LSN 18 Coagulation with Alum

CEEG 340–Introduction to Environmental Engineering
Instructor: Deborah Sills; **4 October, 2019**

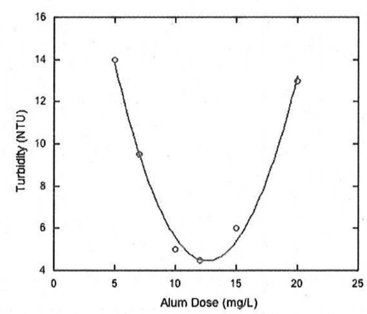
As part of the design of a drinking water treatment plant, you will design a rapid-mix tank used for coagulation. This design will include calculation of chemical requirements (today's lecture), power requirements and sizing of a tank (next class). The design capacity of the plant is 3.25 million gallons per day (MGD). The source is river water with initial turbidity of 10 NTU, alkalinity concentration of 50 mg/L as $CaCO_3$, at 10 ^{0}C, pH = 7.

Background

The purpose of coagulation is to neutralize the charge of small particles (or colloids) in raw (untreated) water, so that can stick to each other during flocculation. A positively charged *coagulant* is added to water to accomplish coagulation. The most commonly used coagulant is aluminum (Al^{3+}) added as alum, $Al_2(SO_4)_3{\bullet}14H_2O$. The main disadvantage of alum is that its efficacy is dependent on alkalinity.

Alum Dose

Estimate the optimal alum dose for coagulation based on the following results of a jar test:



OPT. DOSE ≅ 12 mg/L ALUM

Consumption of Alkalinity

Calculate the alkalinity consumed in units of mg/L as $CaCO_3$ at the optimal alum dosage using the following chemical reaction:

594 g   6 eq ALK

$$Al_2(SO_4)_3{\bullet}14\,H_2O + 6\,HCO_3^- \rightarrow 2\,Al(OH)_{3(s)} + 3\,SO_4^{2-} + 6\,CO_2 + 14\,H_2O$$

$$12\ mg/L\ ALUM \times \frac{6\ eq\ ALK}{594\ g\ ALK} \times \frac{50\ g\ CaCO_3}{eq\ ALK} = 6\ mg/L\ as\ CaCO_3$$

ALK. CONSUMED = 6 mg/L AS $CaCO_3$

Addition of Alkalinity and Alum

1. How much alkalinity (in tons per year of calcium hydroxide, $CaOH_2$) would needed to be added to the rapid mix tank.

STEP ①: CALCULATE ALK REQUIRED

HAVE: 50 mg/L as $CaCO_3$ (GIVEN IN PROBLEM STATEMENT)

NEED: 6 mg/L as $CaCO_3$

SO NEED TO ADD NO ALKALINITY

2. How much alum (in tonnes per year) needs to be added to the rapid mix tank?

$$12\ \frac{mg}{L} \times 3.25\times10^6\ \frac{GAL}{DAY} \times 3.785\ \frac{L}{GAL} \times \frac{1\ g}{1000\ mg} \times \frac{1\ TONNE}{10^6\ g} \times 365\ \frac{DAY}{YEAR} = 54\ TONNE/Y$$

ALUM NEEDED = 54 TONNE PER YEAR

Next Class: Size and Power

Size a rapid-mix tank and determine the power requirements for coagulation? Use the *typical values* presented in Table 8.12 in the textbook, and in Table 1.

Table 1: **Typical values used in design of rapid-mix systems** (adapted from Mihelcic and Zimmerman).

System Category	RMS Velocity Gradient, $\bar{G}$ (s^{-1})	HRT, θ, (s)	$\bar{G}t$ Values
Mechanical Mixing	600–1000	60-120	5.0×10^3 to 5.0×10^5
In-line Mixing	3,000–5,000	1	5.0×10^3 to 5.0×10^5