University of Technology
Engineering Department of Building and Construction
Final Exam 2013-2014

Subject: Water Quality Control **Year: Third**
Division: Water and Dams **Time: 3 hours**
Examiner: **Date /6 / 2014**

NOTE: Answer *FIVE* Questions Only (Question 1 included)

Q1) A river discharges 1.1 m^3/s, with BOD_5 = 1.2 mg/l, DO = 9.5 mg/l, T = 20° C, and K_2 = 0.3/d at 20°C. A wastewater effluent is discharged to this river at a rate of 600 l/s with a BOD_5 = 60 mg/l, DO = 2 mg/l, T = 20°C and K_1 = 0.1/d at 20°C. If the saturation DO is 10 mg/l, find the minimum dissolved oxygen concentration downstream.

Note: use the following equations:

$$K_{1T} = K_{20} \times 1.047^{(T-20)} \quad ; \quad K_{2T} = K_{20} \times 1.015^{(T-20)}$$

$$t_c = \frac{1}{K_2 - K_1} \log\left[\frac{K_2}{K_1}\left(1 - D_0 \frac{K_2 - K_1}{K_1 L_0}\right)\right] \quad ; D_c = \frac{K_1 L_0}{K_2 - K_1}\left(10^{-K_1 t} - 10^{-K_2 t}\right) + D_0\left(10^{-K_2 t}\right)$$ *(20 Mark)*

Q2) A- List briefly the following: (Answer 5 only)

1. A grey water system components
2. Water crisis
3. Advantages of electrodialysis
4. Water pollution signs
5. Limitations of cellulose acetate use as a membrane of reverse osmosis
6. Ion exchange unit requirements *(15 Mark)*

B- For an ion exchange process, explain in details the operating cycle. *(5 Mark)*

Q3) A- Define the following:

1. Rift lake
2. Electrodialysis Reversal
3. Gray-water reuse
4. pH
5. Wet cooling towers *(10 Mark)*

B- Write a mathematical form that express the following (define each parameter):

1- Settling velocity. *(3 Mark)*
2- Suspended – sediment transport. *(3 Mark)*
3- Estimating of landscaped area to be irrigated by grey-water. *(4 Mark)*

Q4) Show the difference between the following: (Answer 5 only)

1- Point sources and Non-point sources of wastewater inputs to rivers.
2- Advantages and disadvantages of aquatic weeds.
3- De-stratification and re-aeration.
4- Autumn overturn and spring overturn.
5- Sheet erosion and gully erosion.
6- Sedimentation and currents in self purification process. *(20 Mark)*

Q5) A family has a three bedroom house. If all fixtures of the house are connected. How much area can be irrigated with that grey water? Take ET = 2 in/week in July and PF = 0.8. *(8 Mark)*

B- Explain in details the forced – circulation (evaporation) process? *(12 Mark)*

Q6) Answer with (TRUE) or (FALSE) and correct the false statement:

1- The presence of calcium and magnesium chloride in water causes hardness.
2- Turbidity is the measure of resistance to the passage of light.
3- pH value is symbol for hydrogen concentration.
4- The quantity of arsenic in water for domestic purposes should not be more than 0.05 ppm.
5- The bacteria which can survive without oxygen is called anaerobic bacteria.
6- The particle will settle down more rapidly in water at high temperatures than at lower temperatures.
7- The presence of chlordane more than 0.002 mg/l causes liver or nervous system problems.
8- Saturation DO decreases as salinity increases.
9- Agricultural is an example of non-point sources of wastewater inputs to rivers and lakes.
10- Distillation is an example of the process that separate water from solution, while ion exchange is an example of the process that separate salt from solution. *(10 Mark)*

B – Explain in details with drawing the thermocline in lakes. *(10 Mark)*

GOOD LUCK

Water and Dams Engineering Branch.

Typical Answers :-
(Water Quality Control)
3rd stage

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Solution: at mixing zone:

$$C = \frac{C_1 Q_1 + C_2 Q_2}{Q_1 + Q_2}$$

$$BOD_{5\,mix} = \frac{1.1 \times 1.2 + 0.6 \times 60}{1.1 + 0.6} = 21.95\ mg/l$$

$$DO_{mix} = \frac{1.1 \times 9.5 + 0.6 \times 2}{1.1 + 0.6} = 6.85\ mg/l$$

T_{mix} = 20°C, K_1 = 0.1/d, K_2 = 0.3/d

$$L_0 = \frac{BOD_5}{(1 - 10^{-k_1 t})} = \frac{21.95}{(1 - 10^{-0.1 \times 5})} = 32.1\ mg/l$$

$$D_0 = 10 - 6.85 = 3.15\ mg/l$$

$$D_c = \frac{K_1 L_0}{K_2 - K_1}(10^{-K_1 t_c} - 10^{-K_2 t_c}) + D_0(10^{-K_2 t_c})$$

$$t_c = \frac{1}{K_2 - K_1} \log\left[\frac{K_2}{K_1}\left(1 - D_0 \frac{K_2 - K_1}{K_1 L_0}\right)\right]$$

$$= \frac{1}{0.3 - 0.1} \log\left[\frac{0.3}{0.1}\left(1 - 3.15 \times \frac{0.3 - 0.1}{0.3 \times 32.1}\right)\right]$$

$$\therefore t_c = 5 \log(3 \times 0.98) = 2.31\ days$$

$$\therefore D_c = \left[\frac{0.1 \times 32.1}{0.3 - 0.1} \times (10^{-0.1 \times 2.31} - 10^{-0.3 \times 2.31})\right] + 3.15(10^{-0.3 \times 2.31})$$

$$\therefore D_c = 6.86\ mg/l$$

$$\therefore DO_{min} = 10 - 6.863 = 3.137\ mg/l$$

Answer

Q2)A- List briefly the following:

1- A grey water system components

- *Plumping system*
- *Surge tank*
- *Filter*
- *Pump*
- *Irrigation system*

2- Water crisis

- *Inadequate access to safe drinking water.*
- *Groundwater over-drafting leading to diminished agricultural yields.*
- *Overuse and pollution of water resources harming biodiversity.*
- *Regional conflicts over scarce water resources sometimes resulting in warfare.*

3- Advantages of electrodialysis

- *All contaminant ions and most dissolved non-ions are removed. Electrodialysis is very effective in removing fluoride and nitrate, and can also remove barium, cadmium and selenium.*
- *Relating insensitive to flow and TDS level.*
- *Low effluent concentration possible.*

4- Water pollution signs

- *Low dissolved oxygen (DO): organic pollution.*
- *Increase of the nutrients, e.g., N and P: agriculture.*
- *Increase of turbidity and its effects on light penetration.*
- *Change in the bed characteristics, e.g., organic matter.*
- *Production or undesirable growth of species, green – blue algae.*
- *Increase in water temperature: power generation, factory.*
- *Existing of toxic substances: industry.*
- *Source of diseases: hospital, laboratory.*

5- Limitations of cellulose acetate use as a membrane of reverse osmosis

- *Feed-water pH must be acidic to prevent membrane hydrolysis, pH = 5 to 7.*
- *Microbial populations must be limited to prevent microbial degradation of membrane.*
- *Process temperatures ≤ 75 – 80^{0}F (23.9 – 26.7^{0}C) for long membrane life.*

- *Projected membrane life is 2-3 year.*

6- Ion exchange unit requirements

- *High – capacity resins.*
- *High degree of column utilization.*
- *High selectivity for exchange ions.*
- *Efficient regeneration.*
- *Rapid exchange rates.*
- *Reasonable production rates.*
- *Inexpensive spent – brine disposal methods.*

Q2) **B- For an ion exchange process, explain in details the operating cycle.**

1. *Service period: Feed-water is passed through the bed with removal of ionized contaminant. As the solution is first fed to the column, it will exchange all its exchangeable ions in a narrow zone of resin near feed point. Then the exchange region will move through the column until the entire resin is exhausted. The service period is ended before complete exhaustion.*
2. *Backwash mode: the water is passed up through the column to remove any foreign matter and to reclassify the resin particles.*
3. *Regeneration period: regenerant solution is pumped down through the bed, displacing undesirable ions from the resin and restoring it to its original condition.*
4. *Rinse period: Feed-water is used to displace spent regenerant remaining in the bed.*

- *An IX processing unit would consist of several columns. The columns would be cycled in different operational phases, to ensure continuous product water.*

Q3) A- Define the following:

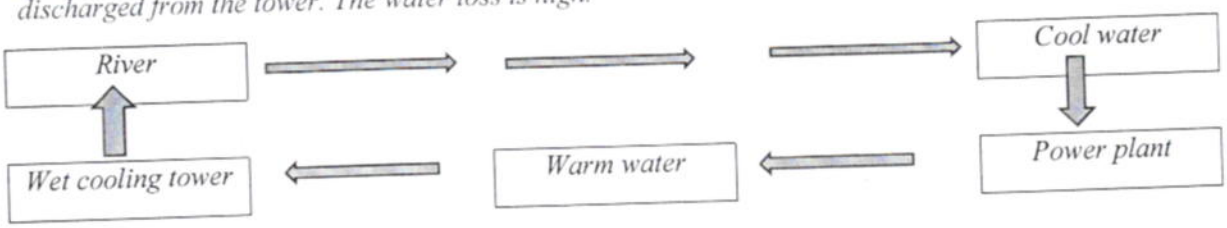
1.Rift Lake*A lake which forms as a result of subsidence along a geological fault in the earth's tectonic plates. Examples includes the Lake Baikal in Siberia.*

2. ElectrodialysisReversal*it is an electrodialysis reversal process that has been commercially used since 1960. The direction of ion flow is reversed by reversing the polarity applied electric current. A reversal of the charge on the membranes, helps to flush the attached ions from the membrane surface, thus extending the time between cleanings.*

3. Gray-water reuse*Is waters from hand basin, shower, bath, clothes washing machine, laundry tub, dishwasher and kitchen sink, not from toilet and urinal. These wastewaters can be separately collected and used for beneficial purposes.*

4. pH*The logarithm of the reciprocal of the hydrogen ion concentration. Water with a pH of 7 is neutral at room temperature. A pH greater than 7 indicates alkaline and pH less than 7 indicates acidic water.*

5. Wet cooling towers *Wet cooling towers may use mechanical means of maintaining an air flow past the heated water or may use natural draft. The principal advantage of them is less land area but with high expensive. Also there may be problems with localized icing or fog caused by the heated moist air discharged from the tower. The water loss is high.*



B- Write a mathematical form that express the following (define each parameter):

1- Settling velocity.

$$w = \frac{2(\rho_p - \rho_f)gr^2}{9\mu}$$

Where, w = settling velocity
ρ = density (the subscripts p and f indicate particle and fluid respectively)
g = acceleration due to gravity

$$r = radius\ of\ particle$$
$$\mu = dynamic\ viscosity$$

2- Suspended – sediment transport.

$$Q_s = KQ^n$$

Where:
Q_s = suspended – sediment transport,
Q = stream flow,
n = constant (2.3).
K = Intercept when Q = 1.

3- Estimating of landscaped area to be irrigated by grey-water.

$$A = \frac{Q}{(ET \times PF \times 0.62)}$$

Where:
A = landscape area, ft^2
Q = estimated grey-water produced, g/week
ET = evapotranspiration, in/week
PF = plant factor
0.62 = conversion factor (from inches of ET to g/week)