

Jar Testing Coagulation Dosage Water Treatment Plants

WQT 134
Aquatic Chemistry II

Determining ALUM Coagulation Rates

<http://www.cee.vt.edu/ewr/environmental/teach/wtprimer/jartest/jartest.html>

http://www.waterspecialists.biz/html/jar_test.html

Week 8 Objectives

Reading assignment:

Tech Brief: Jar Testing

- Understand how to test pH, turbidity, and color on raw water sample
- Understand Jar Testing/Coagulation chemistry
- Understand the role of pH, alkalinity, turbidity, temperature on coagulation and flocculation application

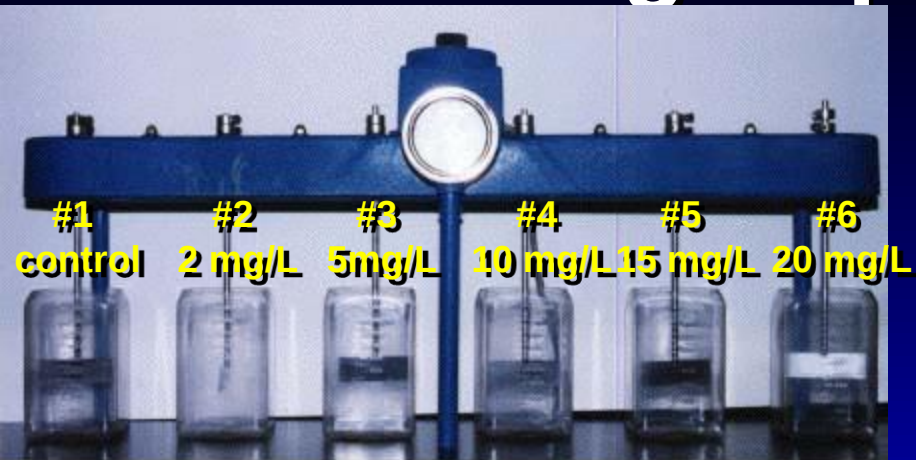
Key Words

- Coagulation: adding and rapid mixing of chemicals to remove particles from water. (flash mixing)
- Flocculation: adding and slow mixing of chemicals and particles to create flocs that settle out of water.
- Turbidity: suspended, dissolved, and colloidal particles in pretreated water that need to be removed to optimize treatment efficiency.

Jar Testing Steps

- Fill the Phipps and Bird jar testing apparatus containers with 1000 ml of sample water.
- Label each Beaker #1 add 1 liter of water =control, Beaker #2 add 2 ml of alum=2 mg/L, Beaker #3 add 5 ml of alum=5 mg/L, Beaker #4 add 10 ml of alum=10 mg/L, Beaker #5 add 15 ml of alum=15 mg/L, Beaker #6 add 20 ml of alum=20 mg/L
- Add the coagulant to each container and stir at approximately 100 rpm for 1 minute (record condition of flocs during rapid mix coagulation).
- Reduce the stirring speed to 25 to 35 rpm and continue mixing for 15 to 20 minutes(record condition of flocs every 5 minutes on data sheet below).
- Determine which coagulant dosage has the best flocculation time and the most floc settled out.
- Test the turbidity of the water in each beaker using a turbidimeter (record value on data sheet).

Jar Testing Experimental Design



Add 1 liter of water Label each

Beaker #1 =control

Beaker #2 add 2 ml of alum=2 mg/L

Beaker #3 add 5 ml of alum=5 mg/L

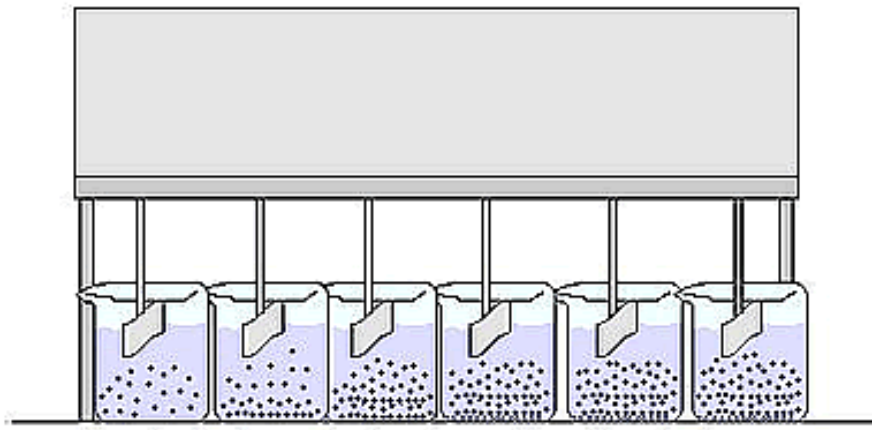
Beaker #4 add 10 ml of alum=10 mg/L

Beaker #5 add 15 ml of alum=15 mg/L

Beaker #6 add 20 ml of alum=20 mg/L

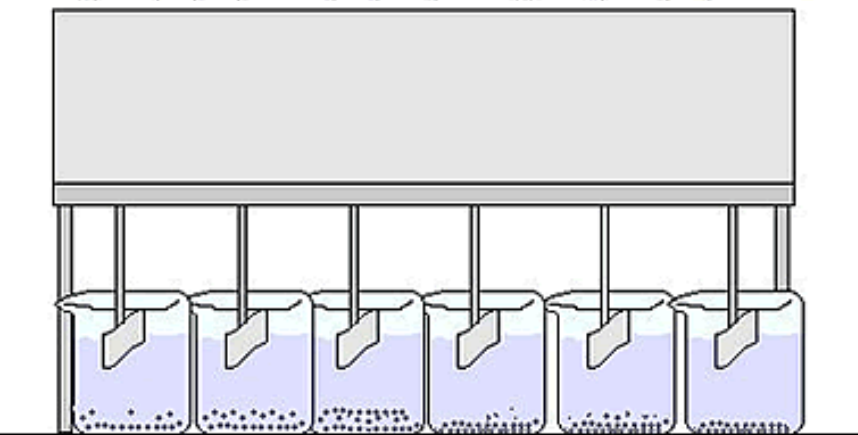
Rapid mix 100 rpm for 1 min

Record floc conditions



Slow mix 25 rpm for 15 min

Record floc conditions every 5 min



Let settle for 10 min

Determine optimal coagulant dosage.

Record Turbidity on optimal coagulant dose

Jar Testing Results

- A hazy sample indicates poor coagulation.
- Properly coagulated water contains floc particles that are well-formed and dense, with the liquid between the particles clear.



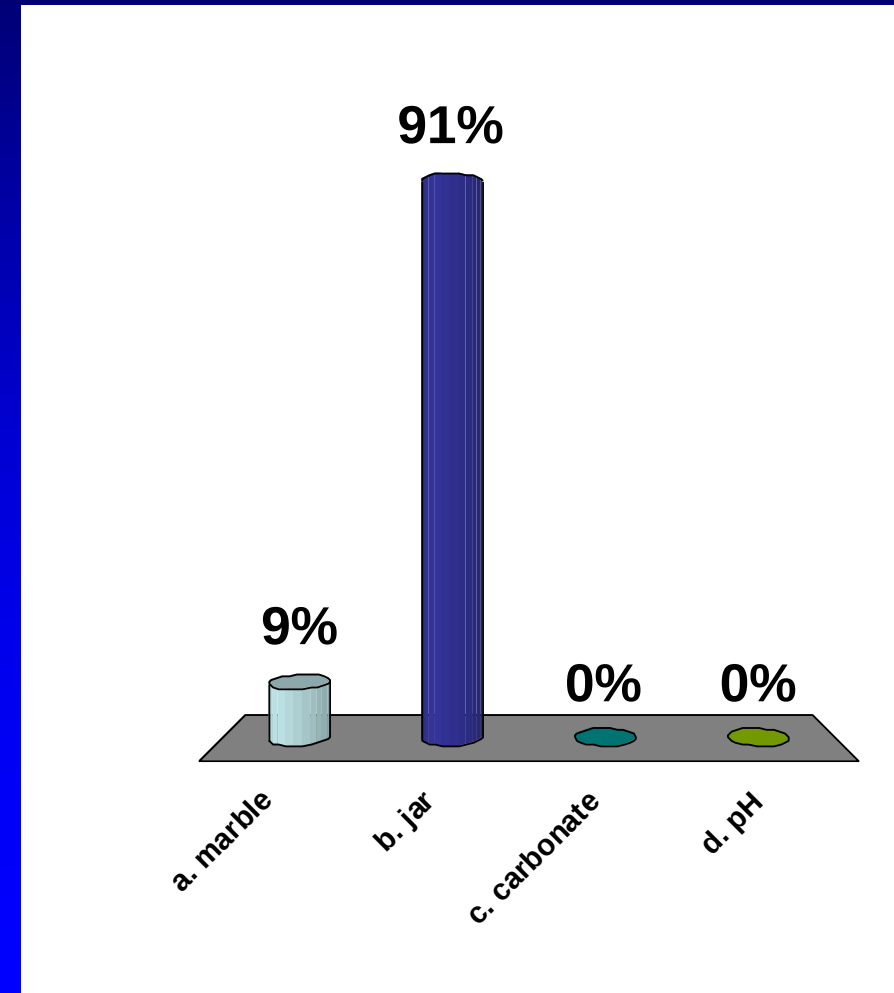
In determining the proper dosage of alum, the most useful test is the _____ test:

a. marble

😊 b. jar

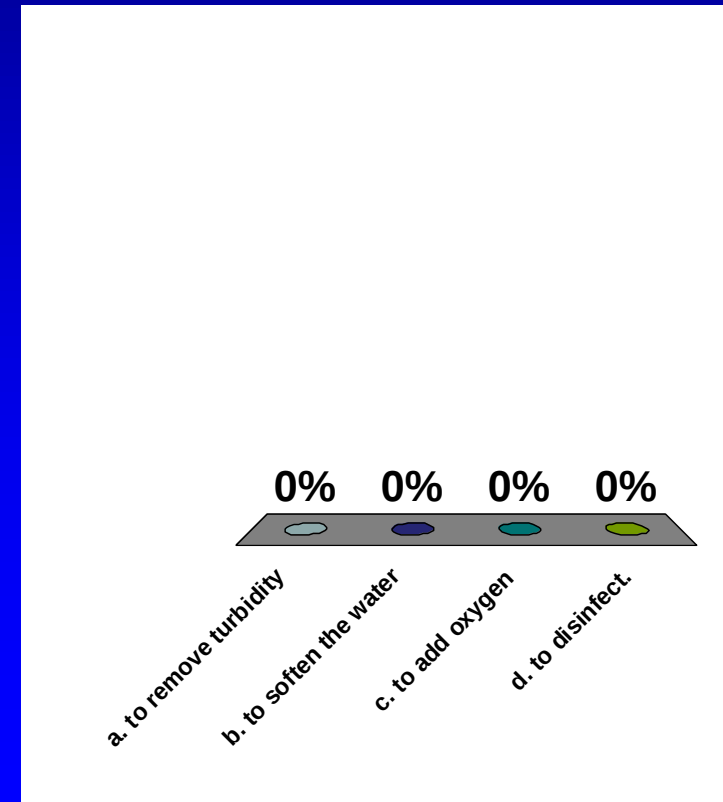
c. carbonate

d. pH



Which of the following is the main purpose of the coagulation/flocculation process?

- 😊 a. to remove turbidity
- b. to soften the water
- c. to add oxygen
- d. to disinfect.



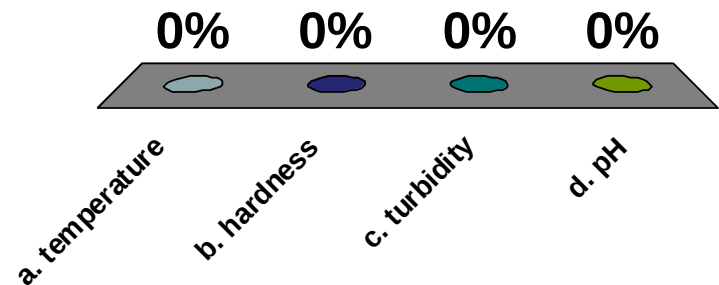
The most important raw water constituent for a surface water plant is:

a. temperature

b. hardness

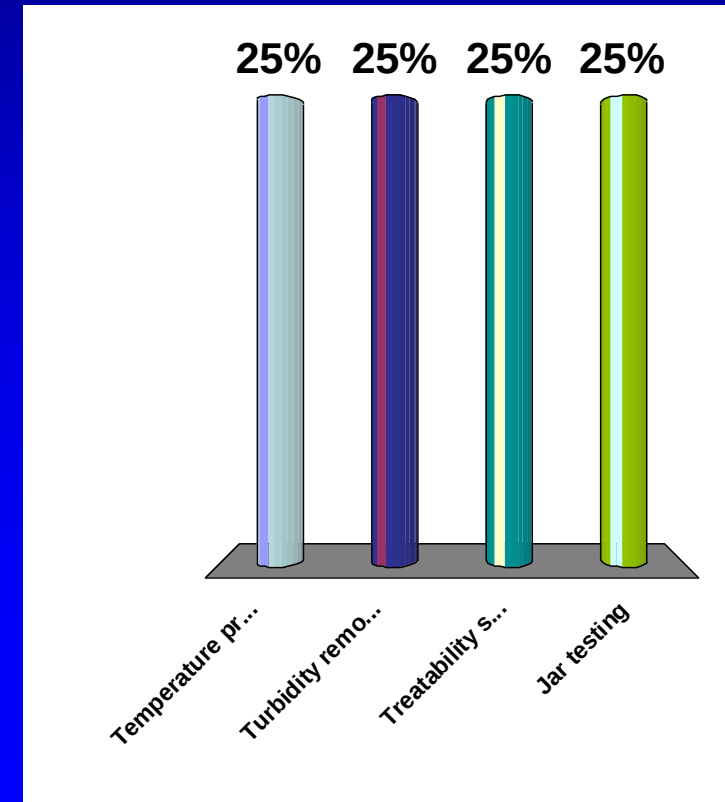
😊 c. turbidity

d. pH



A laboratory procedure for evaluating coagulation, flocculation, and sedimentation is called what?

1. Temperature profile
2. Turbidity removal efficiency
3. Treatability study
- 😊 4. Jar testing



Coagulation and Flocculation at Water Treatment Plants

“Ironically, it is easier to clean up dirty water than to make clean water cleaner. The reason is because particles must collide before they can stick together to make larger flocs. More particles means more collisions.”

Turbidity

- **Turbidity** – particles (sand, silt, clay, bacteria, viruses) in the initial source water that need to be removed to improve treatment.

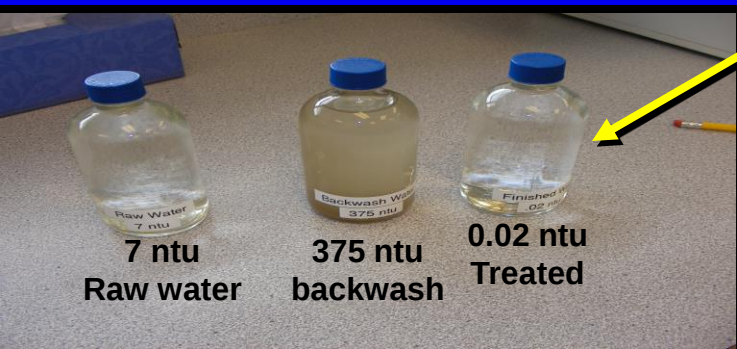
1. Suspended Solids



2. Colloidal Solids (~ 0.1 to $1\ \mu\text{m}$)

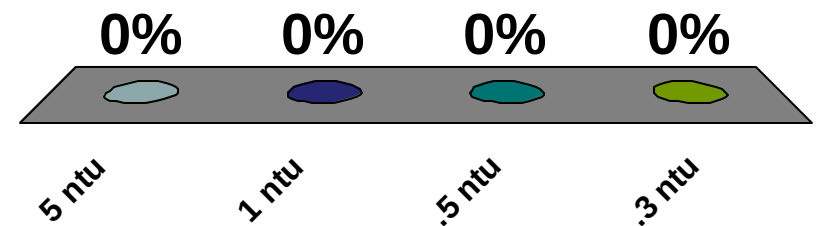


3. Dissolved Solids ($< 0.02\ \mu\text{m}$)



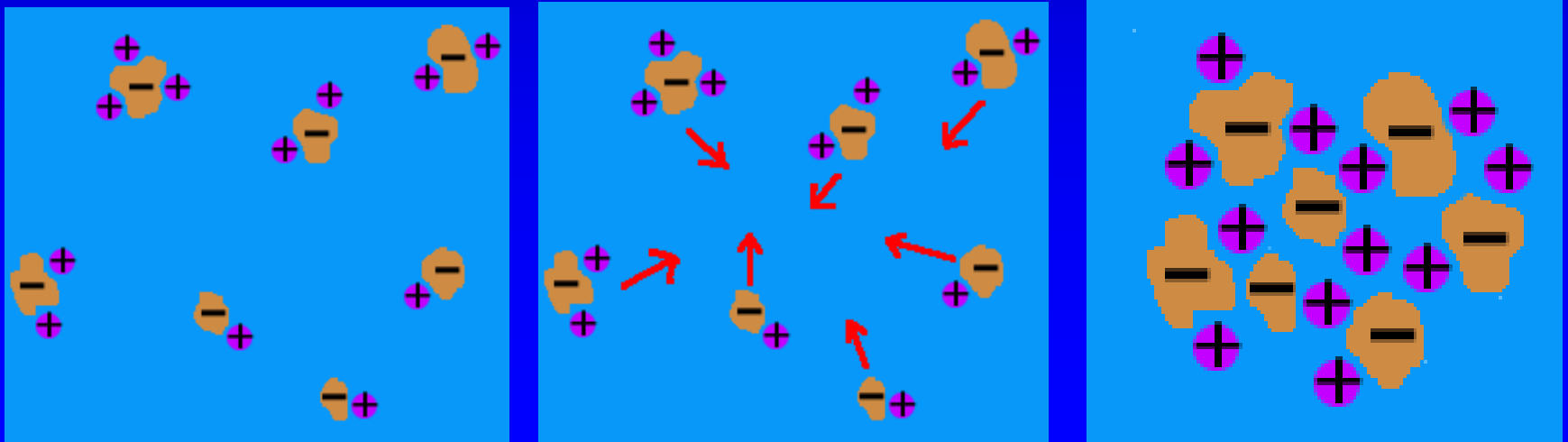
The turbidity of a water treatment plant effluent cannot be above?

1. 5 ntu
2. 1 ntu
3. .5 ntu
- 😊 4. .3 ntu



Coagulation

- Coagulants tend to be positively charged.
- Due to their positive charge, they are attracted to the negative particles in the water
- The combination of positive and negative charge results in a neutral, or lack, of charge
- Van der Waal's forces refer to the tendency of particles in nature to attract each other weakly if they have no charge.



Water Treatment Coagulants

Particles in water are negative; coagulants usually positively charged.

1. Alum- aluminum sulfate



2. Ferric chloride or ferrous sulfate

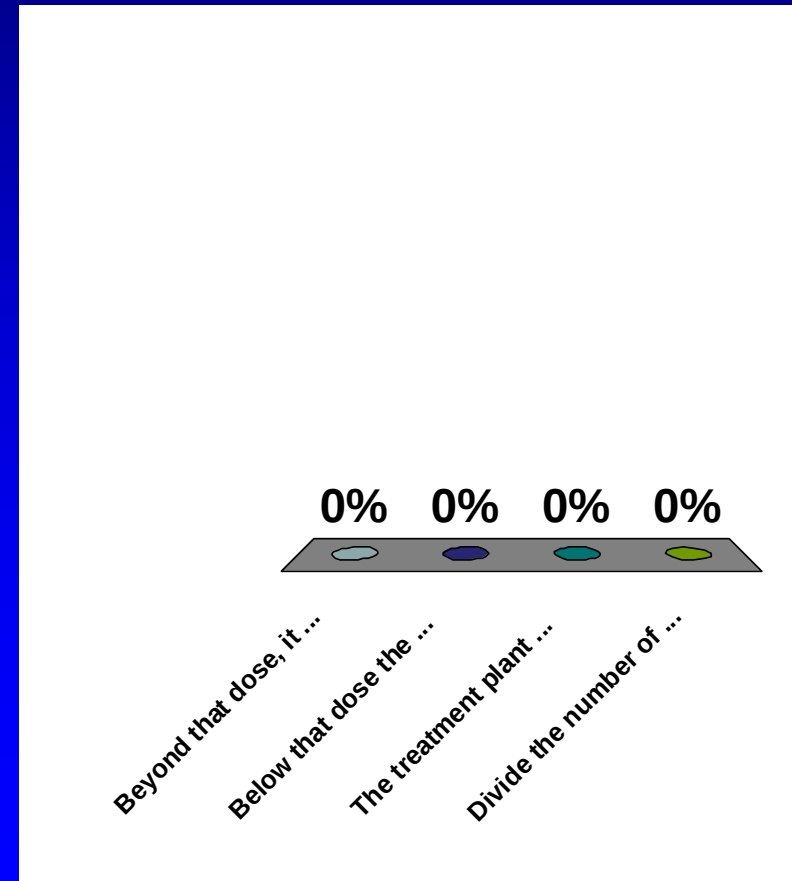


3. Polymers

What determines the optimum and most cost-effective amount of a coagulant to use?:

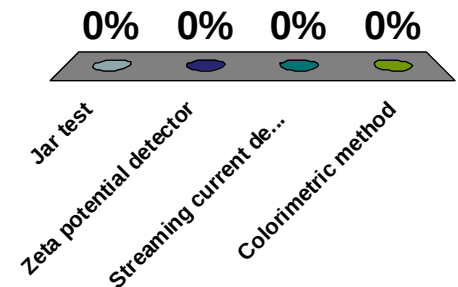


1. Beyond that dose, it takes a very large increase in the amount of chemical to produce a small increase in turbidity removal
2. Below that dose the coagulant results in poor settling
3. The treatment plant budget
4. Divide the number of gallons of water in the coagulation tank by the nephelometric turbidity unit reading to determine the dosage in mg/L.



Which is NOT a common method for determining optimum coagulant effectiveness?:

1. Jar test
2. Zeta potential detector
3. Streaming current detector
- 😊 4. Colorimetric method



Water Treatment Coagulant Alum

Alum- (aluminum sulfate)- particles suspended in natural, untreated water normally carry a negative electrical charge. These particles are attracted to the positive charges created by aluminum hydroxides. Dosage is generally around 25 mg/L.

1. Trivalent Al^{+3} charge attracts neg – particles
2. Forms flocs of aluminum hydroxide ($\text{Al}(\text{OH})_3$).
3. Impacted by mixing, alkalinity, turbidity and temp.
4. Ideal pH range 5.8-8.5



Alum CHEMISTRY

Alum- (aluminum sulfate)- made by dissolving aluminum hydroxide (bauxite or clay) in sulfuric acid

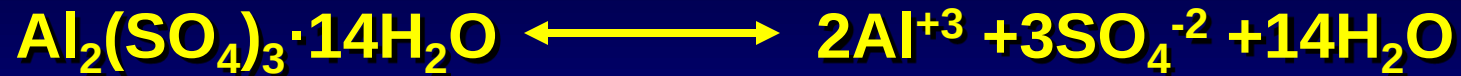


When ALUM is dissolved in alkaline water, it undergoes hydrolysis (reacts with water) to produce a high surface area gelatinous precipitate of aluminum hydroxide, $\text{Al}(\text{OH})_3$ (gibbsite) ($\text{Al}(\text{OH})_3$ sticks the negatives).

When ALUM is reacted with water it hydrolyzes to form aluminum hydroxide and dilute sulfuric acid (lowers pH). -----Need alkalinity adjustment

Alum CHEMISTRY

Alum- (aluminum sulfate)-



$2\text{Al}^{+3} + \text{negatively charged colloids} \leftrightarrow \text{neutral surface charge}$

WHY IS ALKALINITY SO IMPORTANT??



No bicarbonate (low alkalinity, low pH sulfuric acid!):

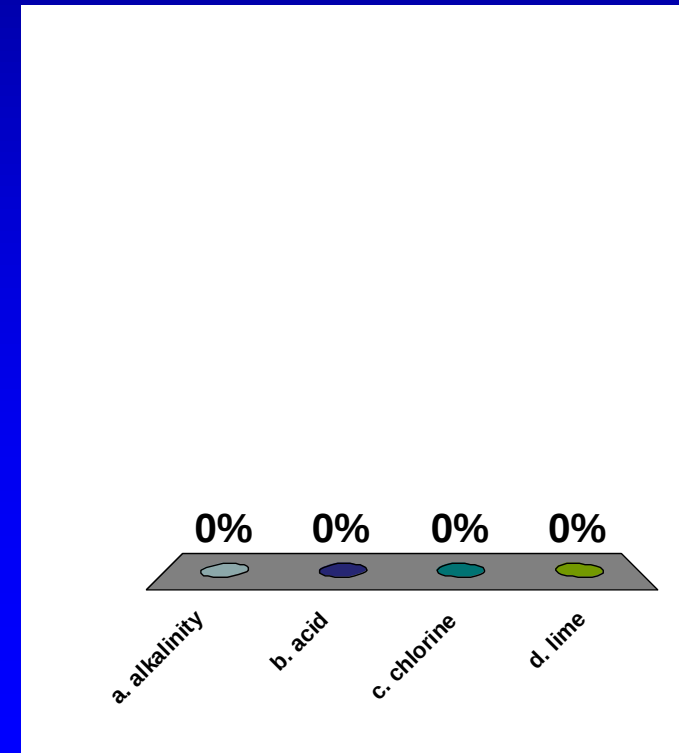


Optimum pH: 5.5 to 6.5

Operating pH: 5 to 8

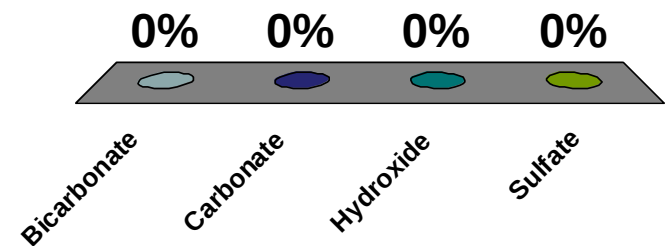
When alum is added to water, a floc is formed from the combination of alum and

- 😊 a. alkalinity
- b. acid
- c. chlorine
- d. lime



The precipitate formed by coagulation with alum is aluminum _____.

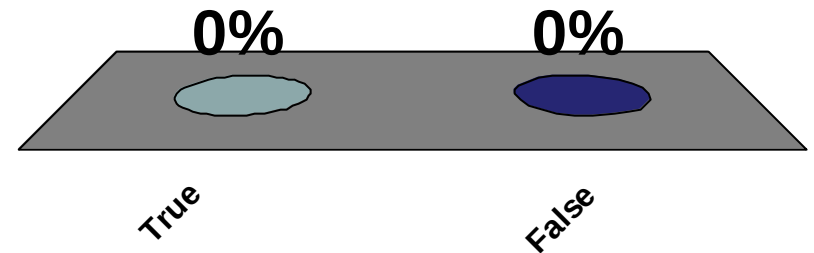
1. Bicarbonate
2. Carbonate
- 😊 3. Hydroxide
4. Sulfate



Adding Alum to water will cause the pH of the water to increase.

1. True

😊 2. False



Alum comes in dry grade as a minimum of 17.5% pure product, in liquid form it is 49% pure or 8.23% by weight Al_2O_3 ?

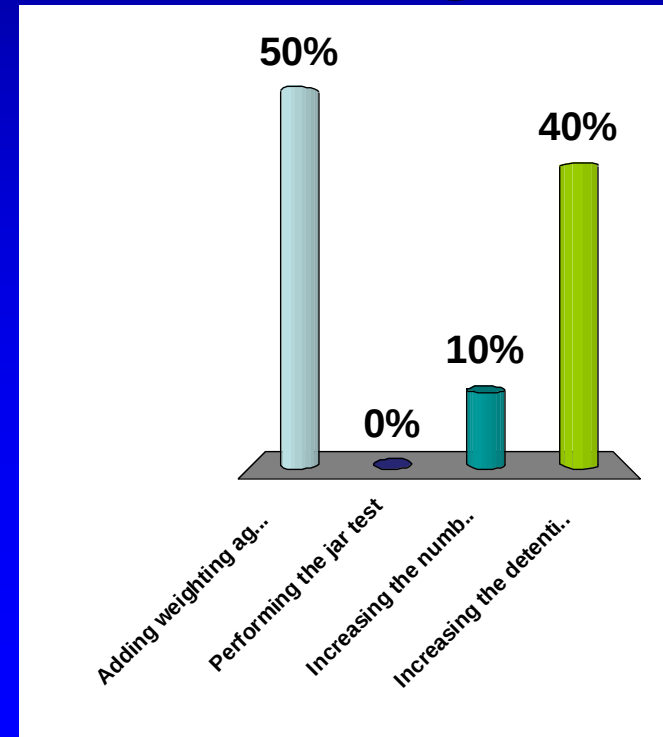
- 😊 1. True
- 2. False



Overcoming problems of cold-water floc can be corrected by operating the process at the best pH for that water temperature, increasing the coagulant dosage,

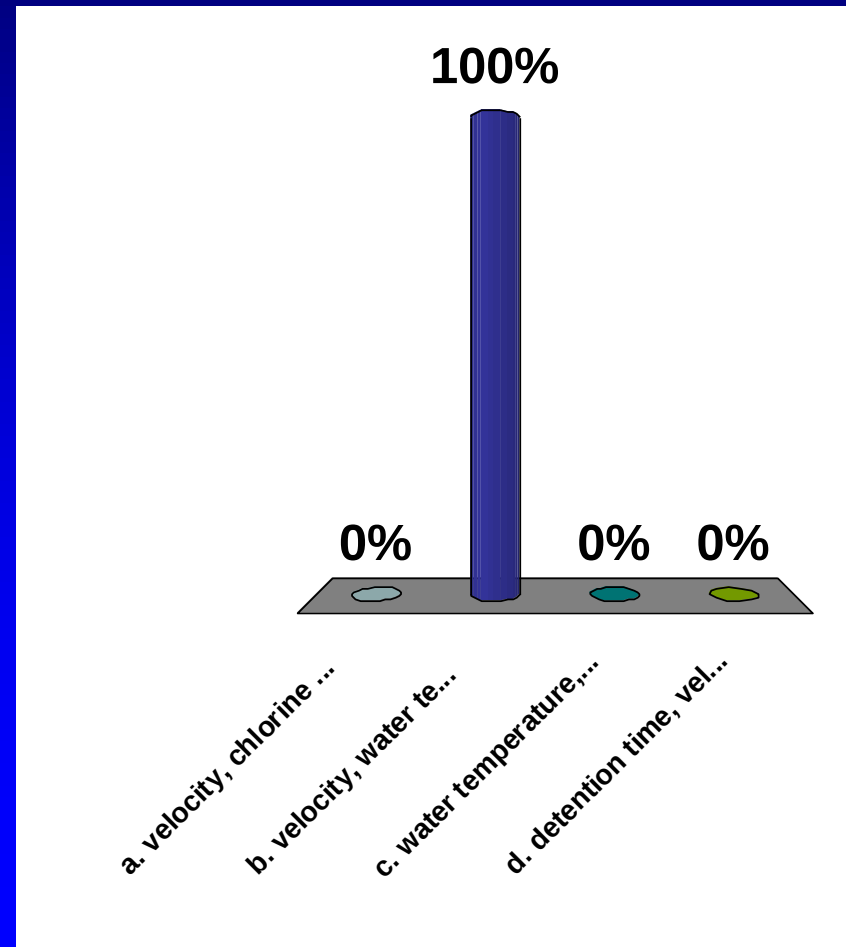


- 1. Adding weighting agents** **or:**
- 2. Performing the jar test**
- 3. Increasing the number and strength of floc particles**
- 4. Increasing the detention time for floc formation**



Which of the following conditions most affect coagulation performance?

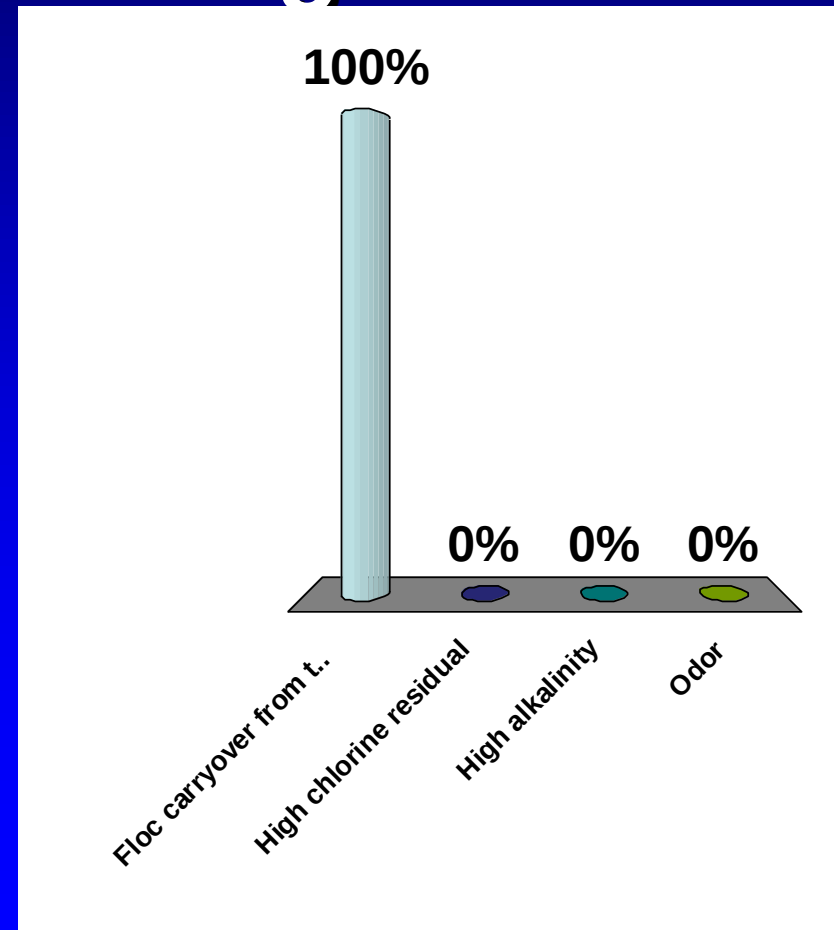
- a. velocity, chlorine dosage, detention time, and air temperature
-  b. velocity, water temperature, detention time and coagulant dosage
- c. water temperature, detention time, air temperature, and chlorine dosage
- d. detention time, velocity, air temperature, and chlorine dosage



With the coming of winter, the water temperature drops. A likely operational problem at a filtration plant with coagulation is:



- 1. Floc carryover from the sedimentation system**
- 2. High chlorine residual**
- 3. High alkalinity**
- 4. Odor**



Water Treatment Coagulant Aids

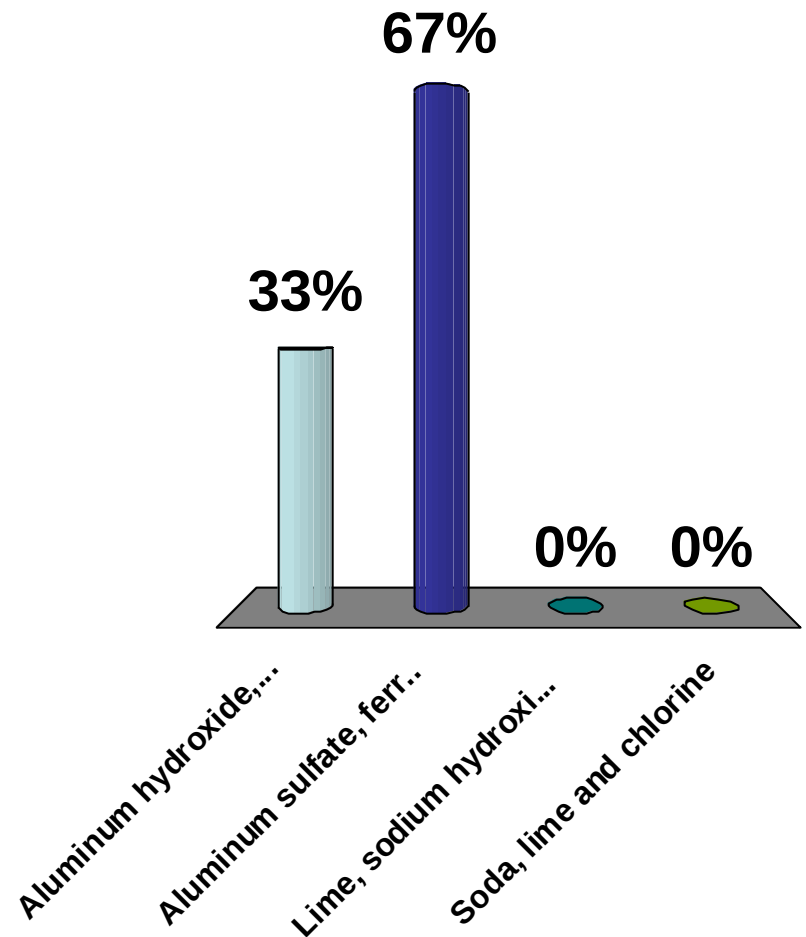
Activated silica (sodium silicate)- helps improve coagulation, decreases volume of coagulant necessary. Typically is sodium silicate.



1. secondary coagulant
2. reduces primary coagulants needed
3. Sodium silicate are alkaline
4. widens pH range for coagulation
5. used at 7-11% of alum
6. Heavier denser floc that settles faster
7. Can be formed on site
8. Corrosion inhibitor (forms a surface coating)

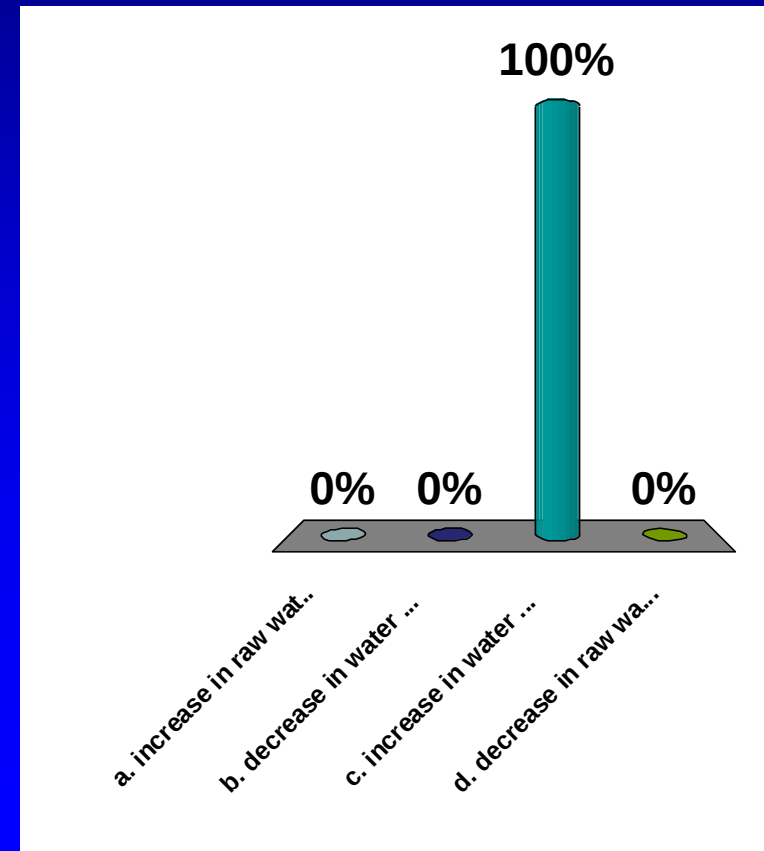
The three most commonly used coagulants in water treatment are:

1. Aluminum hydroxide, lime and sodium hydroxide
2. Aluminum sulfate, ferric chloride, and ferrous sulfate
3. Lime, sodium hydroxide, and chlorine
4. Soda, lime and chlorine



Which of the following would most likely improve the coagulation/flocculation process?

- a. increase in raw water hardness
- b. decrease in water temperature
- 😊 c. increase in water temperature
- d. decrease in raw water alkalinity



Water Treatment Coagulant Aids

Polyelectrolytes- **are water-soluble organic polymers that are used as both primary coagulants and coagulant aids. Act as "bridges" between the already formed particles :**

- **Anionic—ionize in solution to form negative sites along the polymer molecule.**
- **Cationic—ionize to form positive sites.**
- **Non-ionic—very slight ionization.**
- **effectiveness: particles type, turbidity present, and the turbulence (mixing) available during coagulation**

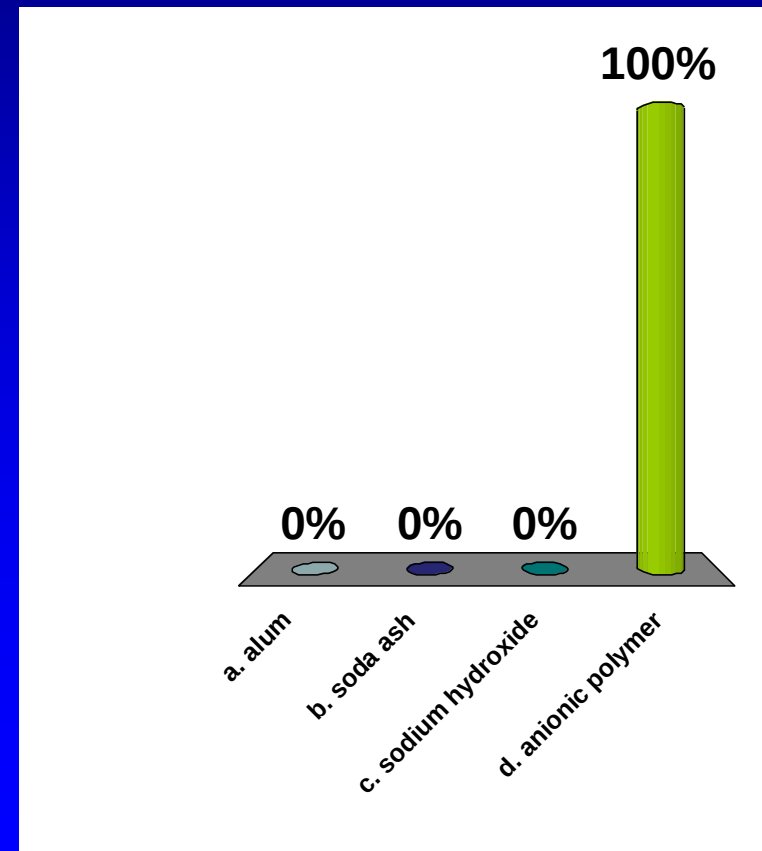
Which one of the following chemicals would be most suitable as a filter aid?

a. alum

b. soda ash

c. sodium hydroxide

😊 d. anionic polymer



Water Treatment Coagulant/pH

Alkalinity- Alkalinity is a measure of the buffering capacity of water. These buffering materials are primarily the bases bicarbonate (HCO_3^-), and carbonate (CO_3^{2-}), and occasionally hydroxide (OH^-), borates, silicates, phosphates, ammonium, sulfides, and organic ligands.

Chemicals applied to raise alkalinity

- Lime— CaOH_2 accompanies alum or iron salt
- Sodium bicarbonate- NaHCO_3 - raise alkalinity
- Soda Ash— Na_2CO_3 -raise alkalinity
- Caustic Soda— NaOH -raise alkalinity