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Measurement of Water Quality Parameters

Engineering Objectives

1. To learn about parameters that characterize water quality
2. To measure water quality parameters using analytical equipment
3. To observe water treatment

Sources of Water

- Groundwater
- Surface Water
- Oceans
- Reclaimed Wastewater

Purposes for Water Treatment

- Disinfection
- Removal of Colloidal Particles
- Removal of Color, and Tastes & Odors
- Removal of Iron & Manganese
- Hardness removal
- Protection from Toxic Organics and Inorganics

Drinking Water Standards

Primary

- **Protection of Human Health**
  - Organics: Pesticides, Solvents, Fuels
  - Inorganics: Metals.
  - Radionuclides: Beta particles, alpha particles, radon
  - Microbes: viruses, bacteria, protozoa, helminthes

Secondary

- **Related to Aesthetics**
  - Taste
  - Odor
  - Clarity
  - Color

Water Quality Parameters

Turbidity - The tendency of water to scatter light at 90 degrees. Turbidity is a measure of water clarity. Caused by suspended solids (thus, turbidity is an indirect measure of suspended solids). Measured in NTUs, using a Turbidimeter. For most people, water with <= 5 NTUs looks clear. The American Water Works Association (AWWA) recommends that water to be disinfected should be <= 0.1 NTU.

Color - True color is caused by dissolved compounds in water. It can be natural or anthropocentric. Dissolved and suspended solids (together) cause apparent color. For example, brown colored water could be the result of dissolved byproducts of plant biodegradation (true color) or suspended clay particles (apparent color) or both (also apparent color). Color is measured in Platinum-Cobalt units. The AWWA recommends <= 15 Platinum Cobalt units. This is also the U.S. secondary drinking water regulation. Color can be measured using light with a wavelength of 455 nm.

Pathogens - Pathogens are disease-causing microorganisms.

pH – pH indicates the intensity of the acid or alkaline condition of a solution. It expresses the hydrogen ion concentration. pH is an important factor that impacts most water treatment processes such as disinfection, coagulation, water softening and corrosion control. The term may be represented by

$$pH = -\log[H^+]$$

Alkalinity- The alkalinity of water is a measure of its capacity to neutralize acids. Three major classes of materials cause the major portion of alkalinity in natural waters. These are as follows: (1) hydroxide (2) carbonates and (3) bicarbonates. Bicarbonates represent the major form of alkalinity.

Hardness - Hardness is caused by the presence of divalent cations. Such ions are capable of reacting with soap to form precipitates with certain anions present in the water to form scale. The main cations causing hardness are calcium, magnesium, ferrous iron and managanous ions. Waters are normally classified in terms of the degree of hardness as follows:

mg/L as Ca CO_3	**Degree of Hardness**
0-75	Soft
75-150	Moderately Hard
150-300	Hard
300 up	Very Hard

Organic Compounds- There are a number of methods for determination of organics such as the Total Organic Carbon Analyzer and the Chemical Oxygen Demand Test. Most organic compounds show absorbance at 254 nm.

Conductivity- This is a measure of the presence of ions (cations and anions) in solution.

Nitrate- Nitrate is a primary drinking water standard. Their presence also causes the blue-baby syndrome in infants. Nitrate is also a nutrient for algae and can stimulate growth of algae.

Total Iron- Humans suffer no harmful effects from drinking waters containing iron. However iron can impart taste to water and impart objectionable stains to plumbing fixtures. Iron oxidation can also lead to scale formation.

Water Treatment: COAGULATION-FLOCCULATION

The Coagulation/Flocculation process is necessary in water treatment primarily because of NONSETTLEABLE SOLIDS, particles too small to be effectively removed by other treatment processes such as sedimentation and filtration. These nonsettleable solids can be changed into larger and heavier settable solids by physical and chemical changes brought about by adding and mixing chemical coagulants in the raw water. These larger and heavier particles can now be removed by sedimentation and filtration processes.

Nonsettleable solids (colloidal suspensions) consist of particles with an electric charge, usually negative. This characteristic prevents the collision and the aggregation of the particles. The addition of certain chemicals to colloidal suspensions can enhance destabilization and aggregation processes, leading to the formation of flocs of considerable dimensions. These flocs can then be further, removed by sedimentation or filtration. A typical flocculation process is shown in Figure 1.

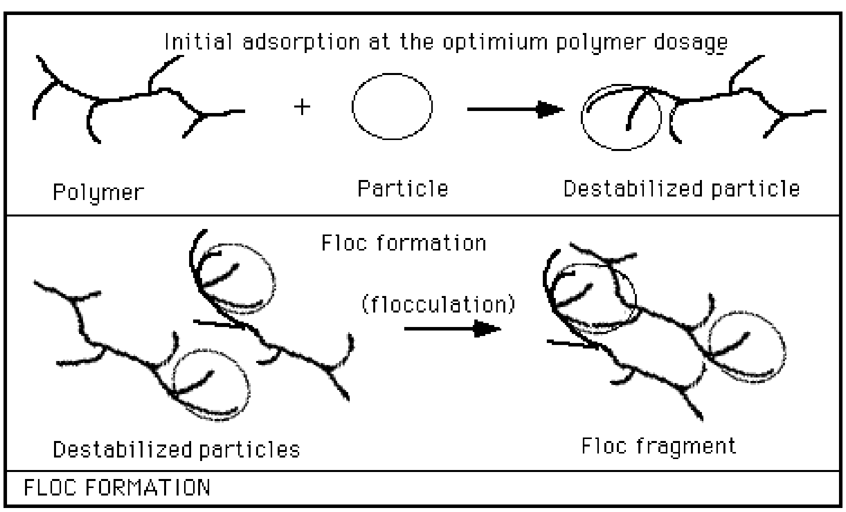


Figure 1: Typical Flocculation Process[1]

Coagulants and Flocculants

The common coagulants in water treatment are the trivalent salts of Iron and Aluminum. Organic polymers, such as polyacrilamides, are usually used as flocculants, in addition to the metallic salts, to improve floc formation. A typical rapid mix basin for adding coagulants and a typical flocculation basin is presented below in Figures 2 and 3.

THE JAR TEST

Jar tests are used in water treatment plants to determine the optimum dose of a coagulant. Results of the test are dependent on current raw water quality, which may vary day-to-day. A typical jar test apparatus is shown in Figure 2. The apparatus is operated to stimulate a mixing, flocculation and settling cycle. Varying amounts of coagulants are added at the same time to the jars that contain water to be treated. The jars are then mixed at high speed for one minute. This rapid mix is followed by a 20-40 minute period of gentle mixing to promote floc growth. The suspension is allowed to settle for a period of 15-60 minutes. The turbidity in each jar is measured and plotted against the coagulant dose. The optimum dose is determined from this plot.

Figure 2: Jar Testing Apparatus[2]

Engineering Objectives

1. To visualize the coagulation-flocculation process in the laboratory
2. To determine the optimum dose of Alum [$Al_2(S04)_3 \cdot 18H_20$] to reduce the turbidity of Rowan Pond Water.
3. To use basic chemical reaction stoichiometry in engineering calculations
4. To understand the role of different types of engineers in providing safe drinking water

Laboratory Procedure

1. Analyze the raw water for turbidity.
2. Place 900 ml of Rowan Pond water into the beakers provided with the apparatus.
3. Calculate the alum dosage required for each jar and the volume of alum solution to be added.
4. Set paddles at 80-100 rpm and, using a pipette, measure the appropriate volume of stock alum solution into the beakers. Keep Jar #1 as a control. Rapid mix for 1-2 minutes.
5. After the 1 - 2 minute coagulation (rapid mixing) step, adjust the mixing speed to about 30 rpm and flocculate for 5 minutes.
6. After the flocculation period, remove the paddles and allow solids to settle for 30 minutes.
7. Transfer the supernatant (the very top portion of sample) from each jar to a turbidity sample cell, taking care not to disturb the sediment during sampling. Measure and record the turbidity.
8. Plot Turbidity versus Alum dose.
9. Determine the optimum alum dose.

<u>Laboratory Exercise</u>

❖ Each team will obtain a sample of Rowan Pond water. Characterize the Rowan Pond water.

Sample Data Collection Form

Date: _________

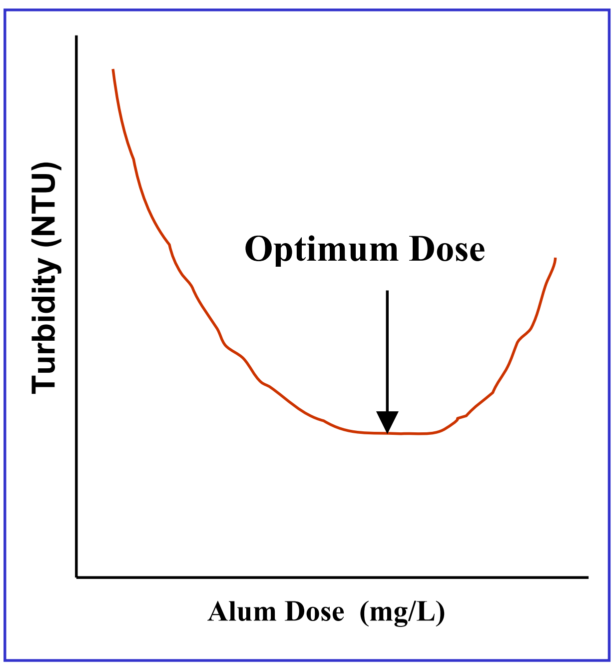
Parameter	**Rowan Pond Water**
pH	
Alkalinity	
Hardness	
Conductivity	
Turbidity	
Nitrate	
DO	
Temperature	

Report the data obtained from the Jar test in the following tabular form.

Alum Stock Solution Concentration 10,000 mg/L

Jar #	Alum added (mL)	Alum Concentration (mg/L)	Turbidity (NTU)
1			
2			
3			
4			
5			
6			

Plot turbidity versus alum concentration as shown below and determine the optimum alum dose.



TEAM LABORATORY REPORT (Due on September 23, 2003)

1. Include a Cover Sheet with Team Member Names and Laboratory Name.
2. State the Objectives of the Laboratory.
3. Include a table showing raw data and calculations.
4. Report values of water quality parameters measured in the laboratory. ***Make sure you have the correct units!!***
5. Include a Plot of final turbidity (Y-axis) versus coagulant dosage in mg/L(X-axis). Discuss the plot.
6. Identify the optimum dose of Alum in mg/L.

TEAM ANSWERS TO THE FOLLOWING QUESTIONS:

The following reaction takes place when alum is added to the water:

$$AL_2(SO_4)_3 \cdot 18H_2O + 3Ca(HCO_3) \leftrightarrow 3CaSO_4 + 2Al(OH)_3\downarrow + 6CO_2 + 18H_2O$$

1. What chemical composition does the precipitate at the bottom of the jar have?

2. What chemical name does this precipitate go by?

3. What will happen to the pH and alkalinity of the water as alum is added?

BONUS: Critical Thinking!!

What is the alum dose in lbs/day for a 10 MGD (Million Gallons per Day) water treatment plant if the optimum dose for alum was determined to be 10 mg/L?

References:

1. http://www.ci.slc.ut.us/utilities/parleys/ February 11, 2002

2. http://www.phippsbird.com/products.html#pb-700 February 11, 2002