UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 4 Examination in Engineering: September 2014(Repeat)

Module Number: CE4312 **Module Name: Water and Wastewater Engineering**

[Two Hours]

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

Q1. a) Table Q1 shows the results of a solids analysis of a wastewater sample taken at an industrial facility. The size of the sample was 150 *mL*. Determine the concentration of total solids, total and suspended volatile solids, total suspended and total dissolved solids.

Table Q1 Results of a wastewater sample analysis for solids.

Description	Weight, (*g*)
Tare mass of evaporating dish	54.6522
Mass of evaporating dish plus residue after evaporation at 105 ^0C	54.7122
Mass of evaporating dish plus residue after ignition at 550 ^0C	54.6822
Tare mass of Whatman GF/C filter	1.5350
Mass of Whatman GF/C filter plus residue after drying at 105 ^0C	1.5653
Mass of Whatman GF/C filter plus residue after ignition at 550 ^0C	1.5553

[2.5 Marks]

b) The 20 ^0C BOD_5 (5-*d* Biochemical Oxygen Demand) of a wastewater is 190 mg/L. What will be the 9-d demand at the same temperature? If the bottle had been incubated at 32 ^0C, what would the BOD_5 have been? The following equation is applicable: $k_T = k_{20}\theta^{(T-20)}$; where k_T = 1st order reaction rate constant at $T\ ^0C$ temperature; θ (temperature coefficient) = 1.056; k_{20}= 0.23 d^{-1}.

[2.5 Marks]

Q2. a) Give a brief discussion on the sedimentation operation of a wastewater treatment plant based on following factors: location of the sedimentation tank at a treatment plant, major components of a sedimentation tank and target wastewater parameters.

[1.5 Marks]

b) Following data are given for the coarse bar screen of a wastewater-treatment plant having a flow rate of 15 000 m^3/d. The peak flow is 1.5 times the average. The velocity through the screen = 0.62 ms^{-1}; bar width = 1.5 *cm*; clear bar spacing = 4.5 *cm*; inclination angle = 62° to horizontal; channel width = 1.2 *m*. Calculate the cross sectional area of the screen and the minimum height of the screen. What will be the head loss through the screen when the screen is half-clogged. The following equations is applicable: $h_L = \frac{1}{0.7}\left(\frac{V^2-U^2}{2g}\right)$; $U = V\frac{(Bar\ spacing)}{(Bar\ spacing+Bar\ width)}$ where;

0.7 = An empirical discharge coefficient to account for turbulence and eddy losses.
g = Acceleration due to gravity,($9.81\ ms^{-2}$)
h_L = Head loss,(m)
U = Approach velocity in upstream channel,(ms^{-1})
V = Velocity of flow through the openings of the bar, (ms^{-1})

[3.5 Marks]

Q3. a) A municipal wastewater - treatment plant processes an average flow of 20 000 m^3/d. The peak flow is 2.0 times the average. Assume that there are two units of channel type grit chambers in this treatment plant, and they are designed to remove particles with a diameter of 0.21 mm and a relative density of 2.6. A flow-through velocity of 0.32 ms^{-1} will be maintained by a downstream proportioning weir. Calculate the length, width and depth of the grit chamber for a depth to width ratio of 1:1.4. The allowable hydraulic detention time is from 1 to 5 minutes. The Stokes law for spherical particles is $V_s = \frac{g(\rho_s-\rho_L)d_p^2}{18\mu}$

where; $\rho_L = 1000\ kgm^{-3}$;$\mu = 10^{-3}\ kgs^{-1}m^{-1}$; $g = 9.81\ ms^{-2}$
ρ_L= Density of water,(kgm^{-3})
ρ_s= Density of solid,(kgm^{-3})
d_p= Particle diameter, (m)
g = Acceleration due to gravity,(ms^{-2})
V_s= Settling velocity,(ms^{-1})
μ = Absoluteviscosity of the liquid, ($kgs^{-1}m^{-1}$)

[3.5 Marks]

b) Assuming that there are two units of circular primary clarifiers in a wastewater treatment plant with an average flow of 20 000 m^3/d, determine the tank diameter and the weir length. The overflow rate at average flow conditions is 45 $m^3/m^2.d$ and the weir loading rate is 260 $m^3/m.d$.

[1.5 Marks]

Q4. Referring to Figure Q4, write mass balances for the micro-organisms (X) and substrate (S) in the entire system. Derive following expressions:
$X = \frac{(S_0-S)Y}{(1+k_dHRT)}$; $S = \frac{K_s(1+k_dHRT)}{\{HRT(Yk-k_d)-1\}}$; and $Y_{obs} = \frac{Y}{(1+k_dHRT)}$

Assume that the cell concentration in the influent (X_0) is zero and steady-state conditions prevail. Following equations are applicable:
$r_g = \mu X;\ k = \mu_m/Y;\ \mu = \mu_m S/(K_s + S)\ ;\ r_g = Yr_{su}$
HRT = Hydraulic retention time, $[T]$
k = Maximum rate of substrate utilization per unit mass of microorganisms$[T^{-1}]$
k_d = Endogenous decay coefficient, $[T^{-1}]$
K_s = Half-velocity constant for the limiting substrate, $[M]/[L^3]$
Q = Influent flow rate, $[L^3]/[T]$
r_g = Rate of bacterial growth, $[M]/\{[L^3].[T]\}$
r_{su} = Rate of substrate utilization, $[M]/\{[L^3].[T]\}$
V = Volume of the reactor, $[L^3]$

Y = Maximum yield coefficient, *[M]/[M]*(the ratio of the cell formed to the mass of substrate consumed during a finite period of logarithmic growth)

Y_{obs}= Observed yield coefficient, *[M]/[M]*

μ = Specific growth rate, *[T^{-1}]*

μ_m = Maximum specific growth rate, *[T^{-1}]*

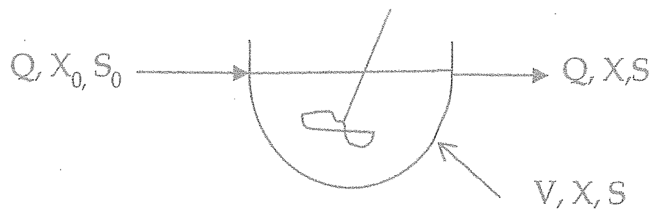

Figure Q4 Schematic of complete-mix reactor with a continuous wastewater flow.

(5.0 Marks)