ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2017 SESSION

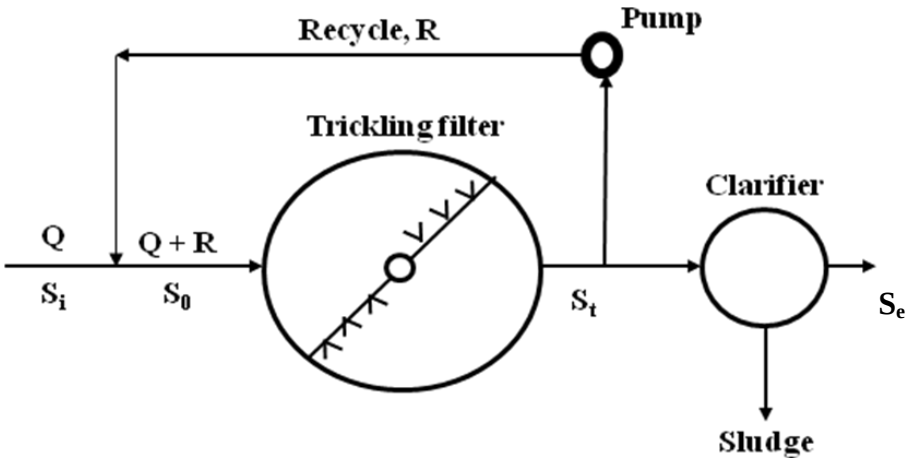
Open-book examination
Calculators : only authorized models
Duration : 3 hours

14-EN-A1
ENVIRONMENTAL ENGINEERING PRINCIPLES

PART I : PROBLEM SOLVING (50 %)

QUESTION 1 (25 %)

A city with the population of 5000 persons has decided to use a trickling filter system for the treatment of its municipal wastewaters after primary clarification according to the schematic diagram presented below:



The performance of trickling filters during the treatment of municipal wastewaters may be expressed by the following equation:

$$S_e/S_i = 1/(1 + c\ (D^{0.67}/Q_L^{0.5}))$$

Where:

S_e = Effluent BOD_5 concentration (mg/L)
S_i = Influent BOD_5 concentration (mg/L)
c = Coefficient, 5.36 in SI system
D = Trickling filter depth (m)
Q_L = Hydraulic loading per unit surface ($m^3/m^2.d$)

The flow rate of wastewater in this city is 380 L/(Person-d), the biochemical oxygen demand (BOD_5) after the primary clarifier is 135 mg/L and BOD_5 after the final clarifier is 20 mg/L. The trickling filter depth is 1.5 m and there is no recycle stream in the treatment system. The treatment plant produces 30 m^3 of wet sludge per week. Determine the following:

a. **(10 points)** Diameter of a trickling filter that should be used in the treatment of wastewater at this city.
b. **(5 points)** Mass of dry solids (kg) generated per year if the produced sludge contains solids at 1.5%.
c. **(5 points)** Annual volume of sludge generation (m^3) after the dewatering of sludge by a filter press that increases the solid content of sludge to 25%.
d. **(5 points)** Ratio of sludge volume reduction due to the dewatering of sludge.

QUESTION 2 (25%):

A completely mixed bioreactor with no recycle stream is treating a groundwater contaminated with toluene by aerobic biodegradation processes. The influent groundwater has a flow rate of 200 m^3/day. The concentration of toluene in the groundwater is 250 mg/L and the required effluent concentration of toluene is 12 mg/L. The bacterial culture in the bioreactor follows a pseudo-first order relationship where the specific rate of toluene removal ($q = 1/X\ dS/dt$) is directly proportional to the toluene concentration (S). If the rate constant (k) is equal to 0.4 liter/(mg cells.hr), determine the following:

a) **(15 points)** The required volume of bioreactor under steady state operation to maintain 500 mg/L biomass in the bioreactor.

b) **(10 points)** The net biomass yield coefficient (Y), assuming that biomass growth follows the Monod relationship, the maximum specific growth rate (μ_{max}) is 0.68 hr^{-1} and the saturation constant is 30 mg/L.

PART II- KNOWLEDGE-BASED QUESTIONS (50%)

Questions:

1. **(4 points)** What is hard water? What are the contaminating elements in hard water? Why is hard water undesirable in industrial operations?

2. **(3.5 points)** Why should chlorine be added to the water for disinfection purposes after the treatment process and removal of organic and inorganic contaminants, not before the treatment process?

3. **(3.5 points)** Name two characteristics of a wastewater that will make it undesirable for treatment by biological processes.

4. **(4 points)** What is referred to as "acid rain"? Briefly explain the nature of acid rain, how acid rain is produced, and environmental impacts of acid rain.

5. **(3.5 points)** Name three different greenhouse gases (GHG).

6. **(3.5 points)** Name three mitigation strategies for the reduction of greenhouse gas emissions in an industrial operation.

7. **(3.5 points)** What are the major constituents of alkalinity in water?

8. **(3.5 points)** What kinds of contaminants are targeted during the coagulation process?

9. **(3.5 points)** What are pathogens? Name two different types of pathogens in water subject to drinking water standards.

10. **(3.5 points)** What are the disadvantages/limitations of using UV light for water disinfection? State three reasons.

11. **(3.5 points)** The decrease of ozone in the atmosphere is mainly due to presence of (Choose a, b, c or d):

    a. PAN, PBN
    b. CFC, HFC
    c. CO, NO
    d. None of the above

12. **(3.5 points)** Identify a major organic compound that is considered as an indoor air pollutant. Give the sources and potential health impacts.

13. **(3.5 points)** Explain which air pollutants contribute to the formation of photochemical smog.

14. **(3.5 points)** Name three different sources of particulate matter (PM) in air. Explain at least one health hazard of PM in air.