorganic metal coagulants used in water treatment.

[1.5 Marks]

b) Explain why 'Polymers' are considered better coagulants than 'Inorganic Metallic Coagulants'.

[1.0 Marks]

c) The 'Velocity Gradient' of the coagulation basin is usually higher than that of the flocculator. Rationalize this.

[1.0 Marks]

d) A water treatment plant is designed to process 50,000 m^3/d of water. Jar testing and pilot plant analysis indicate that an alum dosage of 40 mg/L with a flocculation at a camp no. of 40,000 would produce the optimal results. Assume that the velocity gradient is 30 s^{-1}, and the dynamic viscosity of water is 1.139×10^{-3} $N.s/m^2$.

Determine;

i. the monthly alum requirement
ii. the dimensions of the flocculator
iii. the power requirement for the flocculator

[3.5 Marks]

e) A water treatment plant has a flow rate of 52,000 m^3/d. The sedimentation basin which is 25 m long, 4 m wide and 3.5 m high, has an effective settling volume.

i. Will particles having a settling velocity of 0.005 m/s be completely removed? If not, what percent of the particles will be removed?

[1.5 Marks]

ii. What would be the length of the sedimentation basin that can remove 100 % of the particles having a settling velocity of 0.005 m/s if the width and height are equal?

[1.0 Marks]

iii. What would be the hydraulic retention time of the sedimentation basin with these new dimensions?

[0.5 Marks]

Q3 a) 'Rapid Sand Filters' and 'Slow Sand Filters' are commonly used granular filters in the typical water treatment process. Discuss briefly the advantages and disadvantages of these two types of filters.

[2.0 Marks]

b) A community water treatment plant has the capacity of 20,000 m^3/d. Design a rapid sand filter unit for this treatment plant, allowing 0.5 % of the filtered water for backwashing. The backwashing time is 30 min per day. Assume followings:

- Filtration rate of the filter = 5000 $L/m^2.h$.
- Length to Width ratio = 1.3
- Depth of sand bed = 50 cm

[2.0 Marks]

c) Figure Q3 shows the breakpoint curve of chlorination for the treatment plant described in Q3(b). What will be the weekly chlorine requirement if a chlorine residual of 1.8 mg/L is desired?

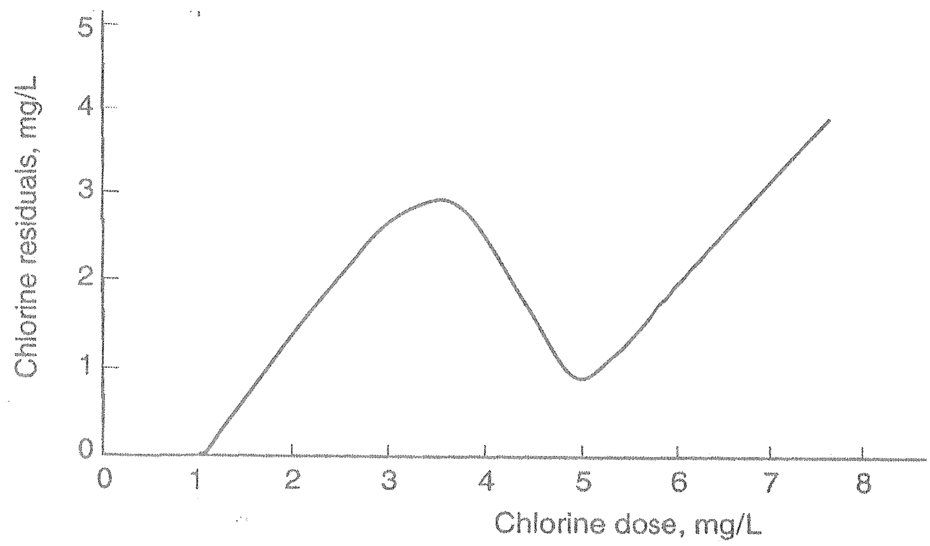


Figure Q3 Breakpoint curve of chlorination

[2.0 Marks]

d) Laboratory experiments revealed that the inactivation (disinfection) constant of chlorine is 3.2 *L/mg.min* for a particular virus. Determine the time required to reduce the concentration of this virus to 1/10,000 of the original concentration using the above chlorine dosage. You may use Chick-Watson law for this calculation.

[2.5 Marks]

e) Name **three** other methods except 'chlorination' that can be used in the disinfection process of this treatment plant.

[1.5 Marks]

SECTION - B

Q4. a) Explain briefly the following terms;

i. The average daily flow
ii. The maximum daily flow
iii. The minimum daily flow
iv. The design peak flow

[2.0 Marks]

b) Estimate the infiltration flow rate, and its percentage of the average daily and peak daily domestic wastewater flows for the following sewer network:

Sewered population = 55,000
Average domestic wastewater flow = 120 *L/capita.d*
Infiltration flow rate = 120 *L/km.d* per 1 *mm* of pipe diameter
Peak factor = 3.0

Table Q4 (b) Sewer data

Type	Diameter *(mm)*	Length *(km)*
House sewers	100	65
Building sewers	150	15
Street laterals	200	50
Submains	300	20
Mains	450	10

[3.0 Marks]

c) Using the weekly industrial flow data for a quarter year of operation in Table Q4 (c), determine the following statistical values of the flow rate: Mean, Median, Mode and Standard Deviation.
Estimate the maximum weekly flow rate that will occur during a full year of operation. You may use Figure Q4

Table Q4 (c) Weekly industrial flow data for a quarter year

Week No	Flow rate *(m^3/week)*
01	2900
02	3040
03	3540
04	3360
05	3770
06	4080
07	4015
08	3675
09	3810
10	3450
11	3265
12	3180
13	3135

[5.0 Marks]

Q5 a) Explain briefly the Preliminary, Primary and Secondary levels of wastewater treatment and list key unit operations/processes of each level.

[2.0 Marks]

b) State water/wastewater parameters for which each of the following pieces of apparatus are used for measurements.

i. Spectrophotometer
ii. Incubator
iii. Desiccator
iv. Imhoff cone

[2.0 Marks]

c) A complete-mix activated sludge process (ASP) (Figure Q5) is designed to treat a primary settled wastewater flow of 0.15 m^3/s. The influent soluble BOD_5 to the ASP is 200 *mg/L* at the average flow conditions. The effluent BOD_5 is expected to be 20 *mg/L*. Following data are available for the ASP:

- Hydraulic regime of the reactor is complete mix.
- Influent volatile suspended solids to the reactor is negligible.
- Mixed Liquor Volatile Suspended Solids (MLVSS) is 4800 *mg/L*.
- Ratio of VSS (Volatile Suspended Solids) to SS (Suspended Solids) is 0.8.
- Return sludge concentration is 12,000 *mg/L* of SS
- Design Mean Cell Residence Time (θ_c) is 10 *d*
- Kinetic coefficients at 20 ^0C:
  Yield Coefficient (Y) = 0.65 *g cells/g* BOD_5 *utilized;*
  Endogenous Decay Coefficient (k_d) = 0.06 d^{-1}
- It is estimated that the effluent will contain about 20 *mg/L* of biological solids, of which 70% is biodegradable.
- Ultimate carbonaceous biochemical oxygen demand (BOD_L) of cell is equal to 1.42 times the concentration of cells.
- $BOD_5 = 0.68 \times BOD_L$
- System temperature is 20 °C.
- Wastewater contains adequate nitrogen, phosphorus and other trace nutrients for the biological growth.

i. Compute the following :Soluble BOD_5 in the effluent
ii. Hydraulic Retention Time (HRT)
iii. Reactor volume
iv. Recirculation ratio
v. Biomass production rate

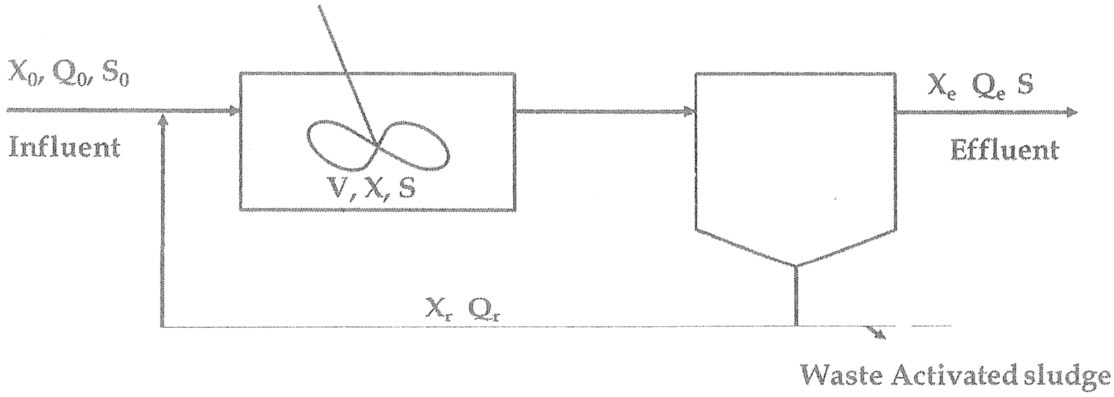


Figure Q5 Schematic of the ASP

[6.0 Marks]

Q6 a) Name **three** wastewater parameters belonging to each of physical, chemical and biological wastewater characteristics.

[3.0 Marks]

b) A coarse bar rack is placed vertically against the approaching flow in a wastewater treatment plant. Table Q6 gives the operating data.
Calculate the (i) cross-sectional area; (ii) number of bars; (iii) width and height of the screen; (iv) the initial head loss through the scree; and (v) head loss when the screen is half clogged.

Table Q6 Operating data of the bar screen

Parameter	Unit	Value
Flow rate	*L/d*	80 x 10^6
Bar width	*cm*	1
Clear spacing between the bars	*cm*	5
Initial channel width	*cm*	0.75
Velocity of the flow through the opening of the bars	*m/s*	0.6
Gravitational acceleration (g)	*m/s*^{2}	9.81

[7.0 Marks]

Equations

$$\theta_C = \frac{V\,X}{Q_w X_r + Q_e X_e}$$

$$Q_r = \frac{Q_0\,X}{X_r - X}$$

$$X = \frac{\theta_c}{\theta}\,\frac{Y\,(S_0 - S)}{1 + k_d\theta_c}$$

$$Y_{obs} = \frac{Y}{1 + k_d\theta_c}$$

$$S = \frac{K_S(1 + k_d\,\theta_c)}{\theta_c\,(Yk - k_d) - 1}$$

$$P_x = Q_0\,\frac{Y\,(S_0 - S)}{(1 + k_d\theta_c)}$$

$$\frac{F}{M} = \frac{S_0}{X\,\theta}$$

$$s=\sqrt{(\sum(X-\bar{X})^2)/(n-1)}$$

$$\text{Mode}=3\,(\text{Med})-2\bar{x}$$

$$WLR = \frac{Q_0}{Perimeter\ of\ the\ weir}$$

$$Y_T = Y_{20}\,(1.056)^{T-20}$$

$$k_{d\,@T} = k_{d\,@20}\,(1.056)^{T-20}$$

$$A = \frac{Q_0}{S.L.R}$$

$$Q_0 = Q_e + Q_w$$

$$Recirculation\ ratio = \frac{Q_r}{Q_0}$$

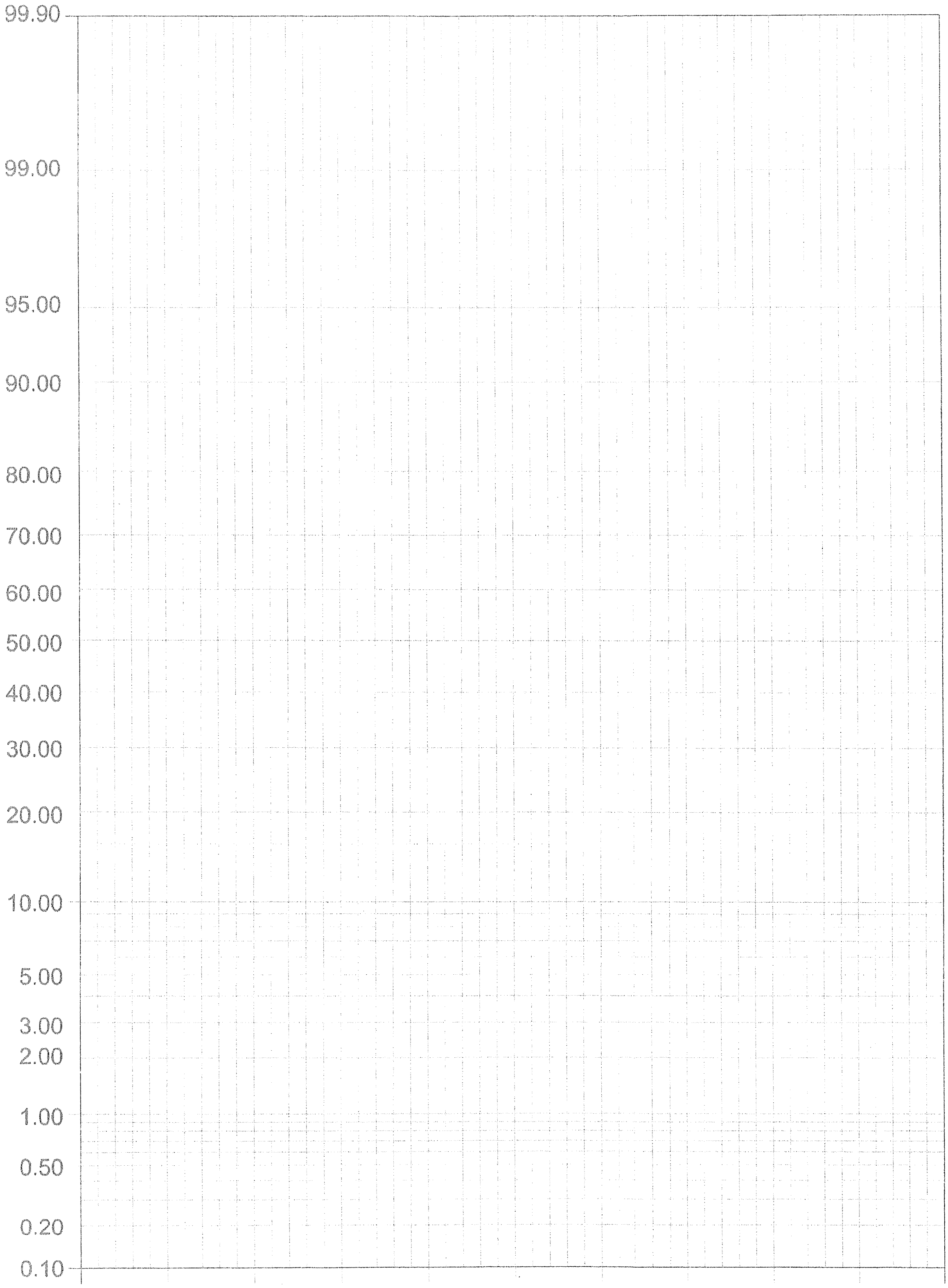
$$U = V\frac{(s)}{(s+w)}$$

$$\frac{A_{net}}{w+s} = \frac{A_E}{s}$$

$$h_L = \frac{1}{0.7} \text{ x } \left(\frac{V^2 - U^2}{2g}\right)$$

$$n = \frac{A_{net} - A_E}{Area\ of\ bars} = \frac{A_{net} - A_E}{Area\ of\ bars}$$

Figure Q4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