Basic Water Treatment

Presented by: Stephanie Layfield

Please make sure you have:

- 2010 edition Basic Manual
- Ionico class handouts
- Electronic device with internet connection (optional)
- Simple calculator (phone is acceptable)
- Pen or pencil
- Social Security number or WTS license number
- Your Brain!!!

We will begin at 9:00

Ionico Technical Services

Instructor:
Stephanie (Hall) Layfield

- Owner and founder of Ionico Technical Services
- Third generation in the water treatment industry behind grandfather (Bill Hall Sr.) and father (Bill Hall Jr.)
- Graduate of Texas State University with a Bachelor's Degree in Aquatic Biology with a minor in Chemistry
- Active member of the Texas Water Quality Association (TWQA)

Basic Water Treatment Math

Starting off with Math!

- Provided is the **Basic Mathematics Conversion Table**

BASIC MATHEMATICS
CONVERSION TABLE

π (pi) = 3.14
1 cu. ft. = 7.48 gallons
1 gallon water = 8.34 lbs.
1 gallon = 231 cu. in.
8.34 lbs. = one part per million by weight of one million gallons of water
1 psi = 2.31 ft.
1 mi = 5,280 ft.
Diameter = The distance across a circle through its center
Radius = The distance from the center of a circle to the edge (½ the diameter)
MG= Million gallons
one day = 1440 minutes
1 grain per gallon (gpg) = 17.1 mg/l

FORMULAE

Area of a circle = πr^2
Volume of a rectangle = Length x Width x Height
Volume of a cylinder = πr^2 x Height
Volume of a pipe = πr^2 x Length
Volume of a rectangular tank = Length x Width x Height
(MG) (mg/l) (8.34) = lbs
lbs of compound= lbs pure chlorine divided by % chlorine
Dosage in mg/l = $\dfrac{\text{lbs of chemical}}{\text{MGD x 8.34}}$
Dosage= Demand + Residual

Follow the "Basic Math" handout sheets follow the math problems presented in this presentation.

Doing Word Problems

- There are always 4 steps to follow with a word problem:
  1. Write down given numbers with units.
  2. Write down the correct formula.
  3. Fill numbers into formula.
  4. Calculate and convert to correct units.
- Conversion (softener capacity) problems only use step 1 and 4.

Conversion Process:

- **Different values can be written as equivalencies such as:**
  - 1 ft. = 12 in. or 15 grains = 1 gallon
  - Units are extremely important. Always write down the unit with every value!
  - “per” is the same as “=1”
  - 250 gallons per day ➔ 250 gallons =1 day
- **Every equivalency can also be written as two different fractions:**
  - 1 psi = 2.31 ft.
  - Can be written as: $\frac{\text{1 psi}}{\text{2.31 ft.}}$ or $\frac{\text{2.31 ft.}}{\text{1 psi}}$
  - A single value such as 4 cu.ft. should be written: $\frac{\text{4 cu.ft.}}{1}$

Conversion Process:

- **These fractions can be orientated in such a way that their units cancel:**
  - **4 ft is equal to how many inches?**
  - **Correct:** $\frac{4\ \cancel{\text{ft.}}}{1}\ \frac{12\ \text{in.}}{1\ \cancel{\text{ft.}}}$ **Incorrect:** $\frac{4\ \text{ft.}}{1}\ \frac{1\ \text{ft.}}{12\ \text{in.}}$
  - **20 cubic feet weighs how many pounds?**
  - $\frac{20\ \cancel{\text{cu.ft.}}}{1}\ \frac{7.48\ \cancel{\text{gal.}}}{1\ \cancel{\text{cu.ft.}}}\ \frac{8.34\ \text{lbs.}}{1\ \cancel{\text{gal.}}}$ *The unit at end will be answer.
- **To perform the calculation:**
  - Put first number into your calculator.
  - If next number is on top, then multiply. If number is on bottom, then divide.
  - 2 cubic feet of zeolite with a hardness removal capacity of 12,000 grains per cubic foot can treat how many gallons of water at 32 gpg before total exhaustion?
  - $\frac{2\ \cancel{\text{cu.ft.}}}{1}\ \frac{12{,}000\ \cancel{\text{gr.}}}{1\ \cancel{\text{cu.ft.}}}\ \frac{1\ \text{gal.}}{32\ \cancel{\text{gr.}}}$ = 2 x 12,000 ÷ 32 = **750 gallons**

Conversions #1

A Large storage tank has a volume of 25 cu. ft. How many gallons of water can this tank hold when full?

1 ➔ Starting Material:

- 25 cu.ft.
- ? Gal.
- 1 cu. ft. = 7.48 gallons

2 ➔ Conversion:

$$\frac{25\ \cancel{\text{cu.ft.}}}{1} \quad \frac{7.48\ \text{gal.}}{1\ \cancel{\text{cu.ft.}}}$$

3➔ Calculation:

- 25 x 7.48 =
- <u>187 Gallons</u>

Conversions #2

A water tower that is 15.4 yards tall shows a pressure of how many psi at the bottom?

1 ➔ Starting Material:

- 15.4 yards
- ? Psi
- 1 psi = 2.31 ft
- 1 yard = 3 ft.

2 ➔ Conversion:

$$\frac{15.4\ \cancel{\text{yard}}}{1} \quad \frac{3\ \cancel{\text{ft.}}}{1\ \cancel{\text{yard}}} \quad \frac{1\ \text{psi}}{2.31\ \cancel{\text{ft.}}}$$

3 ➔ Calculation:

- 15.4 x 3 ÷ 2.31 =
- <u>20 psi.</u>

Conversions #3

A residential water softener holds 1 cubic foot of resin with a hardness removal capacity of 30,000 grains per cubic foot. The water being treated contains 15 gpg total hardness. The household uses 250 gallons per day. How many days can this softener run before total exhaustion?

1 ➔ Starting Material

- 1 cu. ft. resin
- 30,000 grains per cu.ft. ➔ 30,000 grains = 1 cu. ft.
- 15 gpg ➔ 15 grains = 1 gallon
- 250 gallons per day ➔ 250 gallons = 1 day
- ? Days

2 ➔ Conversion:

$$\frac{1 \text{ cu. ft.}}{1} \quad \frac{30{,}000 \text{ grains}}{1 \text{ cu. ft.}} \quad \frac{1 \text{ gallon}}{15 \text{ grains}} \quad \frac{1 \text{ day}}{250 \text{ gallons}}$$

3 ➔ Calculation:

- 1 x 30,000 ÷ 15 ÷ 250 =
- 8 days

Conversions #4 - Your Turn!

A commercial softener holds 50 cubic feet of resin with a hardness removal capacity of 30,000 grains per cubic foot. The water being treated contains 25 gpg total hardness. How many gallons of water can be treated before the exchange capacity is exhausted?

1 ➔ Starting Material:

- 50 cu. ft. resin
- 30,000 grains = 1 cu. ft.
- 25 grains = 1 gallon
- ? gallons

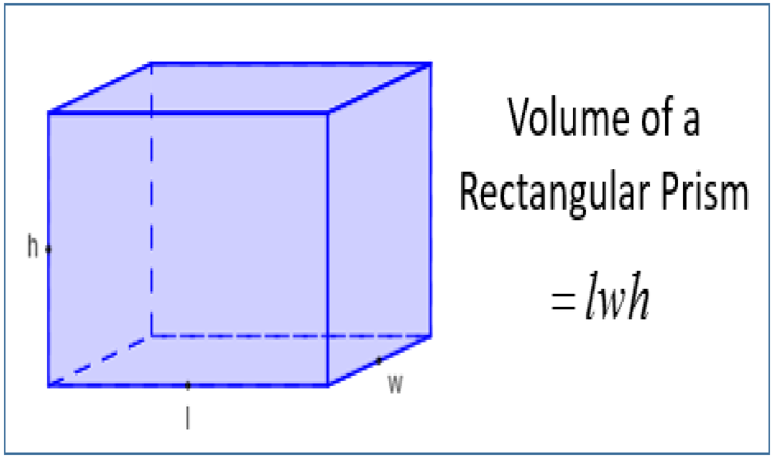
2 ➔ Conversion:

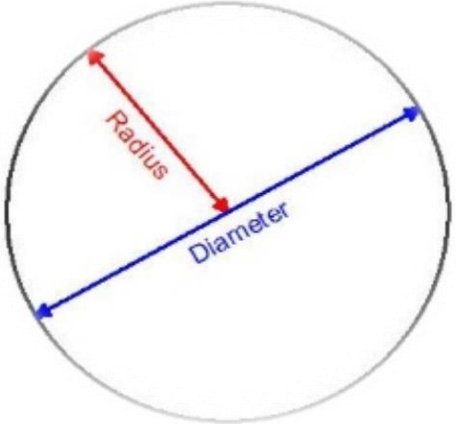
$$\frac{50\text{ cu. ft.}}{1} \quad \frac{30{,}000\text{ grains}}{1\text{ cu. ft.}} \quad \frac{1\text{ gallon}}{25\text{ grains}}$$

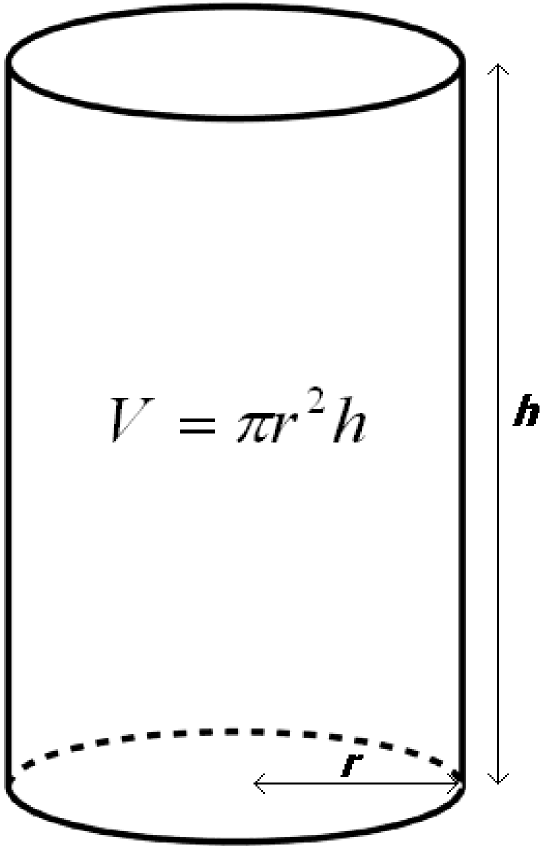
3 ➔ Calculation:

- 50 x 30,000 ÷ 25 =
- <u>60,000 gallons</u>

Volume Basics:







- A pipe is just a really long cylinder.

Remember Steps:

1. Write down given numbers with units.
2. Write down the correct formula.
3. Fill numbers into formula.
4. Calculate and convert to correct units.

Volume #1

A rectangular tank is 2 ft tall, 2 ft wide, and 4 ft long. How many gallons of water can this tank hold when full?

- Step 1
  - Height = 2 ft
  - Width = 2 ft
  - Length = 4 ft
  - ? Gal.
- Step 2
  - V = Length x Width x Height
- Step 3
  - V = 4 ft. x 2 ft. x 2 ft.
- Step 4
  - = 16 cu.ft.
    - $\dfrac{16 \text{ cu.ft.}}{1} \quad \dfrac{7.48 \text{ gal}}{1 \text{ cu.ft.}}$
  - <u>= 120 Gallons</u>

Volume #2 - Your Turn!

A rectangular tank is 96 in. tall, 36 in. wide, and 48 in. long. How many gallons of water can this tank hold when full?

- Step 1
  - Height = 96 in = 8 ft
  - Width = 36 in = 3 ft
  - Length = 48 in = 4 ft
  - ? Gallons
- Step 2
  - Volume = Length x Width x Height
- Step 3
  - ? = 4 ft. x 3 ft. x 8 ft.
- Step 4
  - ? = 96 cu. ft. x 7.48
  - <u>718 gallons.</u>

Volume #3

A cylindrical tank is 2 ft. in diameter and 4 ft. to the overflow. How many gallons of water can this tank hold when full?

- Step 1
  - Diameter = 2 ft
    - Radius = 1 ft
  - Height = 4 ft
  - ? Gal
- Step 2
  - Volume = $\pi\, r^2$ x Height
    - Volume = π x r x r x Height
- Step 3
  - ? = 3.14 x 1 ft. x 1 ft. x 4 ft
- Step 4
  - ? = 12.56 cu.ft. x 7.48
  - **93.9 gallons**

Volume #4 - Your Turn!

A cylindrical tank is 36 in. in diameter and 72 in. to the overflow. How many gallons of water can this tank hold when full?

- Step 1
  - Diameter = 36 in. = 3 ft.
    - Radius = 1.5 ft
  - Height = 72 in. = 6 ft.
  - ? Gallons
- Step 2
  - Volume = π r^2 x Height
- Step 3
  - V = 3.14 x 1.5 ft. x 1.5 ft. x 6 ft
- Step 4
  - V = 42.4 cu. ft. x 7.48
  - **<u>317 gallons.</u>**

Volume #5 - Your Turn!

A 6 in water main is 50 ft. long. How many cubic feet of water can this pipe hold when full?

- Step 1
  - Diameter = 6 in. = 0.5 ft.
    - Radius = 0.25 ft.
  - Length = 50 ft.
  - ? Cu. ft
- Step 2
  - Volume = πr^2 x Length
- Step 3
  - ? = 3.14 x 0.25 ft. x 0.25 ft. x 50 ft
- Step 4
  - =9.8 cu.ft.

Disinfection Basics:

- 1,250,000 gallons = 1.25 MG (Million Gallons)
  - Move decimal 6 places to the left
- 15% chlorine = 0.15
  - Always change a percent to a decimal by moving decimal 2 places to the left
- ALWAYS follow the 4-step process
  - Determining the correct formula is the hardest.
    - Step 1 will help.

Disinfection 1 #1

Determine the chlorine dosage needed to achieve a 0.7 mg/l residual in a system with a demand of 9.3 mg/l.

- Step 1
  - Residual = 0.7 mg/l
  - Demand = 9.3 mg/l
  - Dosage = ?
- Step 2
  - Dosage = Demand + Residual
- Step 3
  - ? = 9.3 mg/l + 0.7 mg/l
- Step 4
  - Dosage = <u>10 mg/l</u>

Disinfection 1 #2 - Your Turn!

Determine the chlorine dosage needed to achieve a 3.5 mg/l residual in a system with a demand of 8.0 mg/l.

- Step 1
  - Residual = 3.5 mg/l
  - Demand = 8.0 mg/l
  - Dosage = ?
- Step 2
  - Dosage = Demand + Residual
- Step 3
  - ? = 8.0 mg/l + 3.5 mg/l
- Step 4
  - Dosage = <u>11.5 mg/l</u>

Disinfection 1 #3

Determine the demand if a residual of 0.5 mg/l is sustained in a system after dosing 3.2 mg/l chlorine.

- Step 1
  - Residual = 0.5 mg/l
  - Dosage = 3.2 mg/l
  - Demand = ? mg/l
- Step 2
  - Dosage = Demand + Residual
- Step 3
  - 3.2 mg/l = ? + 0.5 mg/l
    - Move 0.5 mg/l to other side and subtract
  - ? = 3.2 mg/l - 0.5 mg/l
- Step 4
  - Demand = <u>2.7 mg/l</u>

Disinfection 1 #4 - Your Turn!

Determine the demand if a residual of 0.8 mg/l is sustained in a system after dosing 9.6 mg/l chlorine.

- Step 1
  - Residual = 0.8 mg/l
  - Dosage = 9.6 mg/l
  - Demand = ? mg/l
- Step 2
  - Dosage = Demand + Residual
- Step 3
  - 9.6 mg/l = ? + 0.8 mg/l ➔ ? = 9.6 mg/l - 0.8 mg/l
- Step 4
  - Demand = **8.8 mg/l**

Disinfection 2 #1

Determine how much 100% chlorine must be added to 350,000 gallons of water to produce a 2.5 mg/l dosage.

- Step 1
  - 350,000 gallons
    - =0.35 MG
  - 2.5 mg/l dosage
  - ? Lbs.
- Step 2
  - (MG) (mg/l) (8.34) = lbs.
- Step 3
  - 0.35 x 2.5 x 8.34 = ?
- Step 4
  - Lbs. = <u>7.3</u>

Disinfection 2 #2

Determine how much 100% chlorine must be added to 1,250,000 gallons of water to produce a 5.8 mg/l dosage.

- Step 1
  - 1,250,000 gallons
    - = 1.25 MG
  - 5.8 mg/l dosage
  - ? Lbs.
- Step 2
  - (MG) (mg/l) (8.34) = lbs.
- Step 3
  - 1.25 x 5.8 x 8.34 = ?
- Step 4
  - Lbs. = **60.5**

Disinfection 2 #3 – Your Turn!

Determine how much 100% chlorine must be added to 15,000 gallons of water to produce a 2.0 mg/l dosage.

- Step 1
  - 15,000 gallons
    - = 0.015 MG
  - 2.0 mg/l dosage
  - ? Lbs.
- Step 2
  - (MG) (mg/l) (8.34) = lbs.
- Step 3
  - 0.015 x 2.0 x 8.34 = ?
- Step 4
  - Lbs. = <u>0.25</u>

Disinfection 3 #1

How many pounds of 5% bleach are needed to equal 25 pounds of 100% chlorine?

- Step 1
  - 5% chlorine
    - = 0.05 chlorine
  - 25 lbs.
    - pure
  - ? Lbs.
    - compound
- Step 2
  - Lbs. of compound = Lbs. pure chlorine divided by % chlorine
- Step 3
  - ? = 25 ÷ 0.05
- Step 4
  - = <u>500 Lbs. Compound</u>

Disinfection 3 #2 - Your Turn!

How many pounds of 65% calcium hypochlorite are needed to equal 10 pounds of 100% chlorine?

- Step 1
  - 65% chlorine
    - 0.65 chlorine
  - 10 Lbs. pure
  - ? Lbs. compound
- Step 2
  - Lbs. of compound = Lbs. pure chlorine divided by % chlorine
- Step 3
  - ? = 10 / 0.65
- Step 4
  - = <u>15.4 Lbs. Compound</u>

Disinfection 3 #3

How many pounds of 100% chlorine are needed to equal 50 pounds of 15% bleach?

- Step 1
  - 15% chlorine
    - = 0.15 chlorine
  - 50 Lbs. compound
  - ? Lbs. pure
- Step 2
  - Lbs. of compound = Lbs. pure chlorine divided by % chlorine
- Step 3
  - 50 = ? ÷ 0.15
    - Move 0.15 to the other side and multiply
  - ? = 50 x 0.15
- Step 4
  - = <u>7.5 Lbs. Pure</u>

Disinfection 3 #4 – Your Turn!

How many pounds of 100% chlorine are needed to equal 63 pounds of 85% calcium hypochlorite?

- Step 1
  - 85% compound
    - = 0.85 compound
  - 63 Lbs. compound
  - ? Lbs. pure
- Step 2
  - Lbs. of compound = Lbs. pure chlorine divided by % chlorine
- Step 3
  - 63 = ? ÷ 0.85 ➔ ? = 63 x 0.85
- Step 4
  - = <u>53.6 Lbs. Pure</u>

Disinfection 4 #1

Determine the dosage when you add 20 pounds of pure chlorine to a storage tank that holds 12,000 gallons of water.

- Step 1
  - 20 Lbs. pure
  - 12,000 gallons
    - 0.012 MG
  - ? Dosage
- Step 2
  - Dosage = $\dfrac{\text{Lbs.}}{\text{MGD x 8.34}}$
- Step 3
  - ? = 20 ÷ (0.012 x 8.34)
    - Must do what is in parenthesis first. Write down & clear Calculator
  - ? = 20 ÷ (0.1)
- Step 4
  - = <u>200 mg/l</u>

Disinfection 4 #2 - Your Turn!

Determine the dosage when you add 100 pounds of pure chlorine to a storage tank that holds 24,000,000 gallons of water.

- Step 1
  - 100 Lbs. pure
  - 24,000,000 gallons
    - = 24 MG
  - ? dosage
- Step 2
  - Dosage = $\dfrac{\text{Lbs.}}{\text{MGD x 8.34}}$
- Step 3
  - ? = 100 ÷ (24 x 8.34) ➔ 100 ÷ (200.16)
- Step 4
  - = **0.5 mg/l**

Disinfection 4 #3 - Extra Practice

Determine the dosage when you add 27 pounds of pure chlorine to a storage tank that holds 360,000 gallons of water.

- Step 1
  - 27 Lbs. pure
  - 360,000 gallons = 0.36 MG
  - ? dosage
- Step 2
  - $\text{Dosage} = \dfrac{\text{Lbs.}}{\text{MGD} \times 8.34}$
- Step 3
  - ? = 27 ÷ (0.36 x 8.34) ➔ 27 ÷ (3)
- Step 4
  - = <u>9 mg/l</u>

Chapter 1

Licensing and Regulatory Requirements

Licensing Authority

Texas Commission on Environmental Quality (TCEQ) is the licensing and regulatory agency for Water Treatment Specialist (WTS) Licenses

Texas legislature has defined water treatment as:

- A business conducted under contract that required experience in the analysis of water, including the ability to determine how to treat influent and effluent water, to alter or purify water, and to add or remove a mineral, chemical, or bacteriological content or substance.
- Includes the installation and service of potable water treatment equipment in public or private water systems and making connections necessary to complete installation of a water treatment system.

In order to certify persons as being qualified for the installation, exchange, servicing, and repair of residential, commercial, or industrial water treatment and equipment, TCEQ has established:

- Standards of qualifications.
- Classes of licenses.
- Durations of licenses.
- Reasonable annual certification fees.

Application Procedures for Licenses

For Class 2 license:

1. Complete the Basic Water Treatment Specialist Course.
2. Complete the required years of work experience.
3. Fill out the application with the correct fee.
4. Wait for Approval letter.
5. Take and pass the exam.

License Denial, Warning, Suspension, or Revocation

May be denied for:

- Being insufficient in license Requirements
- Providing fraudulent information or making misstatements
- A history of noncompliance or violations
- Failing to keep or transmit required records
- Being indebted to the state for a fee, penalty, or tax
- Being in default on student loans

May be suspended or revoke for:

- Any violations of the Texas Water Code
- Identification by Office of the Attorney General as being delinquent on child support payments

Potential Ineligibility for License

- TCEQ now checks your criminal history and you may be denied a license with certain convictions.

Please remove your orange acknowledgement form.

- Read this form completely.
- Fill out the top part of the form and sign the bottom.
- Return this form to your instructor at the end of the course.
- You may request a copy of this form from your instructor during the next class break.

Exemptions from the WTS License Requirements

- Individuals who are licensed under the Plumbing License Law.
- Employees of industrial facilities who install or service water treatment equipment **at their facilities**.
- Employees of public water systems installing water treatment equipment **at their system** who hold a Class C license or higher.
- Employees of registered operations companies installing water treatment equipment at the facilities for which their operations company has a contract to operate and who hold a Class C license or higher.

Field Citations

- The TCEQ has the authority to issue a field citation if an unlicensed individual is performing work for which a license is required.
  - Option 1- Settle the Field Citation
    - Sign and pay the fee within 30 days
    - Correct all violations within 45 days
  - Option 2- Choose NOT to accept
    - An enforcement Coordinator will contact you and you may request an evidentiary hearing

Regulatory Requirements

Licensed Residential Water Treatment Facility Operators must be informed about plumbing standards and sanitary protection of public water systems.

Water treatment, water distribution, residential water systems, and residential plumbing are designed to deliver potable water and protect the safety of the water supply. <u>Water is potable when it is safe to drink.</u> Plumbing standards are in place to ensure that safe plumbing practices are followed.

Regulatory Requirements

- **Plumbing codes and ordnances are designed to:**
  - Protect public health
  - Ensure good plumbing practices are followed
  - Prevent contamination of the water supply
  - Prevent cross-connection.
- **Safe practices include;**
  - Maintaining adequate pressures
  - Continuous and effective disinfection
  - Cross-Connection control
  - Maintaining a continuous supply
  - Following plumbing standards

Pressure and Disinfection Residuals

- **In Public water systems:**
  - Maintain a 35 psi at all points
  - 20 psi under fire fighting conditions
- **Minimum disinfection residuals required at the farthest tap:**
  - Free chlorine residual of 0.2 mg/L
  - Chloramine residual of 0.5 mg/L

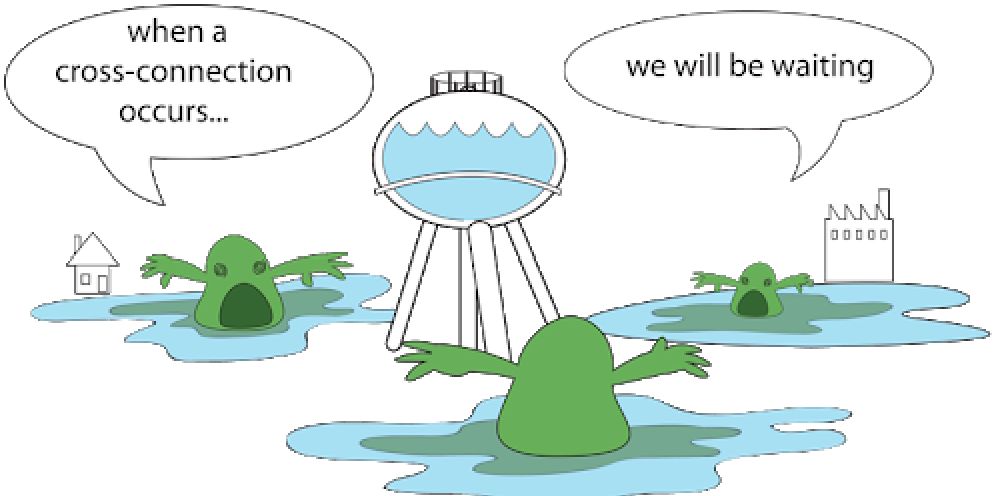
Adequate Sizing & Lead Ban

- **Water treatment devices must be properly sized to prevent excessive pressure loss and maintain a continuous water supply.**
  - Ex. Under sizing the softener is a violation of plumbing standards.
- **Prohibition of Lead-Containing Materials**
  - Pipes, pipe fittings, and fixtures must be considered “Lead Free”
    - Less than 0.25% lean in wet surface areas
  - Solder and flux must contain less than 0.2 % lead

Cross-Connections

- A <u>physical connection </u>between the public water system and:
  - Another supply of unknown or questionable quality
  - Any source which may contain contaminating or polluting substances
  - Any source of water treated to a lesser degree in the treatment process.

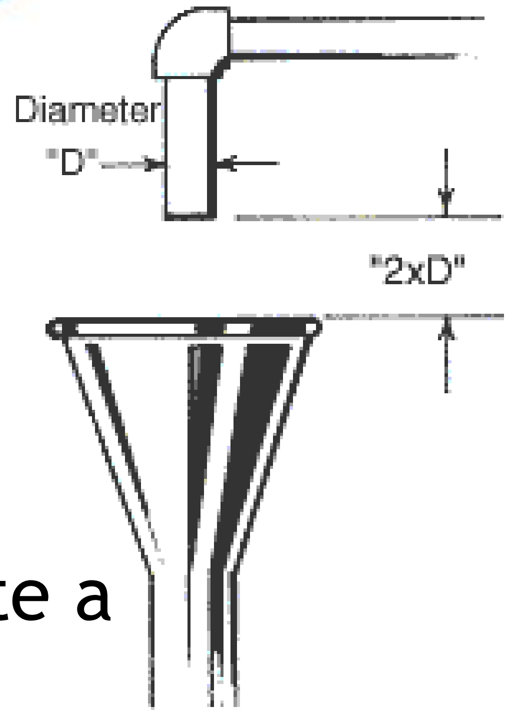
No physical connection shall be made between a drinking water supply and a sewer line.



Cross-Connection Control

- All potential sources of contamination must be excluded from the public water supply by an approved method.
  - Approved methods include airgaps and mechanical backflow preventers (such as RPZs)
- A backflow prevention device must prevent both back siphonage and back pressure backflow.
- Refer to local plumbing codes and NSF standards for requirements.

Air Gaps



- A physical separation between the potable water and any other material.
- Provide true cross-connection control and are the preferred way to eliminate a possible cross-connection.
- Direct connections between potable water piping and sewers are illegal with or without backflow preventers on the supply side.
- Must be two pipe diameters, but in no case less than one inch.

Quick Review

Please open the Quizizz app to complete review

Chapter 2

Water Quality Problems

Unique Properties of Water

Water is the most important material on the surface of the earth. It air conditions the earth by collecting and dissipating the sun's energy.

Water shapes and weathers the surface of the earth and is essential for all living organisms, for without water life soon perishes. Formed from Hydrogen and Oxygen, water is a most unusual material that exhibits unique properties.

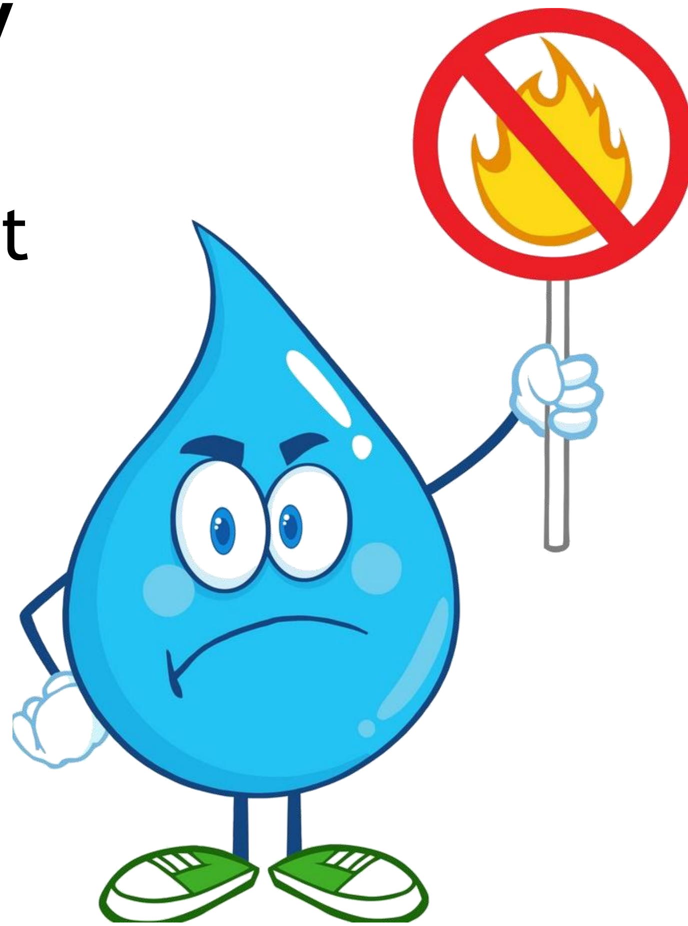
Unique Properties of Water

$$2H_2 + O_2 \rightarrow 2H_2O$$

Quality	Metric	English
Density at 3.98˚c	1.0 g/mL	8.34 lbs/Gal 62.4 lbs/Ft^3
Melting/Freezing Point	0˚c	32˚f
Boiling/Condensing Point	100˚c	212˚f
Temperature at maximum density	3.98˚c	39.16˚f

Unique Properties of Water

- **High Heat absorbing capacity**
  - Stabilizes temperatures by absorbing large amounts of heat with only small temperature changes.
  - Critical to temperatures on the surface of the earth and within living organisms which are mostly water.

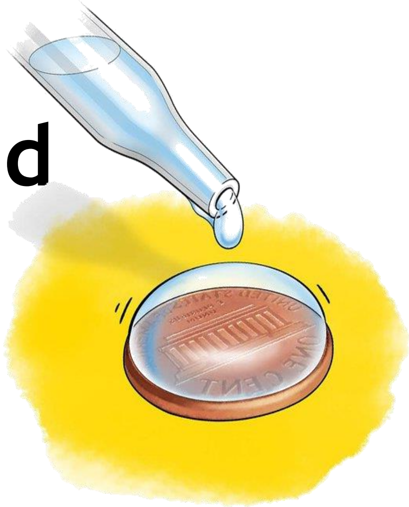


Unique Properties of Water

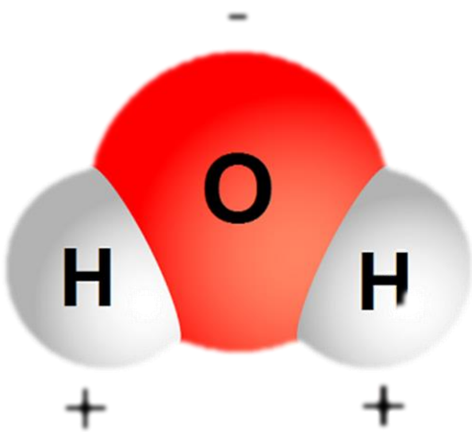
- **Melting requires a LOT of heat and freezing absorbs a lot of heat**
  - Water must release a lot of heat energy before becoming solid. This retards freezing. Ice requires a lot of heat to melt.
- **Highest heat of evaporation of any substance**
  - Important to energy and water transport from earth's surface to atmosphere.

Unique Properties of Water

- **Highest surface tension of any liquid**
  - Controls surface and drop shape
  - Critical to liquid transport in plants and through the soil
- **Dissolves more substances in greater quantity than other liquid**
  - Makes complex biological systems possible.
  - Important for transportation of materials in solution.



Characteristics of Water

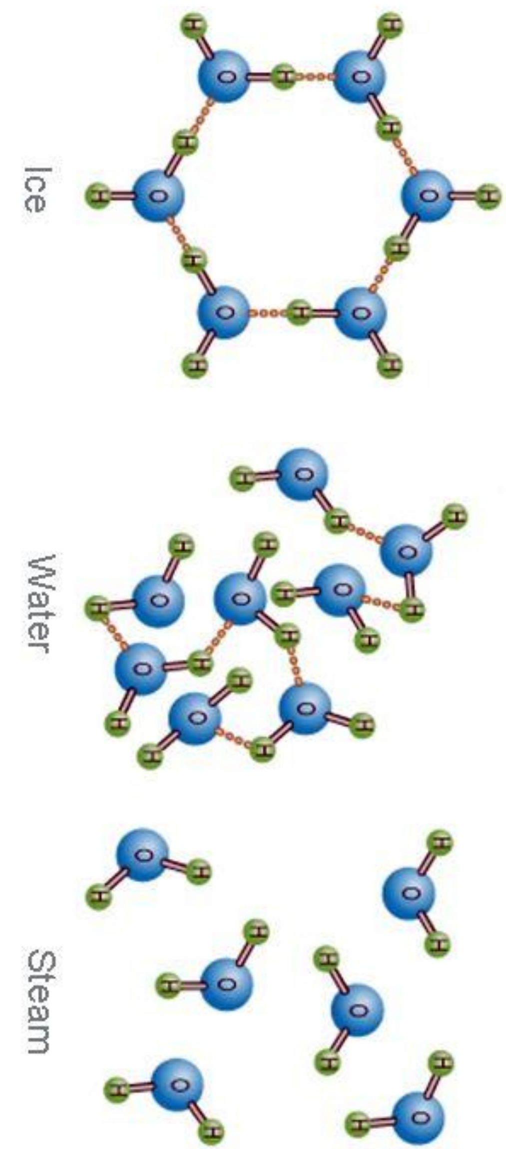


- Highly Polar
  - Have positive and negative poles
  - Molecules are "Polar" and highly attractive to each other
  - Helps water to dissolve salts

- Very Stable
  - Does not decompose easily
  - Does not react easily with MOST other materials

Characteristics of Water

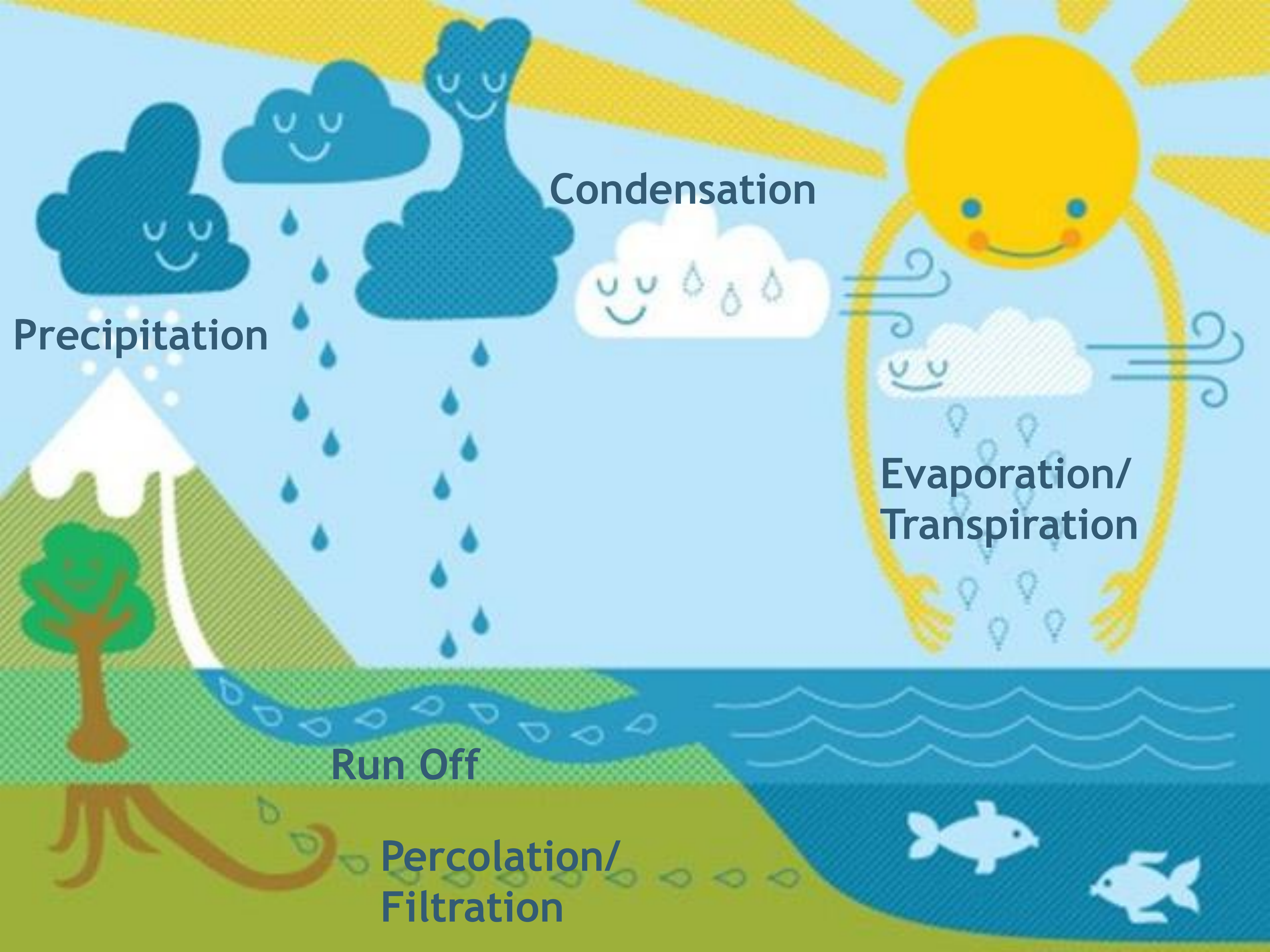
- **Freezing and Expansion**
  - At 4°c water is the most dense
  - As it heats up or cools down the molecules expand
  - Ice is 10% less dense that liquid water
  - Crystalline lattice structure
- **Universal Solvent**
  - Most versatile solvent known
  - Attracts and holds polar molecules and charged particles
  - Causes <u>Ionization</u>



Uses of Water

- **Uses of Water**
  - Drinking
  - Aquatic Organisms and Plants
  - Fishing and Aquaculture
  - Cooling, Manufacturing, and Industry
  - Food Processing and Production

- **Good Quality <u>Drinking</u> Water**
  - Has no disease-causing organisms
  - Contains no chemical or radiological impurities in harmful amounts
  - Has lowest possible levels of color, turbidity, or taste and odor
  - Is non-corrosive, non-scaling, and non-staining
- **Different uses for water require different quality standards**

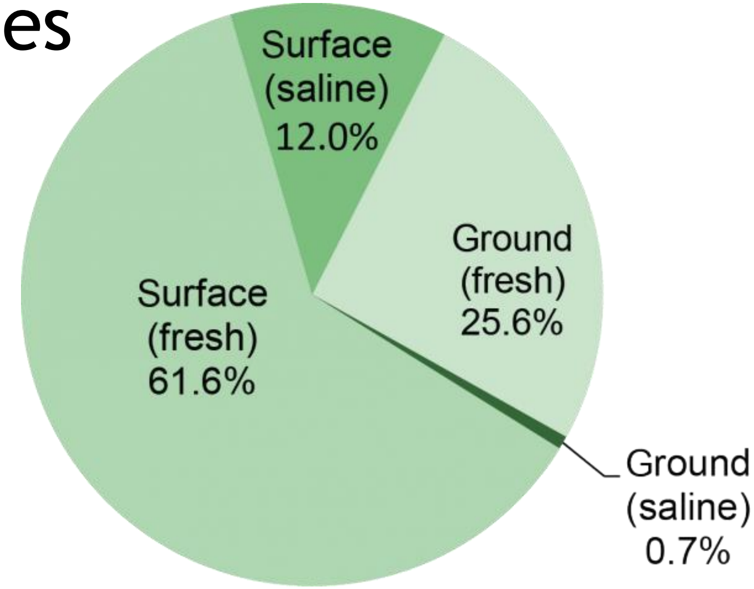

Condensation
Precipitation
Evaporation/
Transpiration
Run Off
Percolation/
Filtration

General Water Quality Indicators

- **Minerals**
  - Sodium, Calcium, Chloride, Bicarbonate
- **Heavy Metals**
  - Lead
- **Organic Chemicals (SOCs, VOCs)**
  - DDT (pesticides), Resist Decomposition
- **Turbidity and Color**
  - Suspended Solids

Sources of Water

- **Federal and State regulations require that potable water be from an approved source.**
  - Safe and Sanitary
  - Protected from sources of contamination
  - Adequate for its intended uses
- **Commonly used sources:**
  - Public water supplies
    - Ground and surface water
  - Private water supplies
    - Ground water

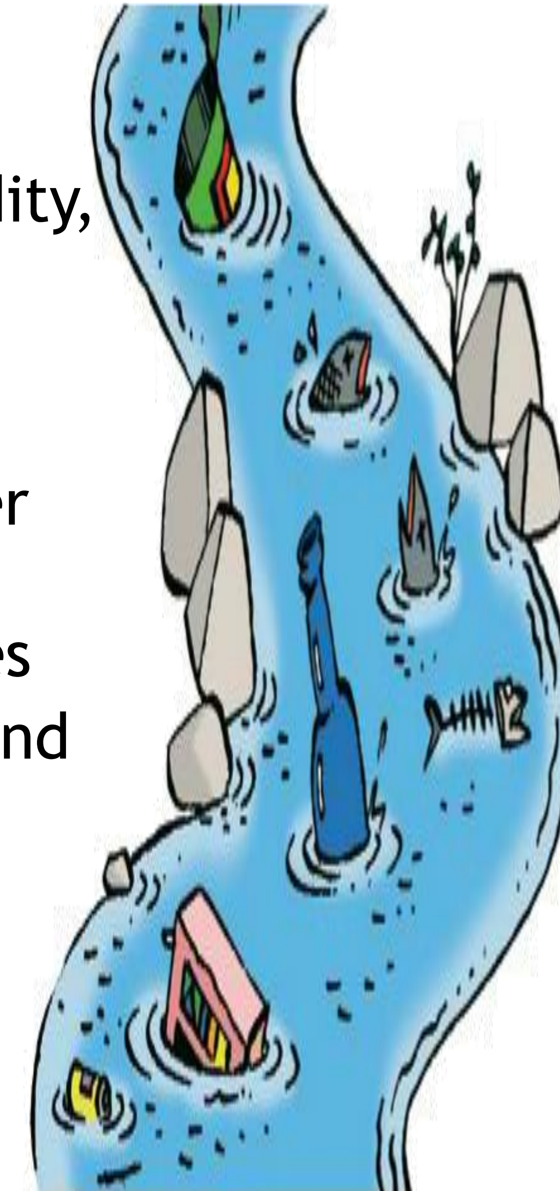


Ground Water

- **Characteristics:**
  - Well filtered with low amounts of suspended solids, turbidity, and color
  - Stable chemical quality and temperature over time
  - Higher mineral content than surface water
  - Lower levels of bacteria, algae, and viruses
  - Higher amounts of dissolved gases.
    - Oxygen, Carbon Dioxide, Hydrogen Sulfide, Methane
  - Higher amounts of Iron and manganese

Surface Water

- **Characteristics:**
  - High amounts of suspended solids, turbidity, and color
  - Rapidly varying chemical quality and temperature over time
  - Lower mineral content than ground water from the same area
  - High levels of bacteria, algae, and viruses
  - Lower amounts of dissolved gases, iron and manganese



Water Problems

- **Rotten egg odor**
  - Hydrogen Sulfide
- **Red Water**
  - Iron
- **Slimy Red Goo**
  - Bacterial iron
- **Black stains**
  - Manganese
- **Scale, Deposits, High Soap Usage**
  - Hard Water
    - (Calcium and Magnesium)
- **Corrosive**
  - Low pH, High gasses
- **Cloudy/ Murky**
  - Turbidity (suspended Solids)
- **Mottled Teeth**
  - Fluoride
- **Infant Cyanoses (Blue Skin)**
  - Nitrate or Nitrite
- **Nervous System Damage**
  - Lead
- **Diarrhea**
  - Sulfates
- **Cancer**
  - Trihalomethanes (THMs)

Quick Review

Please open the Quizizz app to complete review

Chapter 3

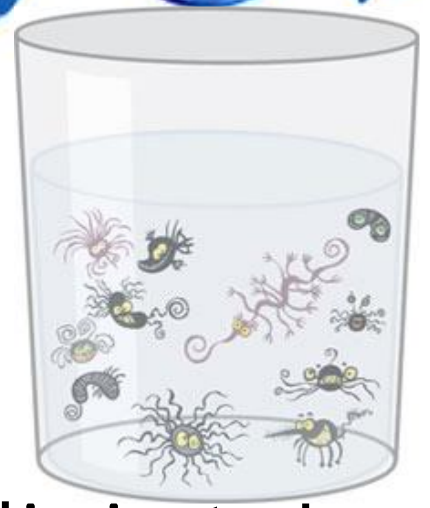
Waterborne Disease

Waterborne Disease

- Water quality problems fall into two broad categories:
  - Outbreaks of severe illnesses
    - Waterborne Pathogens
  - Chemical Contamination

- Water used for drinking, cooking, or washing dishes must not be contaminated with microorganisms that cause disease
- Unsafe water can spread a number of diseases that are known as “waterborne” infections
  - Typhoid, Cholera, and Dysentery
- These illnesses are intestinal disorders and are spread when fecal matter from infected individuals gets into the water supply

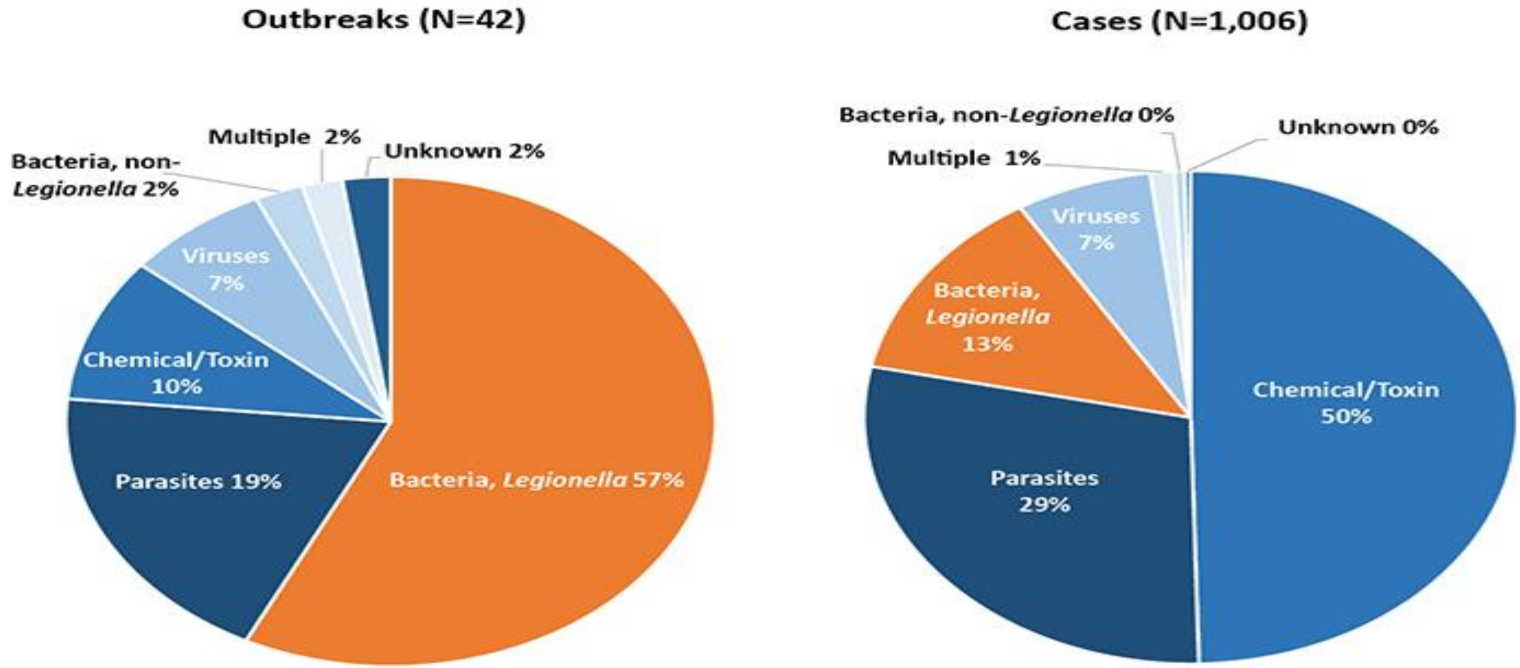
Occurrence and Control of Waterborne Disease



- Poor sanitation and ineffective water treatment magnify the incidence of waterborne disease
- Waterborne Diseases can be reduced or Eliminated:
  - Protecting water sources from contamination
  - Providing complete potable water treatment
    - Minimum includes effective ***filtration*** and ***disinfection***
  - Protecting treated water supplies through cross-connection control
  - Establishing proper sanitation practices in communities
  - Collecting and treating human and animal wastes

Occurrence and Control of Waterborne Disease

- 10 Million Deaths World-Wide Annually
- 1,000 Deaths Annually in the United States



- Most waterborne diseases are intestinal disorders.
- Pathogens are spread through fecal matter.

Occurrence and Control of Waterborne Disease

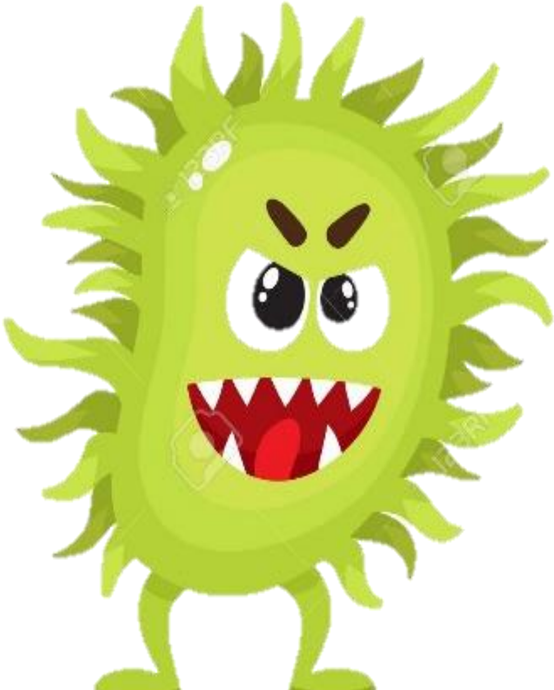
Water Sources of Waterborne Illness Cases: US 2013-2014

• Surface Water	79%
• Groundwater	15.6%
• Unknown	3.9%
• Mixed	1.2%

Waterborne Disease	*Pathogen*
• Cholera	Bacteria
• Cryptosporidiosis	Protozoa
• Giardiasis	Protozoa
• Dysentery	Bacteria
• Legionella	Bacteria
• Typhoid	Bacteria

Bacteriological Quality

- When testing water supplies for disease-causing organisms, an indicator organism is used to check for bacteriological contamination.
    - A group of bacteria that is referred to as coliform bacteria
- Whenever fecal matter is present in water, fecal coliform bacteria will usually be present indicating that disease-causing organisms may also be present.
- *E. coli* is a fecal coliform bacteria that can also be detected by the bacteriological test.



How to take a Water Sample

Do:

- Flame the hose bib or wash with chlorine over time
- Get the sample to the lab within 30 hours of collection
- Control the temperature of sample before/during delivery to lab

Do not:

- Use expired sample bottles or non-lab provided sample bottles
- Over or under-fill the sample bottle

How to take a Water Sample

Sampling equipment:

- Use only sample bottles provided by a certified lab and that have not expired (normally less than 6 months old)
- Gloves, chlorine bleach, spray bottle, lighter, lab forms, sample bottle container from a lab

Sampling time:

- Do not sample on windy (> 20 mph) or rainy days
  - can compromise results

How to take a Water Sample

Sampling location:

- Outdoor faucet or hose bib is preferred, not near tall grass or shrubs
  - Never collect from kitchen sink, bathroom sink, or water fountain
- Faucet or hose bib pointing down at least 18 inches above the ground
- The sample location should be an active connection and one that is used often but not in an area of recent flushing, line extensions, or repairs
- Hose bib / faucet head must be made of material capable of withstanding disinfection (flame, bleach)

How to take a Water Sample

Collecting the sample:

- Wash hands thoroughly
  - wear sterile rubber gloves if possible
- Disinfect the sampling location by applying a concentrated solution of chlorine to completely wet the faucet
- Allow the disinfecting solution to sit on the faucet for 10-15 minutes
  - Alternatively, apply a flame to the outside and inside mouth of the faucet or hose bib using small lighter
- The goal of disinfection is to fully sterilize the faucet so that the sample collected is of the water and not bacteria present on or in the faucet brought by wind, animals, etc. – be very careful with this step
- Open the faucet completely and allow water to run freely for at least 2 minutes before sampling

How to take a Water Sample

Collecting the sample:

- Reduce water flow to diameter of 1/4” (#2 pencil diameter) making sure there is no splash back at the sampling site
- While gloved, remove the lid from the water sample bottle provided by the lab for coliform testing making sure not to touch the mouth of the bottle or inside of the bottle.
- Do not rinse the bottle
- Carefully fill the sample bottle to the fill line at the shoulder of the bottle
- Do not overfill the sample bottle – do not under fill – fill to the line
- Carefully cap the sample bottle making sure the cap is firmly tightened

How to take a Water Sample

Collecting the sample:

- Place the sample bottle in an insulated container with ice after collection and prior to submitting to a certified lab
- Refrigerate (don't freeze!) samples that are held overnight before delivery to the lab.
- Deliver sample to lab within 30 hours from collection or it will be declared "unsuitable for analysis"
- Fill out the lab sample form
- Make sure the date and time sample was taken are included on your form(s), without this data the lab may declare the sample "unsuitable for analysis"

What the Results Mean

- **Positive** = Coliform Organisms Found
  - **Bad**, coliform organisms were present in the sample and drinking water supply is contaminated.
  - <u>Notify homeowners </u>not to drink water and retest
- **Negative** = Coliform Organisms Not Found
  - **Good**, coliform organisms were not found in the sample and water is considered safe.
- Sample **Unsuitable** for Analysis
  - Over or under filling sample containers
  - Samples not submitted within 30 hours
  - Sample contained obscuring turbidity or non-coliform bacteria
  - Sample leaked during shipment
  - Paperwork not completed correctly

Disinfection

- Purpose is to reduce the numbers of disease-causing organisms to safe levels and to destroy pathogenic organisms without impairing the quality of the water
- The most important step in the production of drinking water.

CT Values

- Rated by their ability to reduce pathogens to safe levels
  - To be effective, a disinfectant must contact the microorganisms for a period of time
    - CT value (Concentration x Time)
    - Higher the CT value to kill the microorganism, the weaker the disinfectant

Disinfectant	CT value for 99.99% Virus Inactivation	CV value for 99.9% Giardia Cyst Inactivation
Ozone	1.0	1.43
Chlorine Dioxide	25.1	23
Free Chlorine	6	137
Chloramine	1,491	1,850

Disinfection with Chlorine

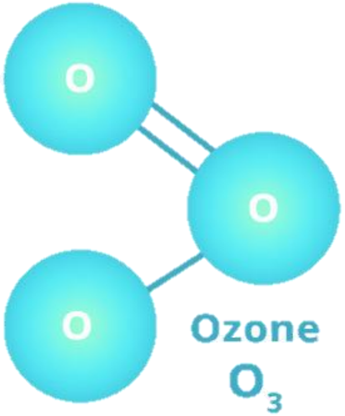
- Most commonly used disinfectant
  - Readily available, effective, low cost, and provides a measurable residual that can be tested periodically
- Commercially available in three forms
  - Liquid solutions of sodium hypochlorite (bleach)
  - Solid calcium hypochlorite
  - Pure chlorine as a compressed gas
- For disinfection to be effective, it must be applied continuously and at high enough concentrations over the required contact time

Chlorination Terms

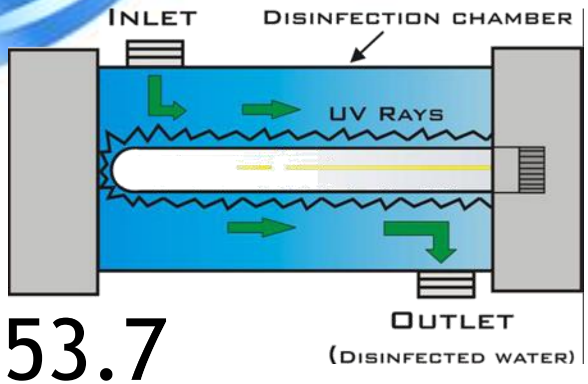
- **Dosage**
  - Amount of chlorine added to the water
- **Demand**
  - Amount of chlorine that is used up by reactions with impurities in the water
- **Residual**
  - Amount of chlorine remaining after the contact period
  - Can be measured by chlorine test methods such as DPD colorimetric method, FAS titration method, or amperometric titration
    - DPD method is commonly used
    - Indicator dye turns pink to red depending on the concentration of chlorine in the sample

Disinfection with Ozone

- Ozone is a very quick and effective disinfectant
  - Nearly 100 times more effective than free chlorine for Giardia cyst inactivation
- Because it is unstable, must be generated on site and used quickly
- Produced by an ozone generator
  - Uses high-voltage electrical corona to convert the oxygen in clean, dry air into ozone
- Can also be produced by ultraviolet light when operated at a specific short wavelength
  - Not how UV usually works
- Only small residual concentrations are required for disinfection
  - 0.1-0.2 mg/L



Disinfection with Ultraviolet Light (UV)



- Wavelength for disinfection is 253.7 nanometers
  - Close to the optimum germicidal wavelength
- In a UV light system;
  - Water enters the disinfection unit and passes through the space between the quartz lamp sleeve and the outside chamber wall
  - Light must penetrate through the water for maximum effectiveness
    - Color, turbidity, low temperature, low voltage, and organic matter may interfere with the effectiveness

Quick Review

Please open the Quizizz app to complete review

Chapter 4

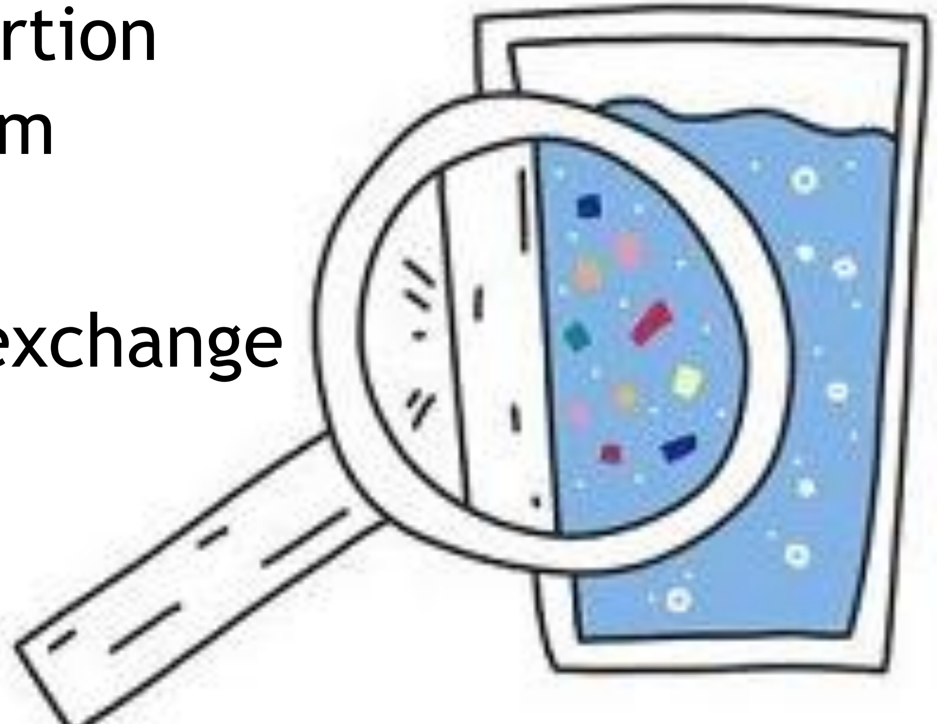
General Water Quality

Water Analyses

- The process of finding out how much of the various impurities are present.
  - Dissolved minerals, organic matter, or metals
  - Dissolved gasses such as Carbon Dioxide and Oxygen
  - Suspended particles of mineral, organic, or metallic nature
  - Turbidity, color, taste, and odor
  - Microorganisms

Measuring Impurities

- Milligrams per Liter mg/L
  - Weight to volume proportion
- Parts per Million ppm
  - Weight to weight proportion
  - In water, 1 mg/L = 1 ppm
- Grains per Gallon gpg
  - Water hardness or ion-exchange
  - 7,000 grains = 1 pound
  - 1 gpg= 17.12 mg/L



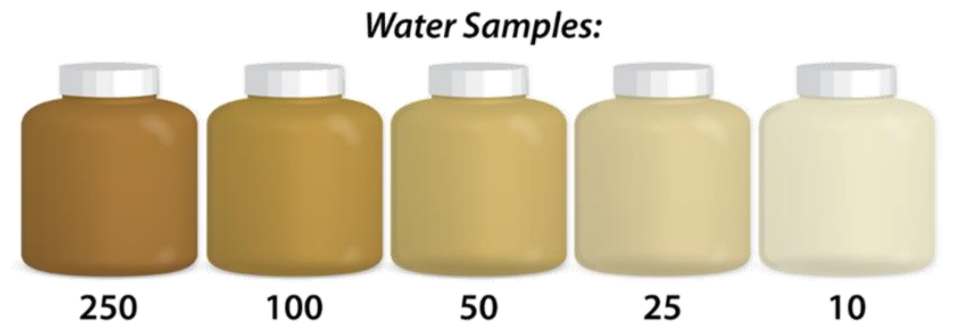
Units of Measurement

Unit of measurement	Equivalent mg/L	Metric Equivalent
1%	10,000	10 g/L
1 ppt	1,000	1 g/L
1 gpg	17.12	17.12 mg/L
1 ppm	1	1 mg/L
1 ppb	0.001	1 ug/L
7,000 grains	1 pound	453.6 g

Physical Descriptions of Water Quality

- Physical quality standards are based on methods that use the physical senses of sight, smell, and feel. The physical quality of water can be evaluated from the results of 5 test procedures.
  - **Turbidity**
  - **Color**
  - **Temperature**
  - **Odor**
  - **Taste**

Turbidity



- Turbidity means cloudiness or haziness.
- SUSPENDED SOLIDS.
  - Anything that prevents sunlight penetration through the water.
- Measured with nephelometric turbidimeter.
  - Standard for treated water is 0.3 NTU.
- Lowering turbidity reduces the possibility of disease organisms hiding in the water.

Color

- Two types of color:
  - True color
    - Caused by dissolved substances (tannins)
    - Cannot be removed by filtration
  - Apparent color
    - Caused by suspended particles in the water
      - Clay particles, oxidized iron, algae
    - Can be removed by filtration
- Color can be read with instruments and compared against color standards.
- Standard for drinking water is 15 color units

Tannins

Temperature

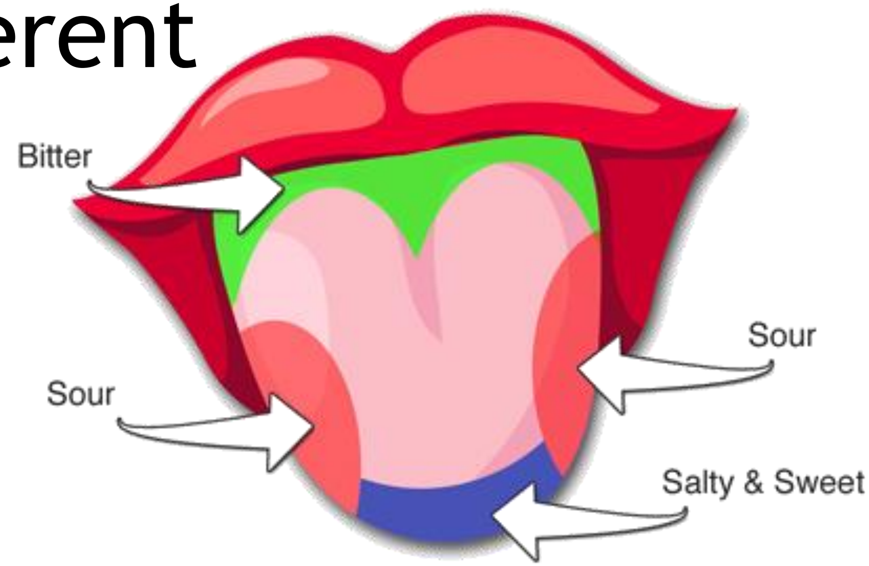
- Measured with thermometers
- No quality standards set (DUH!)
- Boiling can ensure the microbiological safety of water.
- Temperature has a significant impact on density.
  - Maximum density at 3.98*c
  - Ice is 8% less dense than liquid water

Odor

- Test called the threshold odor
  - Produces TON (threshold odor number)
- Quality standard for drinking water is 3 TON

Taste

- No quality standard has been established
- Sense of taste is much less sensitive than smell
- Ions can impart different tastes in water

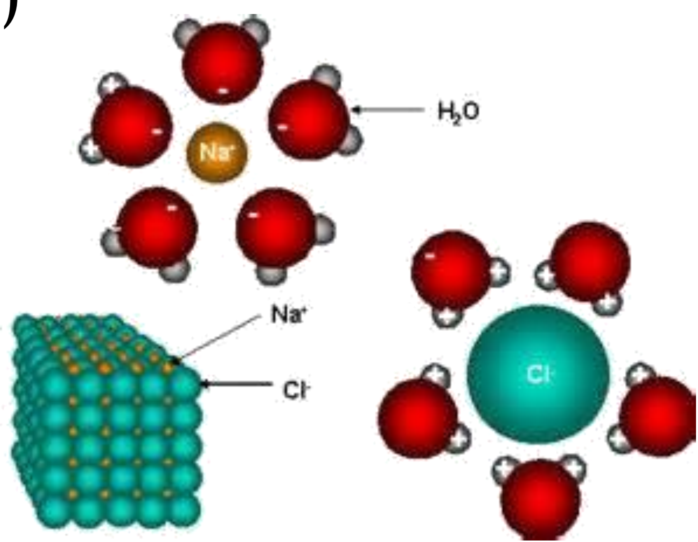


Chemical Quality

- Five general chemical characteristics help define water quality.
  - pH
  - Total Dissolved Solids
  - Alkalinity
  - Conductivity
  - Hardness

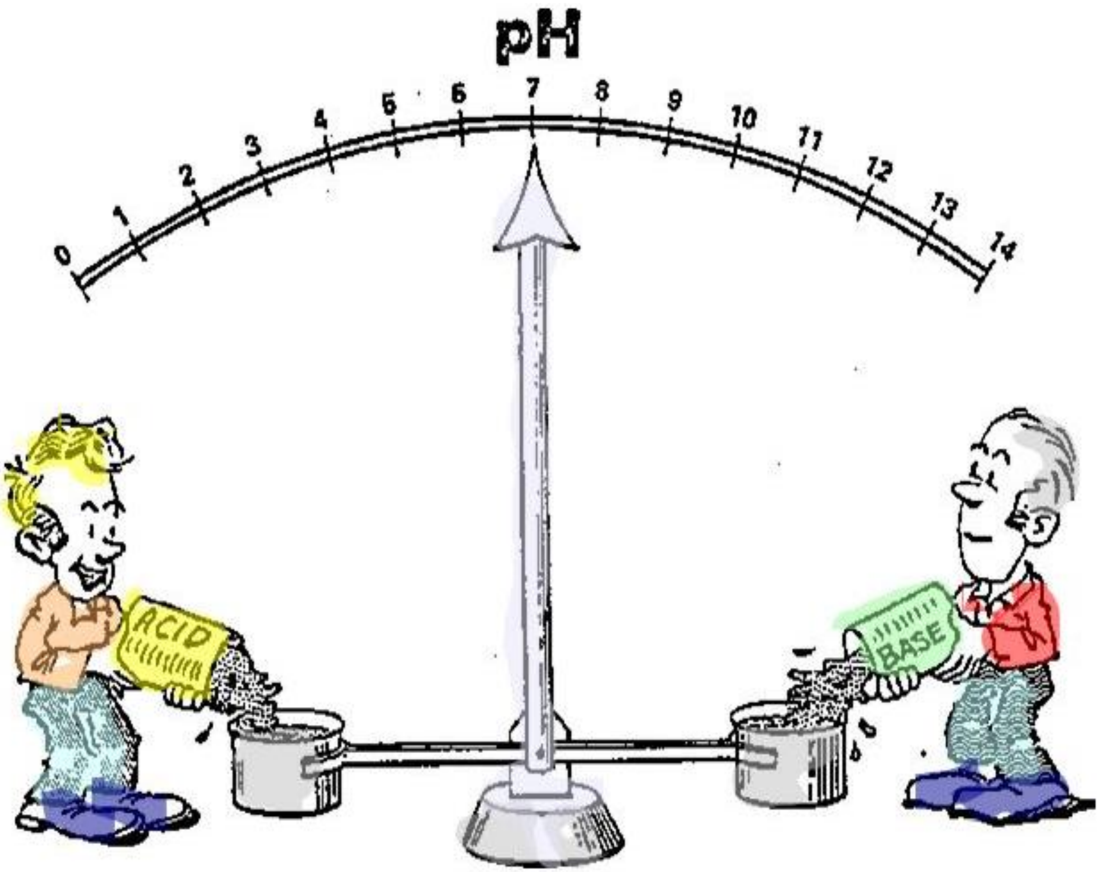
Ions in Water

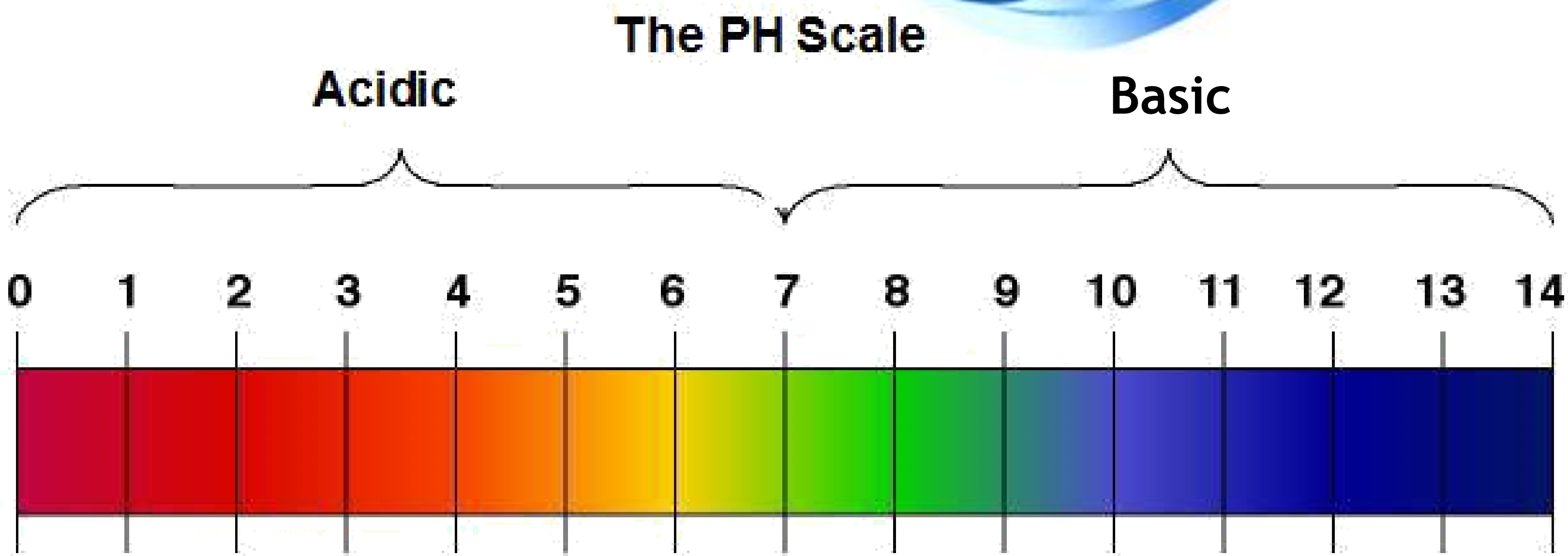
- When minerals such as Sodium Chloride (NaCl) come in contact with water, they dissolve into their ions.
  - Ionization: the process in which an atom, or group of atoms, takes on or gives electrons and becomes charged
- Anions
  - Negatively charged (Cl-, HCO_3-, SO_4-)
- Cations
  - Positively charged (Na+, Ca+, Mg+)
- Act similarly to magnets.
  - Same charge repel
  - Different charge attract



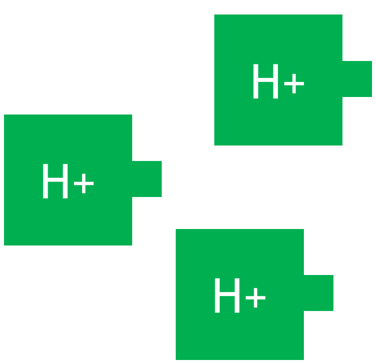
The Meaning of pH

- The pH scale indicates the acidity or basicity of the water.
- Typically 0-14
- 7 is Neutral
- 0-6 is Acidic
- 8-14 is Basic

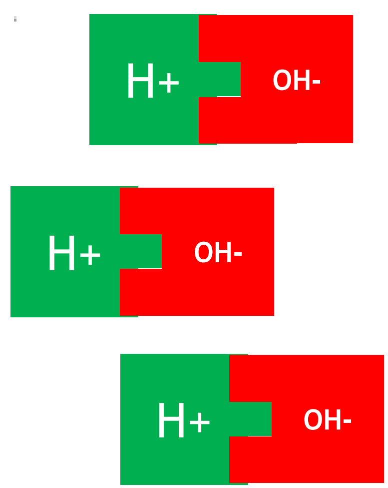




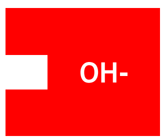
H+
Hydrochloric Acid
HCL

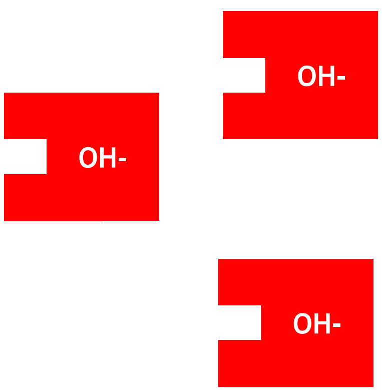


Neutral



OH-
Caustic Soda
Basic
NaOH





Hardness

- Hardness materials in water react with soap to turn the soap into <u>useless soap curds</u>.
- Hardness reacts with alkalinity to form <u>deposits and scale.</u>
- Made mostly of <u>Calcium</u> (Ca^+) and <u>Magnesium</u> (Mg^{++})

Temporary (**Carbonate** Hardness)

- Bicarbonate and Carbonate (anions)

Permanent (**Non-Carbonate** Hardness)

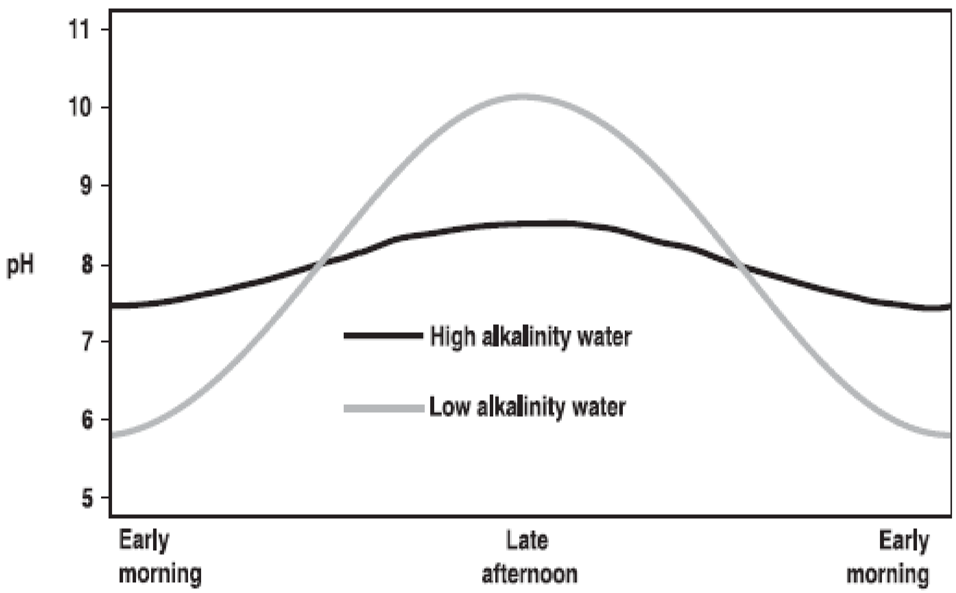
- Chloride and Sulfate (anions)

Total Dissolved Solids (TDS)

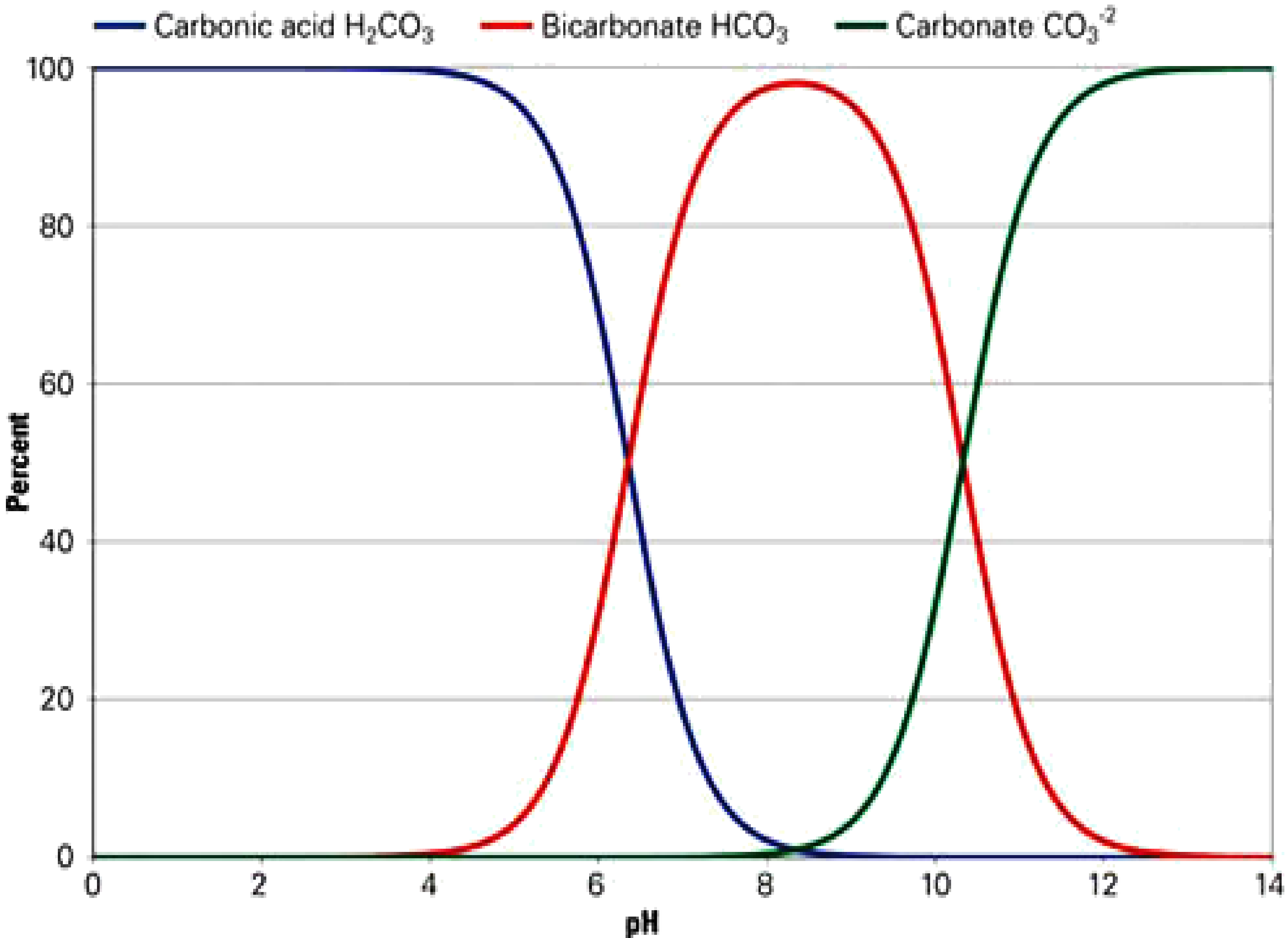
- Determined by filtering the water sample and evaporating the water away from the filtrate.
  - The solid residue is the TDS of the water
  - Mostly the mineral content of the water
- Quality standard for public water supply is 1,000 mg/L for TDS.
- Estimate measure by conductivity:
  - Higher the mineral content, the more electricity the water will conduct

Alkalinity

- Measures the amount of acid that can be neutralized by the water.
- Test performed by adding acid to the water being tested until the pH drops to a specific level.
- Mostly Carbonate and Bicarbonate ions.
- Important to water stability, coagulation, and precipitation softening.



Alkalinity Interpretation



Conductivity

- Measure of the water's ability to conduct an electric current
- The higher the mineral content of the water, the more ions in the water, and the more readily the water will conduct an electric current
- Usually measured in micro siemens (uS)
  - Pure water is theoretically 0.05482 uS
- Another way to describe purity is by resistance
  - Measured in megohms
  - Pure water is theoretically 18.24 megohms

Corrosivity

- Water becomes more corrosive, with a tendency to dissolve steel pipe when;
  - Low pH
  - Low Alkalinity
  - High Dissolved Gasses
    - carbon dioxide, oxygen

- Corrosive water can lead to
  to Lead and Copper problems.

Scaling

- Water tends to deposit scale (calcium carbonate) when there is;
  - High Hardness
  - High Alkalinity
  - High pH

Mineral Content

Cations			Anions		
Name	Symbol	Effect	Name	Symbol	Effect
Sodium	Na+	Metallic Taste	Bicarbonate	HCO_3-	Alkalinity
Calcium	Ca+	Hardness	Chloride	Cl-	Brackish taste
Magnesium	Mg+	Hardness	Sulfate	SO_4-	Laxative Effect

Typically comprise more that 95% of the materials that are found in water.

Regulation and Standards of Quality

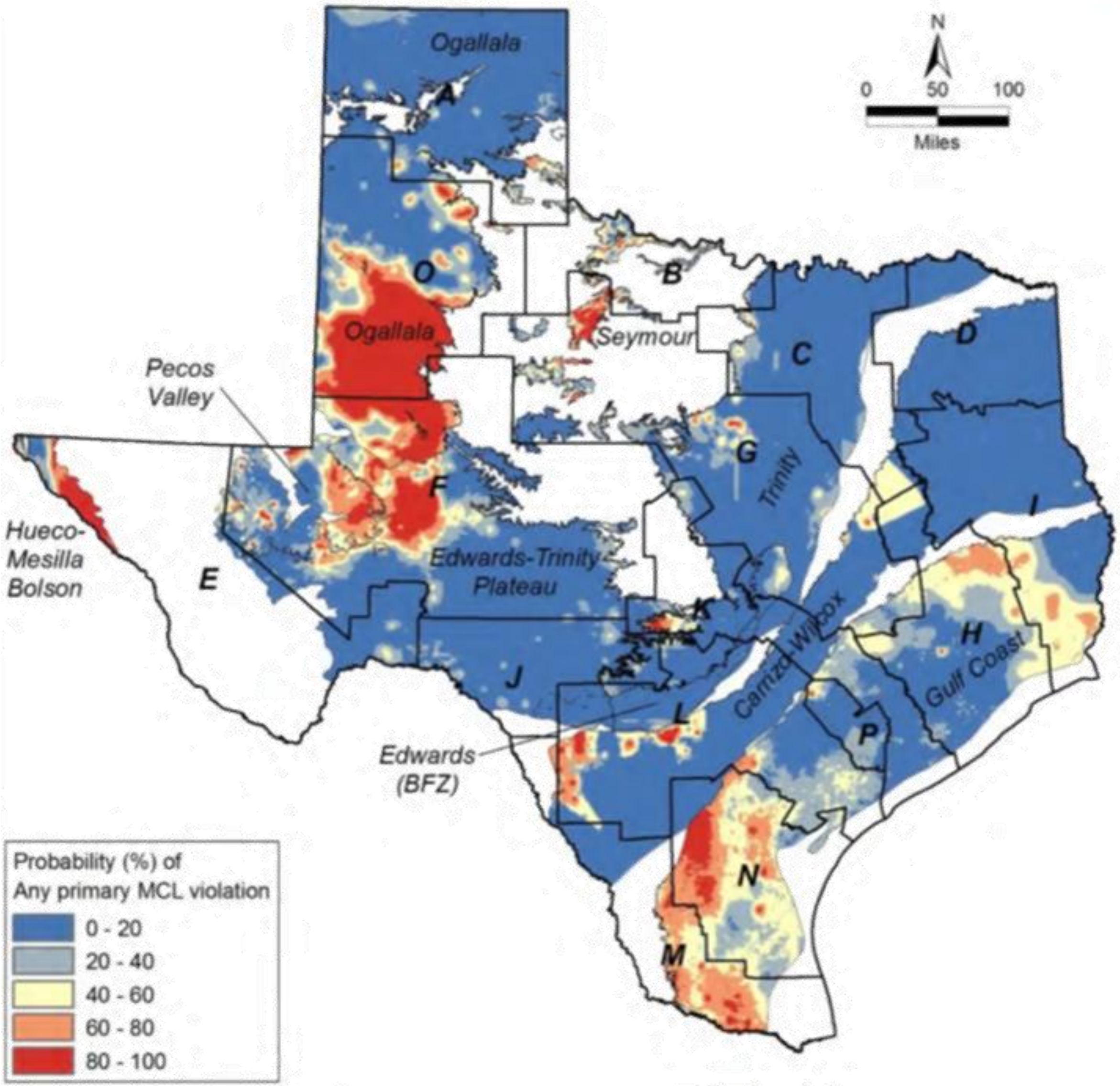
- Water is the most regulated material in this country:
  - Surface and ground water quality is regulated through the Clean Water Act.
  - Drinking water quality is regulated through the Safe Drinking Water Act.
- Potable water is water that is safe to drink.
  - EPA has established 137 primary and secondary standards for drinking water quality

Chemical Quality

- Limits are called Maximum Contaminant Levels (MCLs).
- Chemical Quality is subdivided into three types;
  - Inorganic Chemicals
  - Volatile Organic Chemicals (VOCs)
  - Synthetic Organic Chemicals (SOCs)
- Only rarely will VOCs or SOCs exceed the MCLs in public water supplies.
- Most common chemicals found in water supplies are:
  - Nitrate (MCL- 10 mg/L)
  - Fluoride (MCL – 4.0 mg/L)

MCLs for Inorganic Chemicals

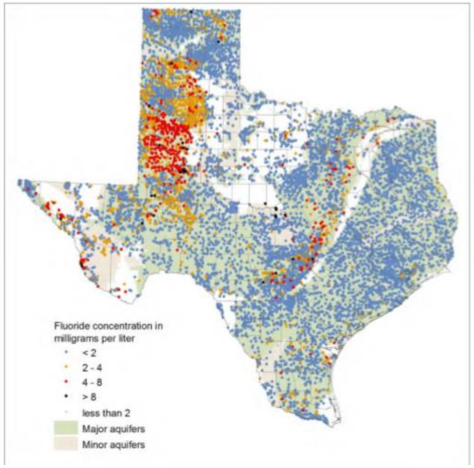
Substance	Problem	Concentration in mg/L
Arsenic	Toxicity	0.010 mg/L
Asbestos	Lung Cancer	7 million fibers per liter
Fluoride	Mottled Teeth	4.0
Nitrate	Blue Babies	10 (as Nitrogen)
Nitrite	Blue Babies	1 (as Nitrogen)
Lead	Nervous System Damage	MCLG- 0.0 Activation level – 0.015

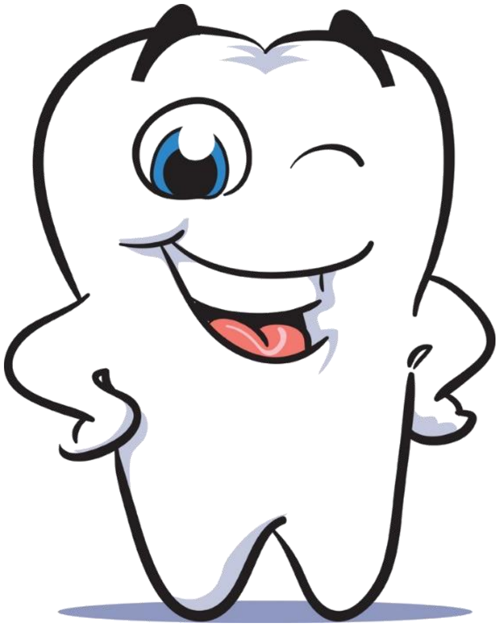


Natural Occurring Groundwater Contamination in Texas

Fluoride

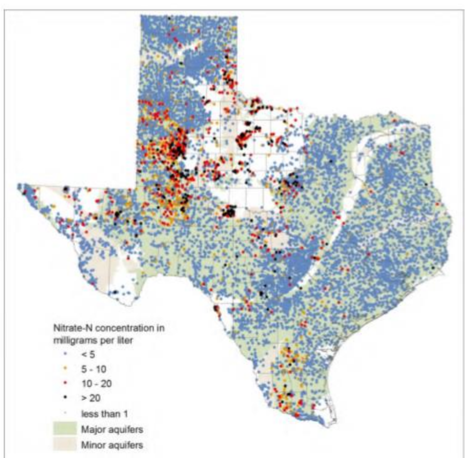
- High levels of fluoride in drinking water may cause **mottled teeth**
  - A brown discoloration that appears in the tooth enamel.
- Secondary standard is 2.0 mg/L
- Primary standard (MCL) is 4.0 mg/L





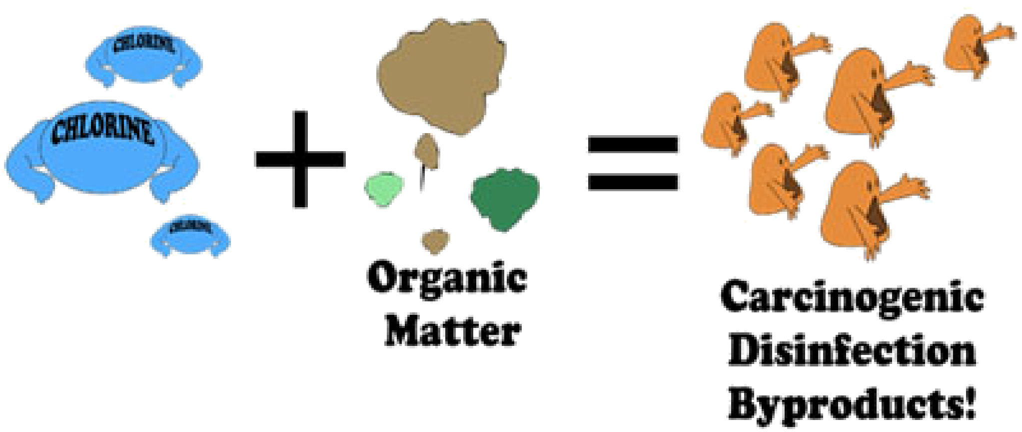
Nitrogen Compounds

- Increase the risk of **blue baby syndrome** and miscarriage.
  - Methemoglobinemia
    - A serious health threat in infants recognized by a blue skin color.



Total Trihalomethane (TTHM)

- Yearly average standard is 0.08 mg/L
  - =80 ug/L
- THMs cause cancer in laboratory animals and have been associated with increased risk of cancer in humans.
- Formed when water containing organic matter (most surface waters) is disinfected with chlorine compounds.



Secondary Standards

- While these impurities generally do not cause adverse health effects, elevated levels can adversely impact the aesthetic quality of the water.

Secondary Drinking Water Standards		
Contaminant	Concentration mg/L	Significance
Aluminum	0.2	Color
*Chloride	300	Salty Taste
Copper	1.0	Taste and Stains
Corrosivity	Non-corrosive	Leaching
Foaming Agents	1.5	Unsightly Foam
*Fluoride	2.0	Mottled Teeth
*Hydrogen Sulfide	0.05	Odor and Taste
*Iron	0.3	Stains and Taste
*Manganese	0.05	Taste and Stains
*pH	>7.0 units	Corrosion
Silver	0.10	Discoloration of skin and eyes
*Sulfate	300	Taste and Laxative Effect
*Total Dissolved Solids	1,000	Taste and Scale
Zinc	5	Taste and Deposits

Quick Review

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Chapter 5

Water Treatment Technologies

Water Treatment Technologies

- The selection of water treatment processes for removing impurities from water is based on specific requirements.
- The factors considered when evaluating the various treatment options are:
  - Quality of the water source, its type, and degree of prior treatment
  - Type and amount of impurities to be removed and quantity to be treated
  - Desired product water quality and treatment requirements
  - Waste disposal requirements
  - Costs

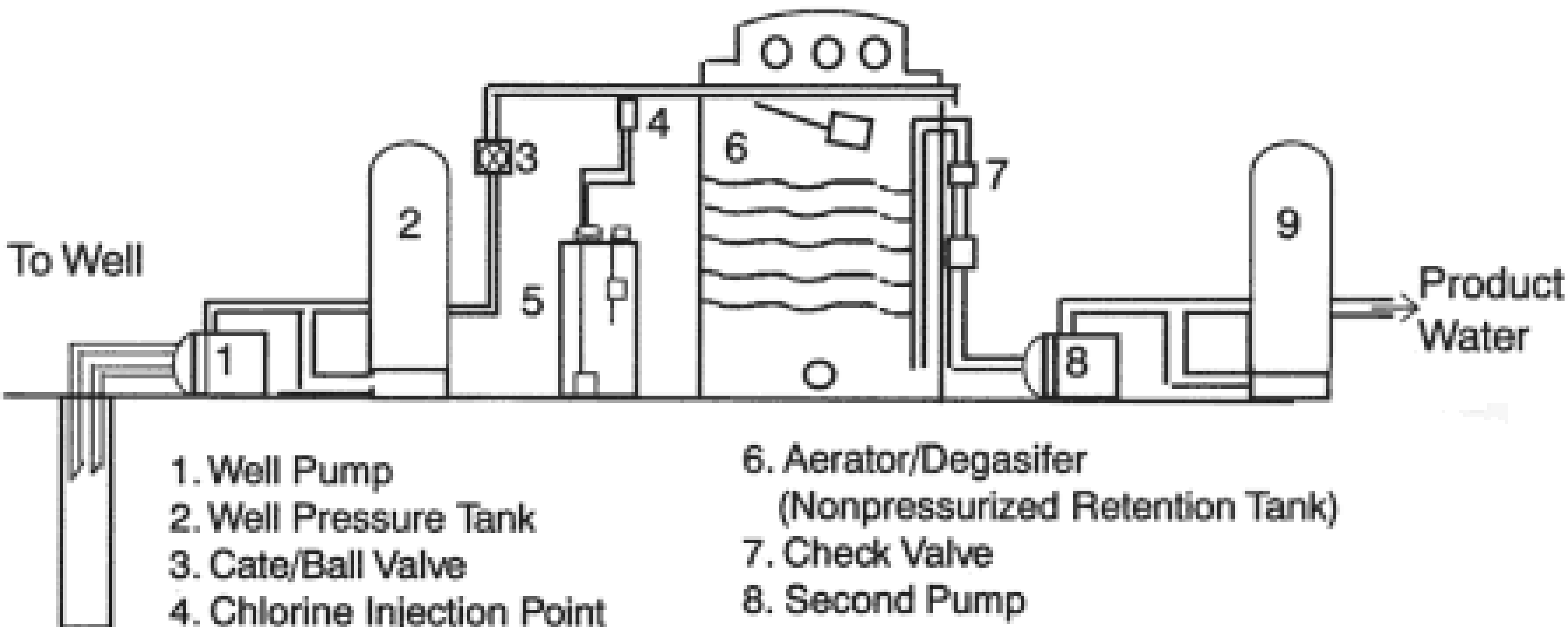
Water Treatment Technologies

- Treatment technologies are used to control a wide variety of impurities including;
  - Microorganisms, Organics, turbidity, fluoride, heavy metals, iron and manganese, hardness, nitrate, color, taste and odor, chlorine, and radioactive materials
- It is unlikely that any single process can produce the desired product quality.
- Treatment is usually provided as a series of unit processes or steps.

Aeration

- Releases:
  - Carbon Dioxide, Hydrogen Sulfide, Methane
  - Radon, heat, VOCs, and SOCs
- Creates a system to bring air and water into contact with each other so that **dissolved gasses** can be released.
- Often used in conjunction with Oxidation/Filtration
  - Iron removal

Typical Domestic Open-Gravity Aerator System



1. Well Pump
2. Well Pressure Tank
3. Cate/Ball Valve
4. Chlorine Injection Point
5. Chemical Feed Pump on 16-gal. Solution Tank
6. Aerator/Degasifer (Nonpressurized Retention Tank)
7. Check Valve
8. Second Pump
9. Second Tank

Source: Water Quality Assoc.

Filtration

- Filters are used to remove particulate matter from water
  - Clay, Silt, and Microorganism
- Placed at the beginning of the treatment sequence to protect other units from fouling materials.

Depth Filters

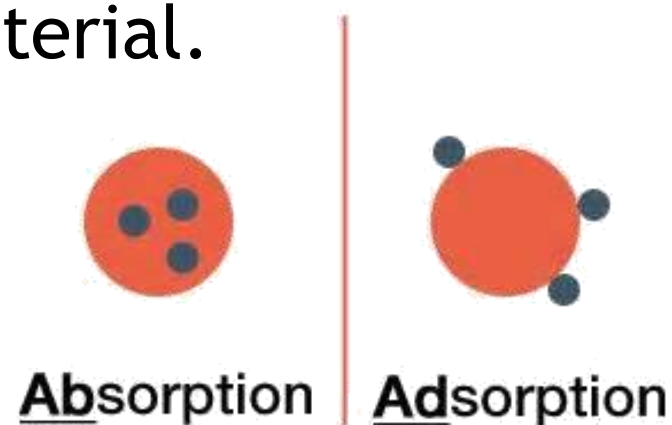
- As the water flows through progressively smaller openings in the filter media bed, progressively smaller particles are removed.
  - Trap particulate matter throughout the depth of the filter
- Treatment of the water with coagulants and filter aids greatly increases the effectiveness of depth filters.

Surface filters

- Typically point-of-use filters.
- Filtration occurs on the surface layer.
  - Using sieves, screens, or fabric with small holes
- Size of the holes in the filter media determines the size of particles that are removed.
- Rated as either Absolute or Nominal.
  - **Absolute** means 99.9% of particles larger that micron rating will be trapped.
  - **Nominal** indicates the approximate size particle which will not pass through
    - 85% or more

Adsorption

- Activated carbon removes;
  - Some inorganic chemicals, chlorine, and chlorine by-products, VOCs, SOCs.
- Used extensively for organic taste and odor.
- Activation acts by adsorbing contaminants
  - The attraction and retention of one material to the surface of a second material.



Activated Carbon

- High Surface area and pore structure.
- 1 pound = more than 100 acres of surface area.
- Think of it as a sponge, with the ability to trap and hold large amounts of organic matter.
- Raw materials:
  - Bituminous coal, lignite, petroleum coke, wood, and nut shells (coconut)
- Provides a medium for the growth and accumulation of bacteria.
  - Microbial control following treatment

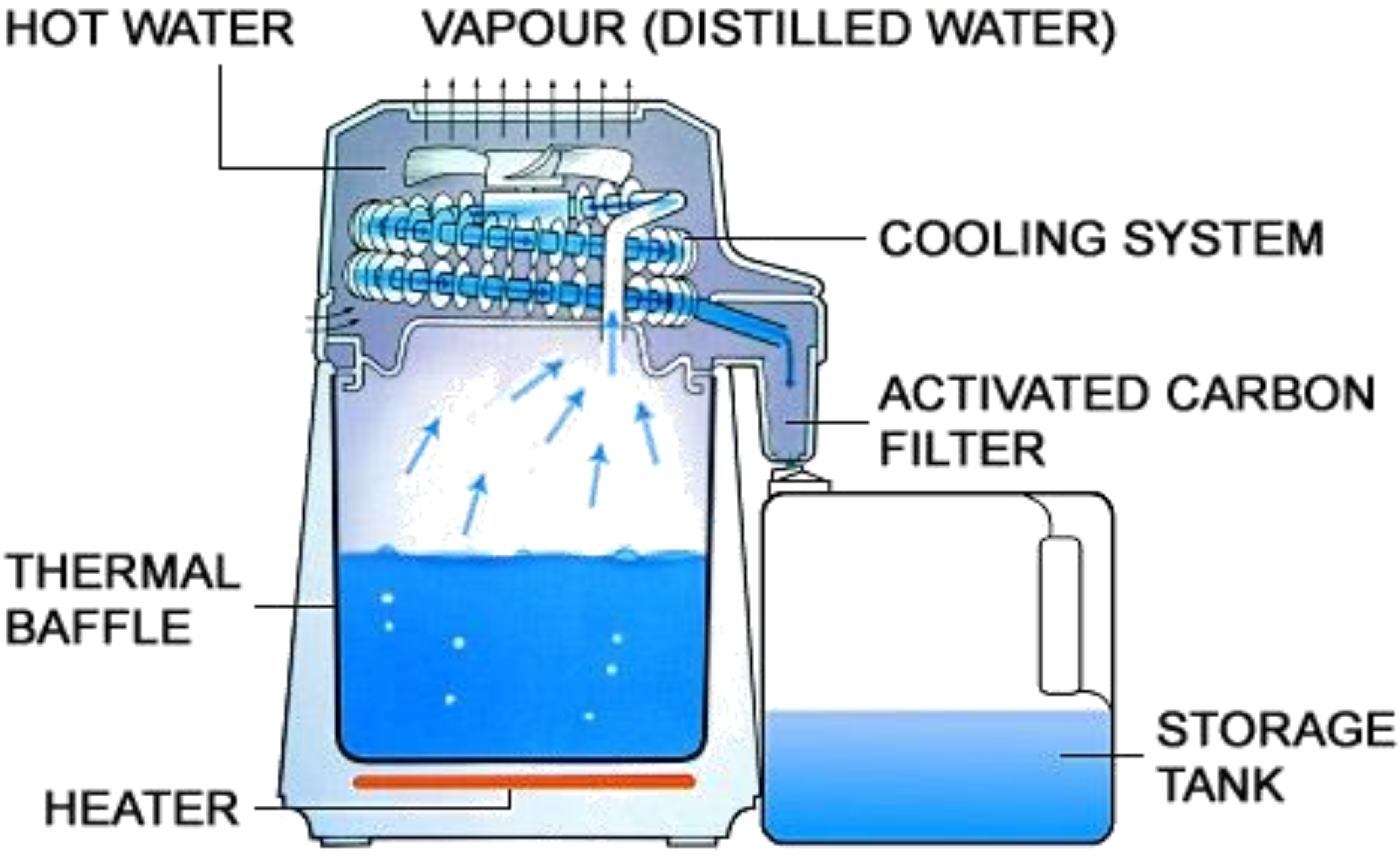
Chemical Oxidation

- Used in a variety of ways:
  - Iron and Manganese oxidized to insoluble ferric and manganese hydroxides to be filtered.
  - Hydrogen Sulfide can be oxidized to elemental sulfur or sulfate.
  - Inorganic Taste and odor control

Chemical Oxidant	Strength
Ozone (O_3)	Very Strong
Hydrogen Peroxide (H_2O_2)	Very Strong
Potassium Permanganate ($KMNO_4$)	Strong
Chlorine Dioxide (ClO_2)	Strong
Free Chlorine (HOCl)	Strong

Distillation

- Process of separating water from organic and inorganic contaminants through **evaporation and condensation.**
- Process:
  - Water heated till steam
  - Particulates are left behind as steam separates
  - Steam cooled and condensed to form pure water
- Effectively removes
  - Metals, hardness, salt, nitrate, and particulates.
  - High temp. used kills bacteria, cysts, and viruses.


HOT WATER
VAPOUR (DISTILLED WATER)
COOLING SYSTEM
ACTIVATED CARBON FILTER
THERMAL BAFFLE
HEATER
STORAGE TANK

Ion Exchange

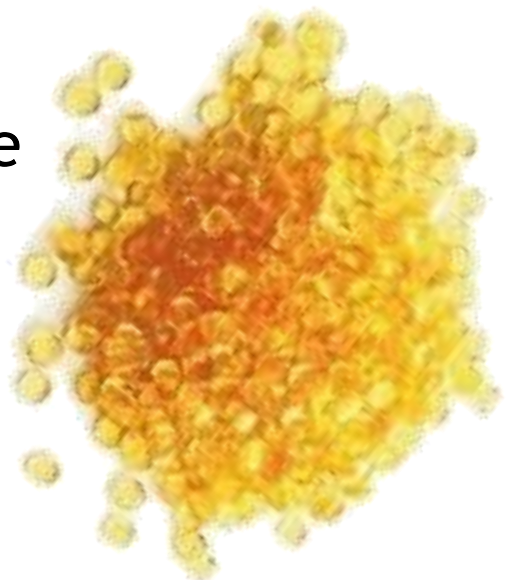
- A process that removes dissolved materials from water by exchanging one type of ion for another
  - Ions in the water exchange with ions of the same charge on the resin surface
  - Softeners and demineralizers are the two most common
    - Softeners remove hardness only
    - Demineralizers remove all ions
- Accomplished on natural or synthetic resins
  - Synthetic resins have a much higher exchange capacity compared to natural Zeolite

Common Ions in Water and Their Effects

Cations			Anions		
Name	Symbol	Effect	Name	Symbol	Effect
Hydronium	H+	Acidity	Hydroxide	OH-	Basic
Sodium	Na+	Metallic Taste	Bicarbonate	HCO3-	Alkalinity
Potassium	K+	Nutrient	Carbonate	CO3--	Alkalinity
Calcium	Ca++	Hardness	Chloride	Cl-	Brackish Taste
Magnesium	Mg++	Hardness	Sulfate	SO4--	Laxative effect
Manganese	Mn++	Taste and brownish stains	Nitrate	NO3-	Blue babies
Ferrous Iron	Fe++	Red Water	Fluoride	F-	Mottled Teeth
Cupric	Cu++	Blue Stains	Sulfide	HS-	Black Stains
Stannous	Zn++	Metalic Taste	Iodide	I-	Allergen
Ammonium	NH4+	Pollutant	Phosphate	PO4---	Pollutant
Selenium	Se++	Toxicity	Silicate	SiO2-	Sealing

Ion Exchange Resins

- Two major groups
  - Cation Resin exchanges positive ions
    - Negative functional (Hands)
  - Anion Resin exchanges negating ions
    - Positive functional (Hands)
- Polystyrene linked with Divinyl Benzene
  - Small plastic bead-like material that can be regenerated almost indefinitely
  - resin



Resins

Strong Acid Cation Resin

- Softening
- Demineralization
- Mixed Bed Demineralization
- Condensate Polishing
- Metal Removal and Concentration

Strong Base Anion Resin

- Acid Neutralization
- Silica and Alkalinity Removal
- Mixed Bed Demineralization

Softening

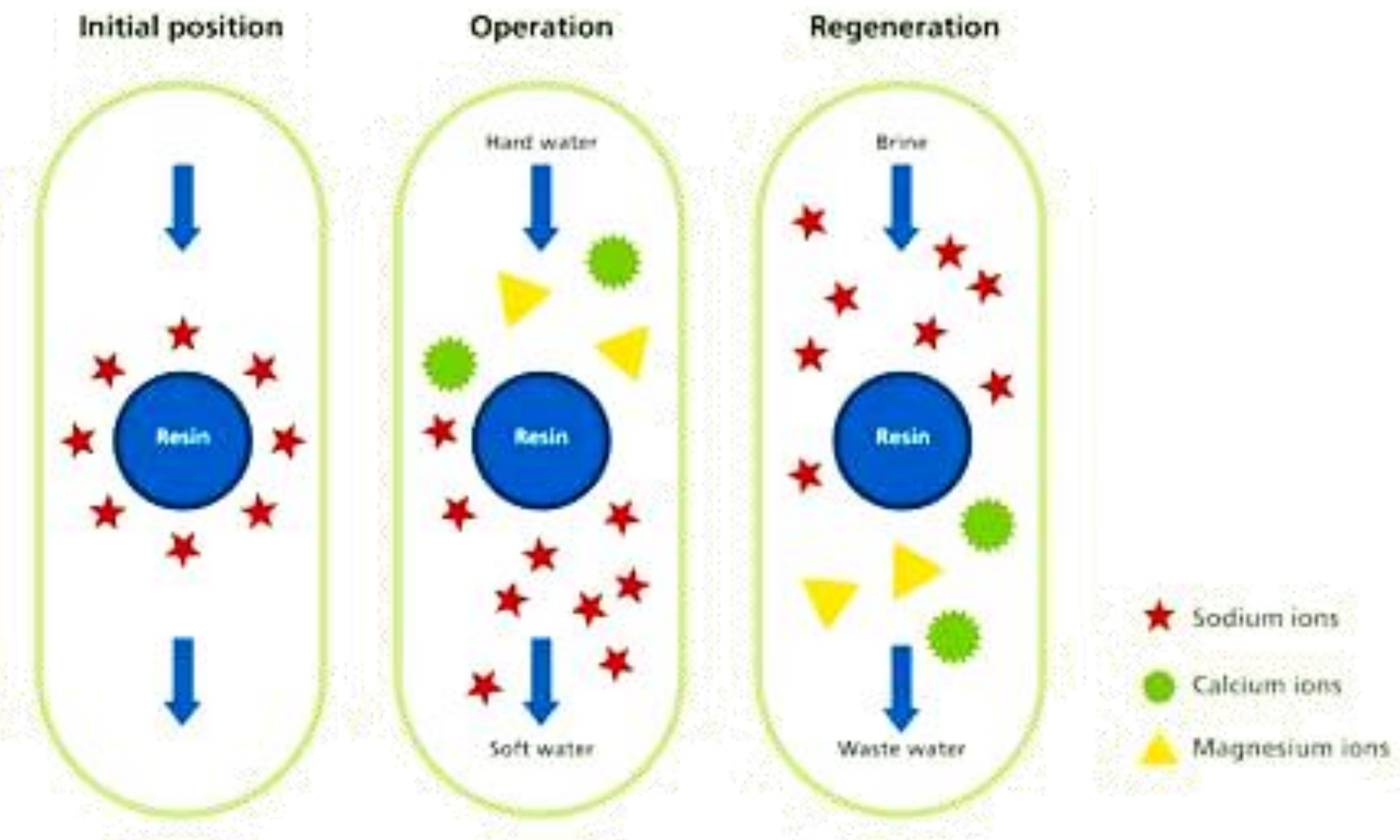
- Removes essentially all hardness from the water
- Contains only Cation Resin
- Regenerated with brine
  - A concentrated solution of sodium chloride and water
- During service, calcium and Magnesium hardness ions attach to the resin at the active exchange sites as sodium ions are released into the water
  - May also remove iron, manganese, and aluminum
    - These materials may foul the resin over time depending on the amount present

Steps in Softener Operation

- Service
  - Removes hardness from the water
- Regeneration
  - Backwash
  - Brine
    - Strong salt solution
  - Rinse
- Return to service
- Some units use a different regeneration sequence
- Since softening increases the sodium content of water, softened water for drinking is often treated by reverse osmosis to remove sodium and other ions from the water

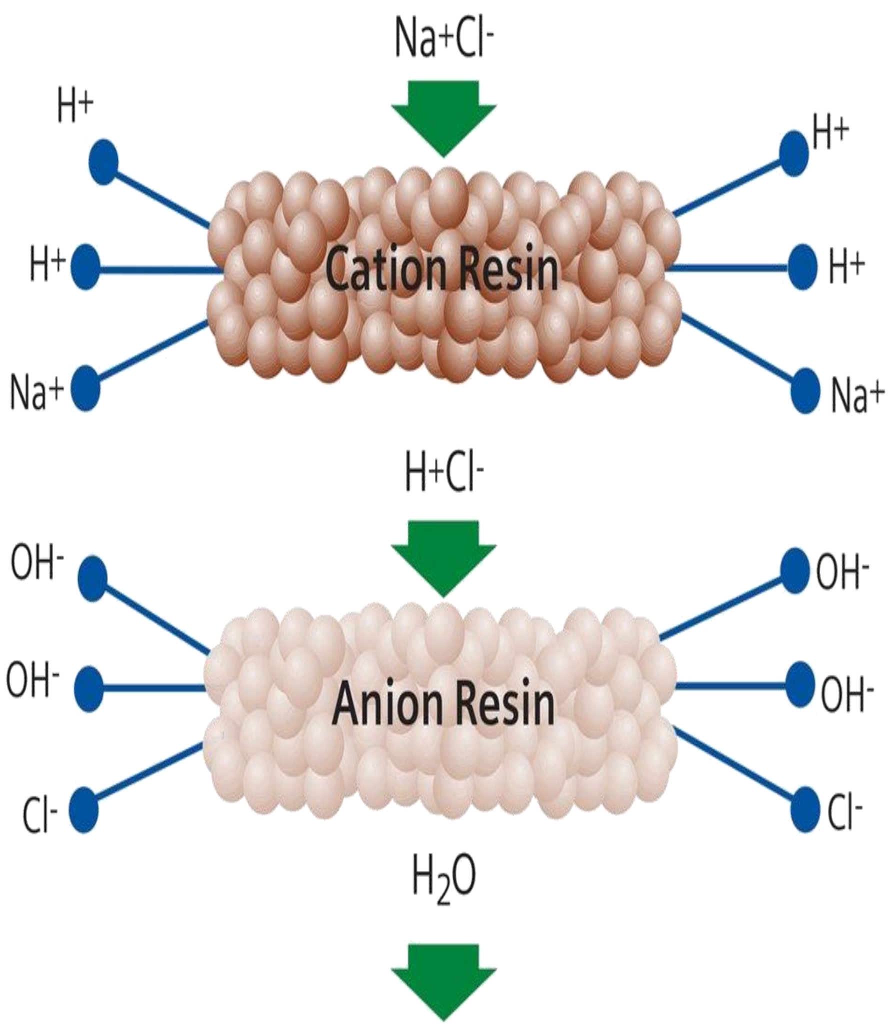
Salt

- Hardness is removed but the water's sodium content increases in proportion to the amount of hardness removed.
- Let's put that into perspective.
- A human should drink one gallon of water each day.
- 5 gpg is hard water typically treated with a softener.
- 1 gallon of water containing 5 grains of hardness when softened will exchange for 5 grains of sodium.
  - 7,000 gr=1 pound of mineral
  - 5 grains ÷ 7,000 gr/lb = 0.0007 lbs sodium
  - 1 pound = 16 oz
  - 1 oz = 28,000 mg
  - 0.0007 lbs x 16 oz/lb x 28,000 mg/oz
  - =314 mg of sodium per gallon of softened water
- 2 slices of white bread typically contain about 300 mg of sodium
- American Heart Association recommends no more than 2,300 mg of sodium per day


Initial position
Operation
Regeneration
Resin
Hard water
Soft water
Resin
Brine
Resin
Waste water
Sodium ions
Calcium ions
Magnesium ions

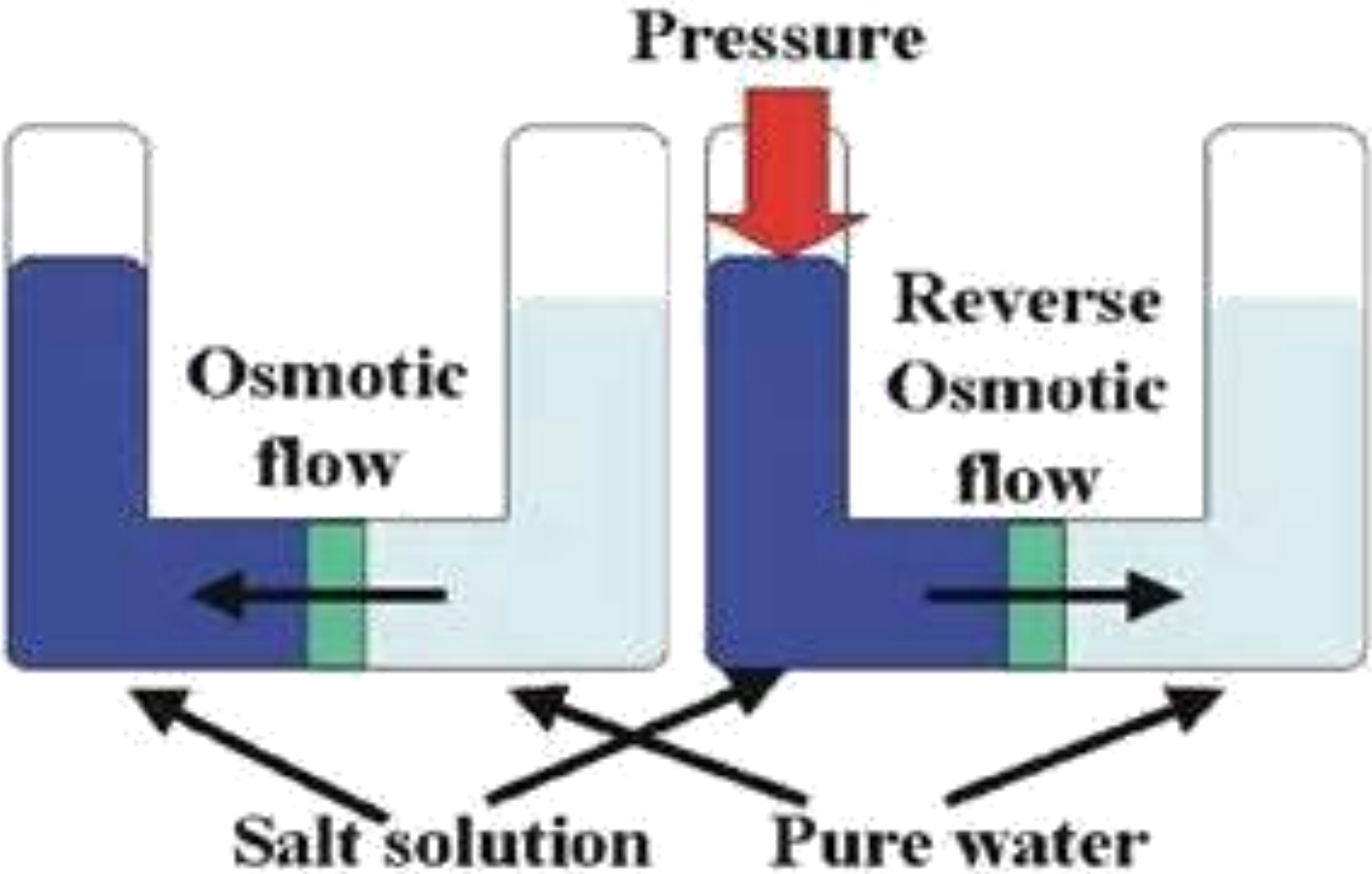
Demineralization

- Ion exchange process that removes ALL ions from the water.
- Contains 2 types of resin
  - Cation resin
    - Removes all cations
    - Replaces cations with H+
    - Regenerated with a strong acid
  - Anion resin
    - Removes all anions
    - Replaces anions with OH-
    - Regenerated with a strong base



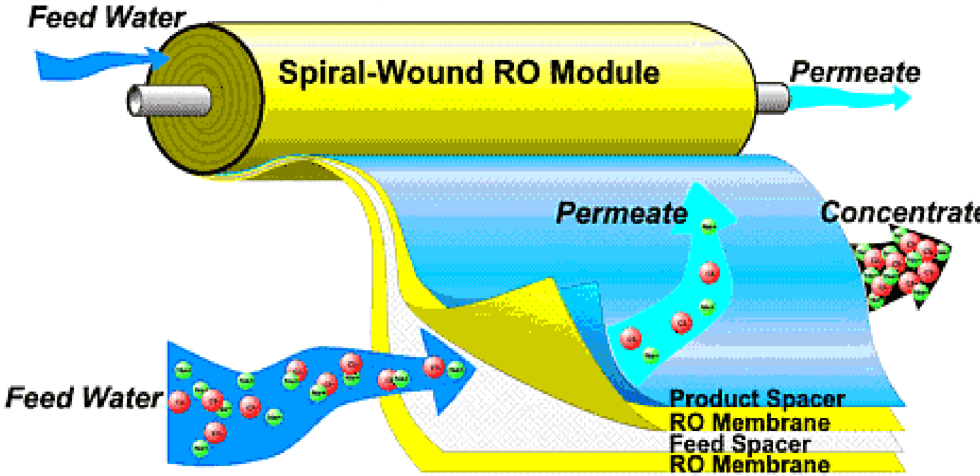
Reverse Osmosis

- Reverse Osmosis (RO) is a membrane separation process which uses pressure to force water through a semipermeable membrane
- Thin polymer membranes along with pressure are used to selectively pass water while limiting the passage of inorganic chemicals, organic molecules, and micro-organisms
- Have no moving parts and do not require regeneration or backwash.
- Recovery means the percent product water from an RO unit.
  - Typically about 30%



Pressure
Osmotic
flow
Reverse
Osmotic
flow
Salt solution
Pure water

Types of Membranes



- Membrane Materials:
  - Cellulose Acetate
  - Cellulose Triacetate
  - Polyamide
  - Polysulfone
- Thin-Film Composite (TFC)
  - Polyamide and Polysulfone layers bonded together
- Commonly arranged in elements as bundles of hollow fibers, or as a spiral wound unit.
  - Arrangement provides a high surface area needed to obtain sufficient product water from each element
- Elements are arranged in series, parallel arrays to obtain higher recoveries and production rates.

Quick Review

Please open the Quizizz app to complete review

Chapter 6

Public Relations and Safety

Public Relations and Safety

- Customer confidence and satisfaction will be increased by prompt and courteous service with high product and service quality.
- What customers want to know;
  - Nutrients, Less Scale, Dietary Sodium, Soap Usage, Slick Skin
- A written safety program to conduct operations in the safest manner possible should be the goal of every company.
- Safety precautions to consider:
  - Clothing, Eye Protection, Chemical Hazards, Working room, Lifting heave objects, etc.
- 90% of accidents are due to unsafe acts and unsafe work conditions.
- Do not roll exchange tanks directly on wood or carpet floors.

Quick Review

Please open the Quizizz app to complete review

Congratulations! Class is completed!

- Please complete the post-class survey on Quizizz.
- Turn-in Criminal History Form.
- Sigh-in for Class Credit!

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