BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, PILANI

SECOND SEMESTER 2022– 2023

CE F323 (INTRODUCTION TO ENVIRONMENTAL ENGINEERING)

MID-SEMESTER EXAMINATION (OFFLINE and CLOSED BOOK)

Duration: 90 mins Max Marks: 70

Note:

- **Please write the assumptions clearly, if any.**
- **In Q1 One eight-mark question is optional. Five out of six eight marks questions can be attended (5*8=40). One five-mark, three-mark and two-mark questions are compulsory. Total 50 marks for Q1 (5*8+1*5+1*3+1*2=50).**
- **Q2: is compulsory.**
- **Q3: Either a or b should be written.**

Q1. The schematic map of a town is given (page 3). The town has 40000 households with an average of 4 persons per home. The local body supplies 135 LPCD (liters per capita per day) of treated water.

a) The water sourced from borewells for treatment have Fluoride content of 0.3 mg/l. The optimum Fluoride content is 0.7 mg/l as per standard and to maintain that sodium fluoride is added to the water. Ten bags of Sodium Fluoride are available, and each bag weighs 25 kg. How many days of water supply can be done with available NaF? (Sodium and Fluoride atomic weights are 23 g and 19 g respectively). [8]

b) Assume that 80% of the supplied water comes out as a wastewater and getting treated at the sewage treatment plant. The BOD_5 of the sewage before treatment was 400 mg/l. The treatment removal efficiency of BOD_5 is 70%. Assume that the input discharge and output discharge from the STP (Sewage Treatment Plants) are same. River upstream (before point P) BOD_5 is 3 mg/l. The cross-sectional area and average velocity of the river flow are 15 m^2 and 0.9 m/s respectively. If the effluent from the STP mixes completely to become uniform concentration, what would be the BOD_5 just after mixing? What are the **designated best uses** of the river before and after mixing as per CPCB based on BOD5 alone? [8]

c) The sewage treatment plant was under repair for a week and the local body collected the sewage for one day and disposed in the lake B. The BOD of the lake before the disposal was 2.5 mg/l. The volume of water in the lake was 500 million cubic feet (1 inch is equal to 2.54 mm). Assuming that the disposed sewage is mixed completely, and lake has enough capacity to absorb the sewage water quantity for a week, what is the initial BOD of the lake if the day of disposal is taken as zeroth day (just after mixing) with BOD is L_0? What is the BOD_5? The temperature of the lake is 25.3 ^oC. Assume that,
   - BOD decay rate at 20^oC is 0.15 per day if log base 10 formula is used.
   - Only carbonaceous BOD exists. [8]

d) Farmlands are supplied with NPK based fertilizers and return flow is discharging to the Lake A. The N/P ratio of the lake is 8. The lake receives return flow of 5 m^3/s and outflow rate is same. Due to excessive use of fertilizer 0.15 mg/l of phosphorous and 0.05 mg/l of Nitrogen are available in the return flow. The settling rate of phosphorous is 12 m/yr and Nitrogen is 5 m/yr. Identify the limiting nutrient and estimate the average total concentration of the **limiting nutrient**. The limiting values for P and N for avoiding Eutrophication are 0.01 mg/L and 0.1 mg/L. Calculate how much of nutrients should be eliminated in percentage in return flow to avoid Eutrophication. The surface area of the lake is 15*10^6 m^2. [8]

e) The underlying aquifer has **intrinsic permeability** of $3*10^{-11}$ m^2/s. The density of water 1000 kg/m^3, gravitational acceleration 9.81 m/s^2, and kinematic viscosity 10^{-6} m^2/s. The slope of the terrain from well A (W_A) to well B (W_B) is 50 m V: 1 km H downwards (50 m vertically downwards per 1 km horizontal) distance. The water level at the wells are 10 m and 20 m below ground level at W**A** and

W_B respectively. If a conservative tracer is injected at well A, what is the time required for the tracer to reach well B (in days)? Assume the principal flow is along AB and porosity is 0.3. [8]

f) Briefly write the meaning of the following:
   - EDC [2]
   - Non-point source pollution [2]
   - Oxygen sag curve and mention the formula (no need for derivation. Just write the formula). Also draw a sample oxygen sag curve and mark the necessary parameters and variable, initial conditions. [4] [8]

g) Use the same rate of return flow as an inflow and 0.05 mg/l of Nitrogen in the return flow to Lake A (from Q1.d). Consider the following Nitrification reaction which is combined reaction of Nitrite and Nitrate bacteria conversions:

$$NH_3 + 2O_2 \rightarrow NO_3^- + H^+ + H_2O$$

Use atomic weight of Nitrogen 14 g and Oxygen 16 g to find the total amount of oxygen needed for oxidizing the Nitrogen supplied to the Lake A each day. [5]

h) The captive powerplant belongs to cement factory the must produce 20 MW power for the manufacturing process. The efficiency of the thermal plant is 1/3. The river water which is at 25 deg C is used for cooling. If the cooling water only allowed to rise in temperature by 5 deg C what flow rate from the river would be required? How much would the river temperature rise as it receives the heated cooling water? [3]

i) The Lake B water sample is tested, and the results are following:
Total Coliforms Organism MPN/100ml shall be 30 or less, pH is 7.1, Dissolved Oxygen 5.5 mg/l, Biochemical Oxygen Demand 5 days 20°C 2.5 mg/l. No trace of free ammonia and Boron, sodium absorption ration is 24, Electrical Conductivity at 25°C is 1500 micro mhos/cm. What is the designated best use of the lake? [2]

Q2: Compulsory

2. The following is used for modeling contaminant transport:

$$\left[\frac{\partial}{\partial x}\left(D_x\frac{\partial C}{\partial x}\right)+\frac{\partial}{\partial y}\left(D_y\frac{\partial C}{\partial y}\right)\right]-\left[\frac{\partial}{\partial x}(v_xC)+\frac{\partial}{\partial y}(v_yC)\right]=\frac{\partial C}{\partial t} \quad \text{---- (A)}$$

$$D_x = \alpha_L v_x + D^*$$

$$D_y = \alpha_T v_x + D^*$$

$$D^* = \omega D_d$$

Answer the following:

a) It is a steady state equation. True or false? [1]

b) What is the term v_x? [1]

c) Equation (A) is a scalar equation or a vector equation? [2]

d) Is it conservation of mass or momentum. Conservation of groundwater or solute? [2]

e) What is ω? Why is it needed? What is D_d? [2]

f) Is Fick's first law related to advection or molecular diffusion? State the law. [2]

g) Write the name and physical meaning of α_L and α_T? [2]

[12]

Q3: Either a or b should be written.

3a. Write the equation (A) and show advection terms, hydrodynamic dispersion terms, molecular diffusion term in the equation. Explain physical meaning of each term? [8]

Or

3b. Write briefly on the following:
   - Darcy Law and its limitations. How is Darcy law used in Equation (A)? [4]

- LNAPL and DNAPL. Can it be modeled with Equation (A)? [2]
- Ground subsidence and major cause(s) for it [1]
- Open system and closed system [1]

[8]

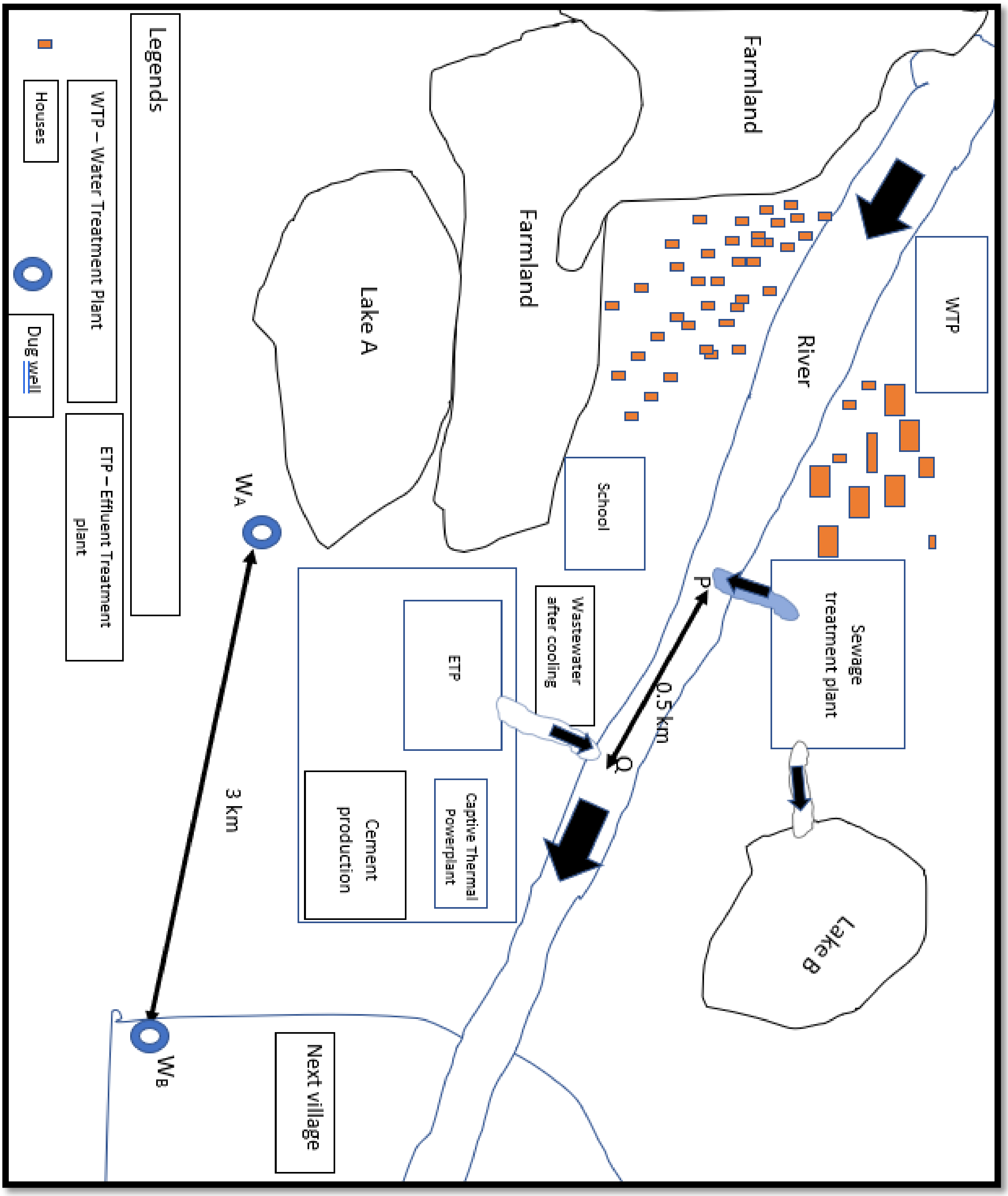

Figure: Question 1

Temp deg C	Specific heat Capacity (kJ/kg/K) of water
0.01	4.2199
10	4.1955
20	4.1844
25	4.1816
30	4.1801
40	4.1796
50	4.1815

$$k_T = k_T \cdot \theta^{T-20};\ \theta = 1.047$$

$$DO = DO_s - \frac{k_d \cdot L_0}{k_r - k_d}\left(e^{-k_d t} - e^{-k_r t}\right) + D_0\, e^{-k_r t};$$

$$k_r = \frac{3.9\, u^{0.5}}{H^{1.5}};$$

$$\left[\frac{\partial}{\partial x}\left(D_x \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_y \frac{\partial C}{\partial y}\right)\right] - \left[\frac{\partial}{\partial x}(v_x C) + \frac{\partial}{\partial y}(v_y C)\right] = \frac{\partial C}{\partial t}$$

$$D_x = \alpha_L v_x + D^*$$

$$D_y = \alpha_T v_x + D^*$$

$$D^* = \omega D_d$$

Hydraulic conductivity

$$K = \frac{k \quad \rho g}{\mu};$$

$$R_e = \frac{\rho v \cdot d}{\mu}$$

$$Fr = \frac{v}{\sqrt{g \cdot d}}$$

$$\nabla^2 h = 0$$

$$E = \frac{p}{\rho g} + \frac{v^2}{2g} + z$$

Designated Best Uses of Water (CPCB Water Quality Criteria)		
Designated Best Use	Class	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	1.Total Coliforms Organism MPN/100ml shall be 50 or less
		2. pH between 6.5 and 8.5
		3. Dissolved Oxygen 6mg/l or more
		4. Biochemical Oxygen Demand 5 days 20 °C, 2mg/l or less
Outdoor bathing (Organised)	B	1.Total Coliforms Organism MPN/100ml shall be 500 or less
		2. pH between 6.5 and 8.5
		3. Dissolved Oxygen 5mg/l or more
		4. Biochemical Oxygen Demand 5 days 20 °C, 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less
		2. pH between 6 and 9
		3. Dissolved Oxygen 4mg/l or more
		4. Biochemical Oxygen Demand 5 days 20 °C, 3mg/l or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 and 8.5
		2. Dissolved Oxygen 4mg/l or more
		3. Free Ammonia (as N)
		4. Biochemical Oxygen Demand 5 days 20 °C, 2mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 and 8.5
		2. Electrical Conductivity at 25 °C micro mhos/cm, maximum 2250
		3. Sodium absorption Ratio Max. 26
		4. Boron Max. 2mg/l
	Below-E	Not meeting any of the A, B, C, D & E criteria