CE 412 A: Water Supply & Wastewater Disposal Systems

Tutorial – 2022-23 II ● Part II: Wastewater Management

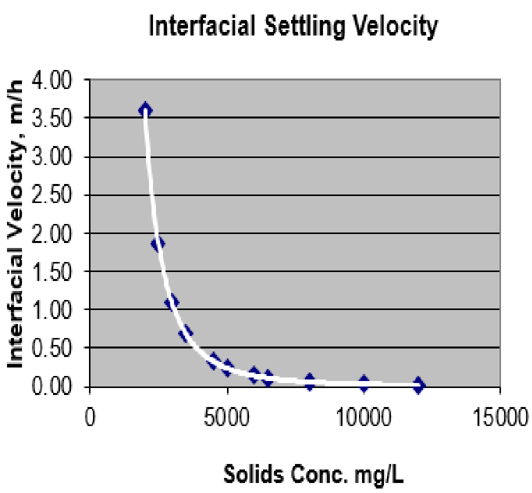
TUTORIAL 5 ● Wednesday, April 12, 2023

Exercise 1: Design Secondary Settling Tank(s) as a part of Secondary Treatment operations adopting an Activated Sludge Process for a locality with following information for which preceding unit were designed in Tutorials 3 & 4.

Water Supply	=	250 lpcd
Population density	=	350 person per hectare
Area served	=	690 hectares
Wastewater reaching sewers	=	80% of W/S
Peak Factor	=	3.0
Infiltration Rate	=	7391 l per day per hectare
Design Flow Reaching Sewage Treatment Plant (STP)	=	50 MLD
Some Relevant Parameters/Data/Information		
Concentration of Fixed Suspended Solids	=	50 mg/L
Mixed Liquor Suspended Solid Concentration, X	=	2,500 mg/L
Suspended Solids Concentration in Settled Sludge from SST, X_r	=	8,500 mg/L
Maximum Specific Substrate Utilization Rate, qmax	=	4 /d
Ks	=	25 mg/L
True Yield Coefficient, YT	=	0.5
Endogenous Respiration Coefficient, kd	=	0.05 /d
Outlet Weir Loading Rate	≤	125 m3/m/d
HRT	≤	3 h

Interfacial Velocities of Sludge Solids

Solids (C+X) mg/L	u, m/hr
2000	*3.60*
2500	*1.86*
3000	*1.09*
3500	*0.69*
4500	*0.33*
5000	*0.24*
6000	*0.14*
6500	*0.11*
8000	*0.06*
10000	*0.03*
12000	*0.02*



$$u = g\, c^{-h};\ g = 2 * 10^{10};\ h = 2.9521$$

u = Interfacial settling velocity (in m/hr); C = Mixed Liquor Suspended Solids Concentration (in mg/L) = X + C_o * (θ_c/θ); X = Biomass Concentration in Aeration Tank (AT), mg/L; C = Fixed Suspended Solids Concentration in inlet to AT, mg/L

Hint: Step1 – Compute q for given values of S_o, S, q_{max}, K_s; Step 2 – Compute θ: Step 3 – Compute θ_c; Step 4 – Compute C ; Step 5 - Compute SOR for clarification using $\boldsymbol{u = g\, c^{-h}}$; Step 6 – Compute R given X, X_r, θ & θ_c; Step 7 – Compute SOR for Limiting Solids Flux ; Step 8 – Compute surface area of secondary settling tank using SOR from Steps 5 and 7; Choose whichever is larger; Step 9 – Compute Effluent Weir Length and Check for Weir Loading.

SOR for Limiting Solids Flux is given by following expression:

$$\frac{Q}{A} = \frac{g(h-1)(\frac{h}{h-1})^{h}(R)^{h-1}}{(C_0)^{h}(1+R)^{h}}$$

Exercise 2: Estimate the minimum concentration of nitrogen and phosphorous in the sewage that must be present for the biological activity to sustain in ASP as designed.

Exercise 3: Design a high-rate trickling filter followed by secondary clarifier with the information provided as follows.

Trickling Filter		
Design Flow Reaching Sewage Treatment Plant (STP)	=	50 MLD
Design Value of BOD	=	250 mg/l
Effluent Total BOD	=	30 mg/L
Number of Filters	=	4
Depth of packing media	=	3.0 m
Recirculation Ratio	=	2
Hydraulic constant for Packing media (n)	=	0.5
Rate constant at T at 20 °C (k_{20})	=	1.36 / d
Depth of Secondary Clarifier	=	4.0 m
Surface Overflow Rate of SC	=	27 $m^3/m^2/d$

Filter Type	**Filter Medium**	**OLR, $kg/m^3/d$**	**HLR, $m^3/m^2/d$**	**% Removal**	**Depth**	**R**
Low Rate	Rock, Slag	0.1 – 0.3	1 – 4	80 – 85	1.8 – 3	0
Intermediate Rate	Rock, Slag	0.3 – 1.2	10 – 30	65 – 85	1 – 3	0.5 – 3
High Rate	Rock	1.2 – 3	40 – 90	65 – 85	2 – 5	1 – 4
Super High Rate	Plastic	3 – 4	60 – 120	65 – 80	4 – 12	1 – 4
Roughing	Plastic	4 – 6	60 – 180	40 – 65	4 – 12	1 – 4