ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2015 SESSION

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

14-CI-B4
WATER SUPPLY AND WASTEWATER TREATMENT

QUESTION 1 (15 %)

Determine the clean-water head loss in a filter bed composed respectively of 0.65 m of homogeneous anthracite (d = 1.6 mm; $\Phi = 0.68$; $\alpha = 0.40$) placed over 0.35 m of homogeneous sand (d = 0.5 mm; $\Phi = 0.90$; $\alpha = 0.38$). The average water flow on the filter is 33 000 m^3/d while the surface area of the filter bed is 180 m^2. The average water temperature is 5°C ($\mu = 0.001518$ $N \cdot s/m^2$; $\rho = 1000$ kg/m^3). (d = average grain diameter; Φ = shape factor; α = porosity; μ = dynamic viscosity; ρ = density). Use the Carmen-Kozeny equation to calculate the clean-water head loss.

QUESTION 2 (16 %)

A groundwater respectively contains 6,6 g-Fe^{2+}/m^3 and 4.7 g-Mn^{2+}/m^3, which causes continual problems of gray or brown spotting in toilet bowls, sinks and on clothing. Which method will solve simultaneously the manganese and iron problem? If sludge is produced, determine the approximate volume knowing that the sludge presents a solid content of 1.5 % (express your result as kg of produced sludge/m^3 of treated water). Suppose that 95 % of iron and manganese is removed.

QUESTION 3 (12 %)

Explain the incidences related to the distribution (aqueduct) during several years of water that was not at an equilibrium pH (pH_{sat}). When required, how does one correct the pH in a drinking water treatment plant? Justify your answer.

QUESTION 4 (12 %)

Compare the advantages and the disadvantages of physicochemical and biological wastewater treatment systems. In which situations is it preferable to use one or the other of these systems?

QUESTION 5 (25 %)

The following data were obtained from an activated sludge process (CFST type with secondary sedimentation tank):

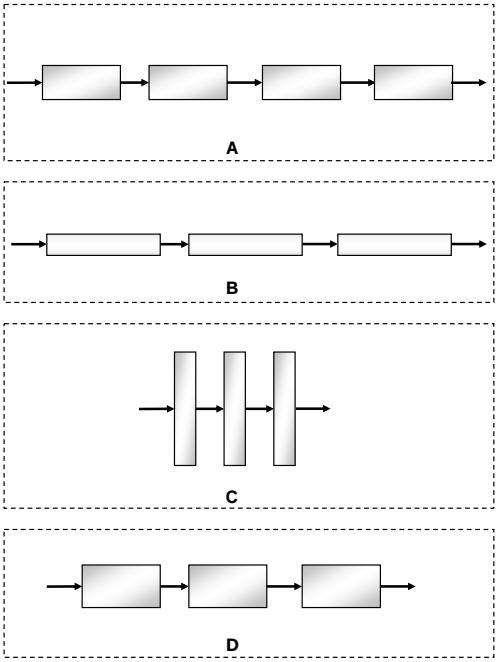
$V_{aeration\ tank}$	=	48 000 m^3	$X_{influent}$	=	negligible
Q	=	185 000 m^3/d	X	=	3000 g/m^3 (aeration tank)
Q_w	=	2000 m^3/d	X_e	=	20 g/m^3
Q_r	=	90 000 m^3/d			
$DBO_{5\ influent}$	=	300 g/m^3			
$DBO_{5\ effluent}$	=	20 g/m^3			

Determine:

i) the aeration tank hydraulic detention time θ; (2 %)
ii) X_r; (2 %)
iii) the sludge age θ_c; (3 %)
iv) the activated sludge growth rate r_g; (2 %)
v) the activated sludge specific growth rate μ; (3 %)
vi) the specific substrate utilization U; (3 %)
vii) Y expressed as g of biological sludge produced/g of BOD_5 removed; (3 %)
viii) the F/M ratio; (3 %)
ix) the approximate removal of phosphorus and nitrogen (g/m^3) by biological assimilation in bacteria cells. (4 %)

QUESTION 6 (10 %)

The opposite figure presents various configurations of facultative aerated ponds system where each configuration has an identical liquid total volume (e.g.: total volume of the four basins of the configuration A = total volume of the three basins of the configuration B…). Note that for a given configuration, the basins have identical volumes and that each configuration receives the same wastewater flow with the same BOD_5 concentration.



Taking into account these configurations, classify the four configurations by decreasing performances order of expected BOD_5 removal (two configurations could offer the same performance). Justify your answer if you need to (you do not necessarily need to carry out calculations to answer this question). If you must choose only one configuration for a municipality, which one would you propose and why?

QUESTION 7 (10 %)

Explain the impact of urban wastewater discharge to a receiving stream.