ENV-405 | Water and Wastewater Treatment

Lecture 3. Coagulation/flocculation/sedimentation

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Exercice #1 | Calculation of coagulant doses, alkalinity consumption, and precipitate formation

A chemical supplier reports the concentration of stock alum chemical ($Al_2(SO_4)_3{,}14H_2O$) as 8.37% as Al_2O_3 with a specific density of 1.32 kg/L.

Q1. Calculate the concentration of alum in the stock chemical as mg/L Al_2O_3

Q2. Calculate the molarity of Al^{3+}

Q3. Calculate the alum concentration if reported as $Al_2(SO_4)_3{,}14H_2O$

Q4. For a 30-mg/L alum dose applied to a treatment plant with a capacity of 43'200 m^3/d, calculate the chemical feed in L/min

Q5. Calculate the alkalinity consumed (expressed as mg/L as $CaCO_3$) knowing that

$$Al_2(SO_4)_3.14H_2O \rightarrow 2Al(OH)_3 + 6\,H^+ + 3SO_4^{2-} + 8H_2O$$

Q6. Calculate the amount of precipitate produced in mg/L and kg/day

Q7. DWTP often used caustic soda (NaOH) or other alkaline solutions to counteract the consumption of alkalinity. Calculate the amount of NaOH to be added to avoid a decrease of alkalinity knowing that

$$Al_2(SO_4)_3.14H_2O + 6\,NaOH \rightarrow 2Al(OH)_3 + 3\,Na_2SO_4 + 14H_2O$$

Exercice #2 | Calculating terminal settling velocity

Q1. Calculate the terminal settling velocity for sand in water at 10°C having particle diameters of 75 and 180 um and a density of 2'650 kg/m^3

Table C-1
Physical properties of water (SI units)

Temperature T (°C)	Specific Weight γ (kN/m^3)	Density[a] ρ (kg/m^3)	Dynamic Viscosity[b] μ ($\times 10^{-3}$ kg/m·s)	Kinematic Viscosity ν ($\times 10^{-6}$ m^2/s)	Surface Tension[c] σ (N/m)	Modulus of Elasticity[a] E ($\times 10^9$ N/m^2)	Vapor Pressure P_v (kN/m^2)
0	9.805	999.8	1.781	1.785	0.0765	1.98	0.61
5	9.807	1000.0	1.518	1.519	0.0749	2.05	0.87
10	9.804	999.7	1.307	1.306	0.0742	2.10	1.23
15	9.798	999.1	1.139	1.139	0.0735	2.15	1.70
20	9.789	998.2	1.002	1.003	0.0728	2.17	2.34
25	9.777	997.0	0.890	0.893	0.0720	2.22	3.17
30	9.764	995.7	0.798	0.800	0.0712	2.25	4.24
40	9.730	992.2	0.653	0.658	0.0696	2.28	7.38
50	9.689	988.0	0.547	0.553	0.0679	2.29	12.33
60	9.642	983.2	0.466	0.474	0.0662	2.28	19.92
70	9.589	977.8	0.404	0.413	0.0644	2.25	31.16
80	9.530	971.8	0.354	0.364	0.0626	2.20	47.34
90	9.466	965.3	0.315	0.326	0.0608	2.14	70.10
100	9.399	958.4	0.282	0.294	0.0589	2.07	101.33

Exercice #3 | Particle removal in sedimentation basin

A rectangular sedimentation basin has the following design: a depth of 4.5 m, a width of 6 m, a length of 35 m and a process flow rate of 525 m3/h.

Q1. Calculate the overflow rate and critical velocity

A laboratory analysis shows the number of particles according to settling velocities (see excel file)

Q2. Compute the percent removal of particles in each size range using a data table (average settling velocity will be used for calculation)

Q3. Calculate the influent and effluent particle concentrations and plot the data as a function of particle size using a histogram.

Q4. Calculate the overall particle removal efficiency