GXS08

OLLSCOIL NA hÉIREANN, GAILLIMH

NATIONAL UNIVERSITY OF IRELAND, GALWAY

SECOND SEMESTER EXAMINATIONS, 2000

B.E. DEGREE EXAMINATION

DESIGN OF WATER/WASTEWATER TREATMENT SYSTEMS

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Time allowed: *two* hours.
Attempt *four* questions.

1. (i) Illustrate the operation of the following biofilm systems: fluidised bed, moving bed and submerged stationary biofilter. Distinguish between hydraulic erosion and complete sloughing off of biofilms. Show, using neat sketches, how (a) oxygen and (b) organic substrate can be rate limiting in a biofilm.

   (ii) A trickling stone filter with recycle has a diameter of 10 m and a height of 3 m, and is loaded with 200 m^3/d of mixed and industrial wastewater having a biochemical oxygen demand (BOD) of 500 g/m^3. If the hydraulic surface loading rate is 1.2 m/h, find the volumetric loading rate and the recycle flow.
   In order to eliminate the recycle, it was proposed to replace the stone media with plastic media having a surface area of 150 m^2/m^3 and an organic areal loading rate of 5 g $BOD/m^2.d$. Calculate the new height of filter required.

2. (i) Illustrate in detail a nitrification-denitrification activated sludge system using (a) the influent wastewater as the organic substrate for denitrification and (b) methanol as the substrate. Comment on why methanol may be required.

   (ii) A denitrification activated sludge system, consisting of a completely mixed anoxic tank, a completely mixed aerobic tank and a clarifier in series, with return of nitrate to the anoxic zone, treats an influent wastewater flow of 12,000 m^3/d.The influent has a substrate biochemical oxygen demand (BOD) of 0.25 kg/m^3 and a total nitrogen concentration (TN) of 0.05 kg/m^3. The effluent has a BOD of 0.020 kg/m^3 and a TN of 0.005 kg $/m^3$. The stoichiometric yield constant for heterotrophs is 0.8 in terms of BOD, and for autotrophs is 0.2 in terms of nitrogen. The amount of nitrogen used in cell synthesis is 0.05 kg N/kg suspended solids (SS). The volatile suspended solids (VSS) in the anoxic zone is maintained at 4 kg $/m^3$ and the denitrification rate is 0.5 g N/kgVSS.h. Calculate the anoxic tank volume. Show how you would obtain the recycle ratio for the system. State any assumptions you make.

3. (i) Write detailed notes on the biological removal of phosphorus in an activated sludge system. Illustrate your answer with a line diagram of a suitable system. Describe what happens in both the anaerobic and aerobic zones of the system. What effect would the introduction of nitrate to the anaerobic zone have on the phosphorus removal.

(ii) Wastewater, with an acetic acid concentration of 60 g/m^3, flows into the completely mixed anaerobic tank of an activated sludge biological phosphorus removal system at a rate of 3000 m^3/d. The volume of the tank is 200 m^3. Using a Monod expression to model the uptake of acetic acid to cell storage, calculate the concentration of acetic acid in the effluent from the anaerobic tank. Assume that the maximum uptake rate of acetic acid is 1.5 kg/m^3.d and that the saturation constant for the acetic acid in the Monod expression is 3 g/m^3.

4. (i) Illustrate the following anaerobic digesters: (a) an upflow fixed film reactor, (b) a fluidised bed reactor and (c) a completely mixed reactor with recycle. Write notes on anaerobic digestion, paying particular attention to hydrolysis, acid production, methane production, temperature, pH and operational problems.

(ii) A wastewater with a biodegradable COD of 3 kg/m^3 and a flow of 1400 m^3/d is to be treated in a biofilm anaerobic digester to give a final effluent with a biodegradable COD of 0.3 kg/m^3. The sludge concentration in the digester is 10 kg/m^3 and the removal rate is assumed to be 0.5 kg COD for every kg of sludge. If the biofilm media has a specific surface area of 100 m^2/m^3, calculate the total area of media required.

5. (i) Describe how the composition of industrial wastewaters may differ from that of municipal wastewater. Make reference in your answer to specific industrial wastewaters.

(ii) Discuss why phosphorus is of concern in Ireland in terms of our rivers and lakes, making reference to the main sources of phosphorus discharged to our inland waters. What legislative and technical measures are available to reduce the effect of phosphorus on our rivers and lakes?

6. (i) Briefly discuss the process of coagulation as applied to the treatment of potable water; in particular, make reference to the coagulants used, pH buffering and temperature effects.

(ii) Design a three-compartment flocculator having the general configuration shown in Figure 1. It is required to design the details for the first compartment only.

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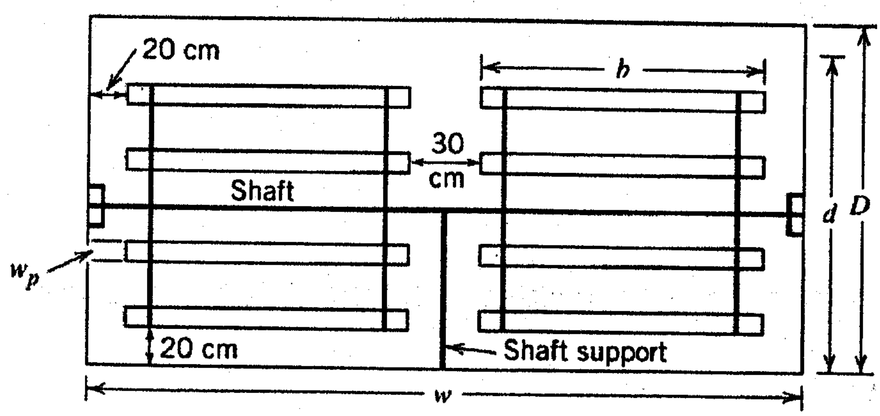

Figure 1

The flocculator must designed for following conditions:

Design flow	20,000m^3/d
G values	30, 20, 10
Max paddle length	4.2m
Min paddle clearances	20cm
Total detention time	25mins
Shaft supports	30cm spacing
Lowest temperature	10°C
Max depth	4.1m

Flocculator Design Aids

General

Peripheral speed of paddles	0.09 m/s - 0.9 m/s
k	0.25
C_D	1.8 for flat blades

Area of Blades

Paddles oriented normal to flow:
15 – 20% of the tank cross-sectional area
Paddles oriented parallel to flow:
15 – 20% of the tank side area

Depth – Area Ratio

No specific limits -- Max depth < 5m

Freeboard

0.5m

Width

Paddle width, 10cm < w < 20cm
Basin width, same width as sedimentation basin

Water Properties @ 10°C

ρ = 999.7kg/m^3
μ = 1.307 x 10^{-3} N.s/m

Power Requirements

$$G = \sqrt{\frac{P}{\mu V}}$$

$$P = (1.44 \times 10^{-4})\rho C_D b[N(1-k)]^3(r_o^4 - r_i^4)$$