Source Water Characteristics and Basic Water Chemistry

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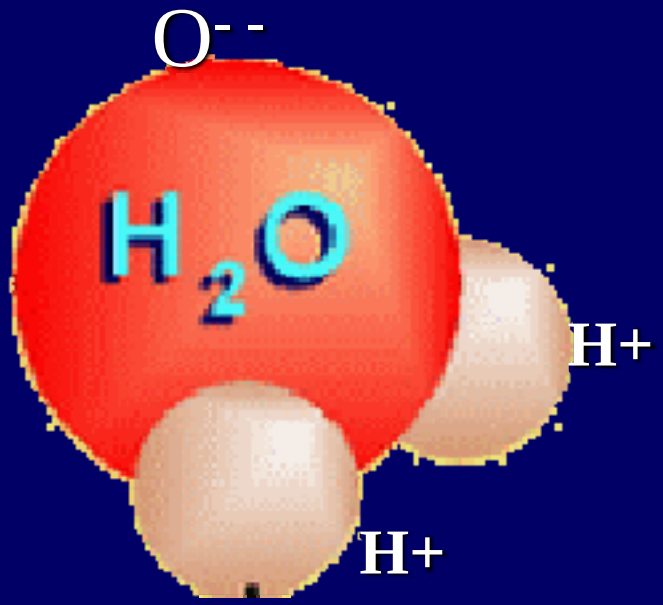
Water -
"The Universal Solvent"

- Solids
- Microorganisms
- Gases
- Chemicals
- Minerals



What is the main, most important reason for having a trained, certified water system operator?

PROTECT PUBLIC HEALTH

Maximum Contaminant Level (MCL)

The maximum permissible amount of a contaminant in water delivered to a user of a public water system.

CONTAMINANTS

- **PRIMARY STANDARDS**

  - Known acute or chronic health effects

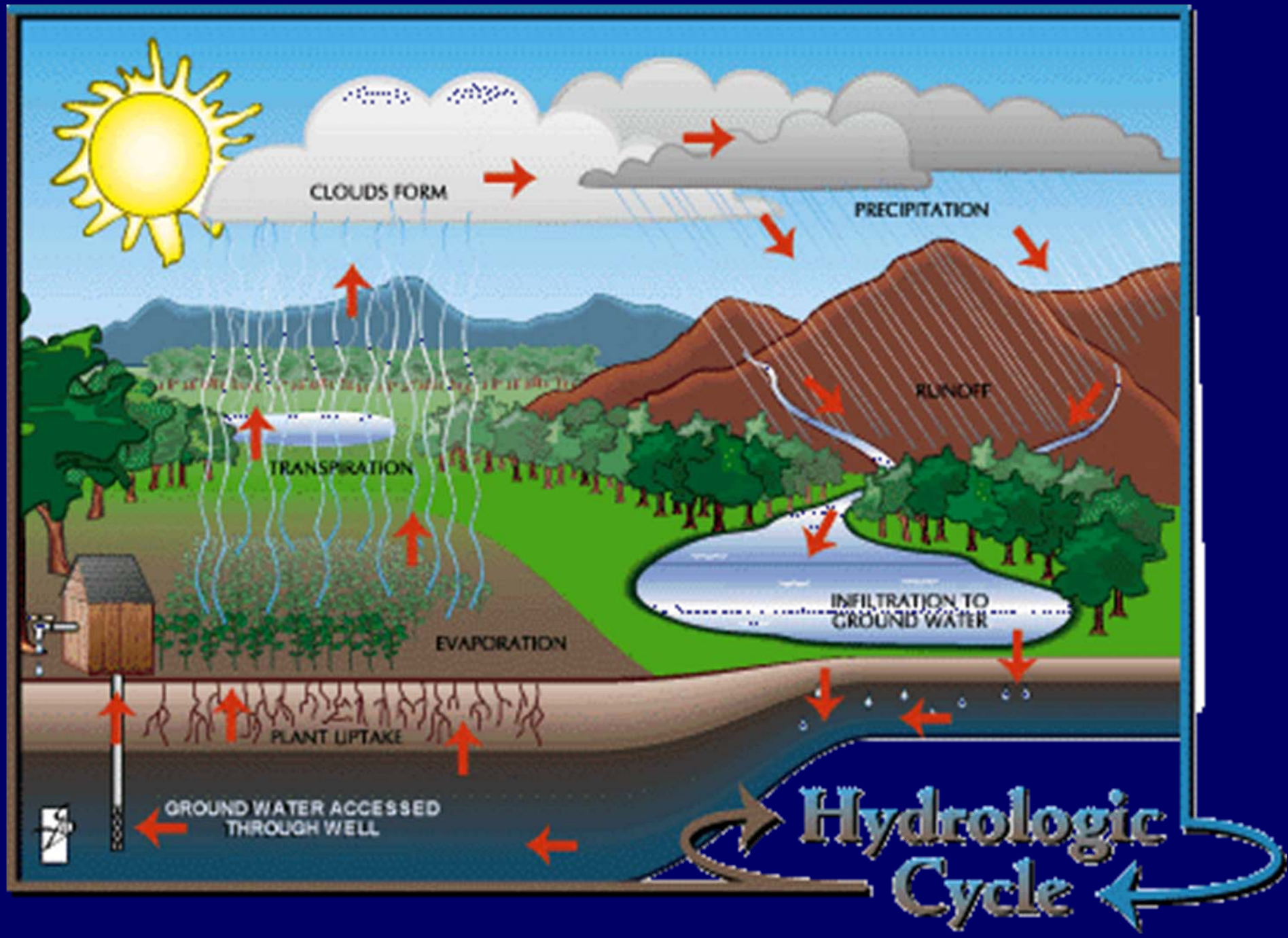
- **SECONDARY STANDARDS**
  - **Associated impacts that are not directly related to health, such as taste and staining.**

PRIMARY CONTAMINANTS

- Pathogens – bacteria, viruses, protozoa
- turbidity
- organics – DBPs, VOCs, SOCs
- metals, including lead & copper
- rads
- inorganics – cyanide, F, nitrate

SECONDARY CONTAMINANTS

- Iron, Manganese
- Hardness – calcium, magnesium
- Sulfate
- pH
- Aluminum
- Fluoride


CLOUDS FORM
PRECIPITATION
RUNOFF
TRANSPIRATION
INFILTRATION TO GROUND WATER
EVAPORATION
PLANT UPTAKE
GROUND WATER ACCESSED THROUGH WELL
Hydrologic Cycle

Source Water

Groundwater: Drilled wells, springs

Surface water: Lakes, rivers, streams

Groundwater under the direct influence of surface water (GUDISW): Shallow wells influenced by surface water

Is groundwater 'better' than surface water?

Common Groundwater Characteristics

- ✓ Iron
- ✓ Manganese
- ✓ Fluoride
- ✓ Calcium
- ✓ Sulfate
- ✓ Magnesium
- ✓ Arsenic
- ✓ Hydrogen sulfide
- ✓ Nitrate
- ✓ Radiological contaminants

Common Surface Water Characteristics

- ✓ Turbidity
- ✓ Biological
- ✓ Chemical
- ✓ Physical
- ✓ Living organisms
- ✓ Radiological contaminants
- ✓ Industrial/ commercial
- ✓ Sediment
- ✓ Decaying animal/ vegetation
- ✓ Hydrocarbons

Surface water changes depending on human activity, climatic changes and seasonal disturbances.

GUDISW

"Groundwater under the direct influence of surface water"

Shallow wells and springs which are recharged by surface water

GUDISW can contain the impurities that surface water contains, which also means more complex treatment methods.

Influenced by surface water?

- Is water quality same as for lake?
- Does turbidity increase/decrease with lake level?
- Does well level increase/decrease with lake level?
- Is Cryptosporidium or Giardia present?

Source Water Characteristics

Physical characteristics

Water characteristics that can be seen, smelled or tasted, generally the basis for customer complaints – turbidity, taste/odor, color, temperature.

Chemical characteristics

Can be organic, inorganic, radioactive; includes pH. Health effects can be acute or chronic. Includes chemicals that affect water's aesthetics.

Biological characteristics

Microorganisms that are living in the water.

Inorganic NPDWR Contaminants

- **These contaminants are mostly heavy metals (by RCRA definition), but also include other non carbon-based chemicals**
  - **15 contaminants**
  - **They may enter the water supply naturally through groundwater formations or from mining runoff and industrial discharges**

Inorganic Contaminant	**MCL (mg/L)**
Antimony	0.006
Arsenic	0.010
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium	0.1
Cyanide (as free Cyanide)	0.2
Mercury	0.002
Selenium	0.05
Thallium	0.002
Copper	***1.3* Action level***
Lead	***0.015* Action level***
Nitrate (as N)	**10 Acute Chemical Health Hazard**
Nitrite (as N)	1
Total Nitrate/Nitrite (as N)	10
Fluoride	***2.0 Secondary MCLG***
	4.0 Violation
Turbidity **Acute Physical MCL**	***0.3 NTU in 95% of samples***
Asbestos	***7,000,000 Fibers/L***

Turbidity

An ACUTE physical health hazard ----- WHY?

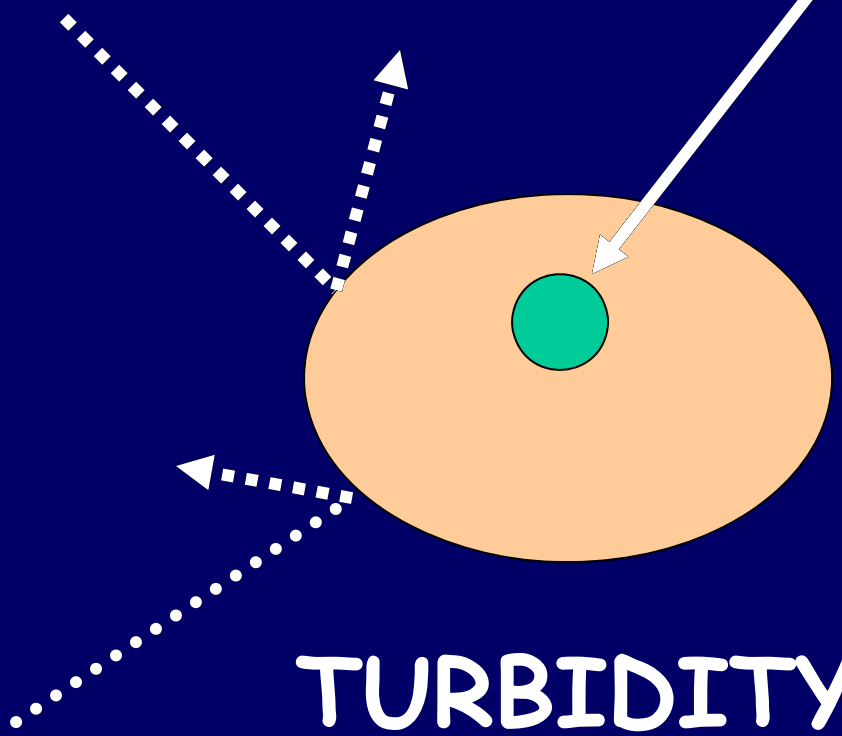
The cloudy appearance of water caused by the presence of suspended or colloidal matter

- **Suspended solids, colloidal in size**
- **The property of water that causes light to be scattered or absorbed**
  - **Problems**
    - **Taste**
    - **Odor**
    - **Hiding place for microorganisms**
    - **Interfere with disinfection**

The reading is in NEPHLOMETRIC TURBIDITY UNITS or NTUs

PATHOGEN

DISINFECTANT



CAN HARBOR PATHOGENS AND EXERT A HIGH DISINFECTANT DEMAND

TURBIDITY PARTICLE

Organic NPDWR Contaminants

- **There are 51 of these contaminants:**
  - **herbicides and insecticides that are primarily used in agriculture applications,**
  - **organic solvents used in industrial applications,**
  - **organic by-products of industrial processes, and**
  - **chemical by-products from chlorination of drinking water**

SOURCES OF CONTAMINATION INCLUDE:

- **Runoff from agricultural spraying**
- **Industrial discharges**
- **Accidental spills**
- **Improper disposal of hazardous wastes**

Organic Contaminants

Contaminant	MCL (mg/L)
Acrylamide	TT[1]
Alachor	0.002
Atrazine	0.003
Benzene	0.005
Benzo(a)pyrene	0.0002
Carbofuran	0.04
Carbon Tetrachloride	0.005
Chlordane	0.002
Chlorobenzene	0.1
2,4-D	0.07
Dalapon	0.2
DBCP	0.0002
o-Dichlorobenzene	0.6
p-Dichlorobenzene	0.075
1,2-Dichloroethane	0.005
1,1-Dichloroethylene	0.007
cis-1,2-Dichloroethylene	0.07
trans-1,2-Dichloroethylene	0.1
Dichlormethane	0.005
1,2-Dichloropropane	0.005
Di(2-ethylhexyl) adipate	0.4
Di(2-ethylhexyl) phthalate	0.006
Dinoseb	0.007
Dioxin	0.00000003
Diquat	0.02
Endothall	0.1
Endrin	0.002
Epichlorohydrin	TT[1]
Ethylbenzene	0.7
Ethylene dibromide	0.00005

Contaminant	MCL (mg/L)
Lindane	0.0002
Methoxychlor	0.04
Oxamyl (Vydate)	0.2
Polychlorinated byphenyls (PCBs)	0.0005
Pentechlorophenol	0.001
Picloram	0.5
Simazine	0.004
Styrene	0.1
Tetrachloroethylene	0.005
Toluene	1
Toxaphene 0.003	
Trichloroethylene	0.005
2,4,5-TP (Silvex)	0.05
1,2,4-Trichlorobenzene	0.07
1,1,1-Trichloroethane	0.2
1,1,2-Trichloroethane	0.005
Vinyl chloride	0.002
Xylenes (total)	10

[1] – TT refers to approved Treatment Technology rather than MCL

Radiological NPDWR Contaminants

- Most radioactive substances occur naturally in ground water and in some surface supplies

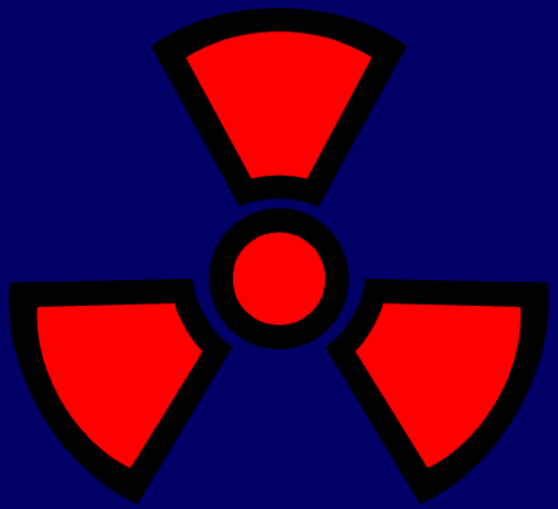
- Some man-made substances may also enter drinking water supplies from processing facilities, mining areas, and nuclear power plants

Radioactive Contaminants

The 4 contaminants include:

Contaminant	MCL
Radium 226 and 228	5 pCi/L
Gross Alpha Activity	15 pCi/L
Gross Beta Activity (man-made)	4 millirem/yr, or 50 pCi/L
Uranium	30 μg/L (ppb)

RADIOLOGICAL CONTAMINANTS

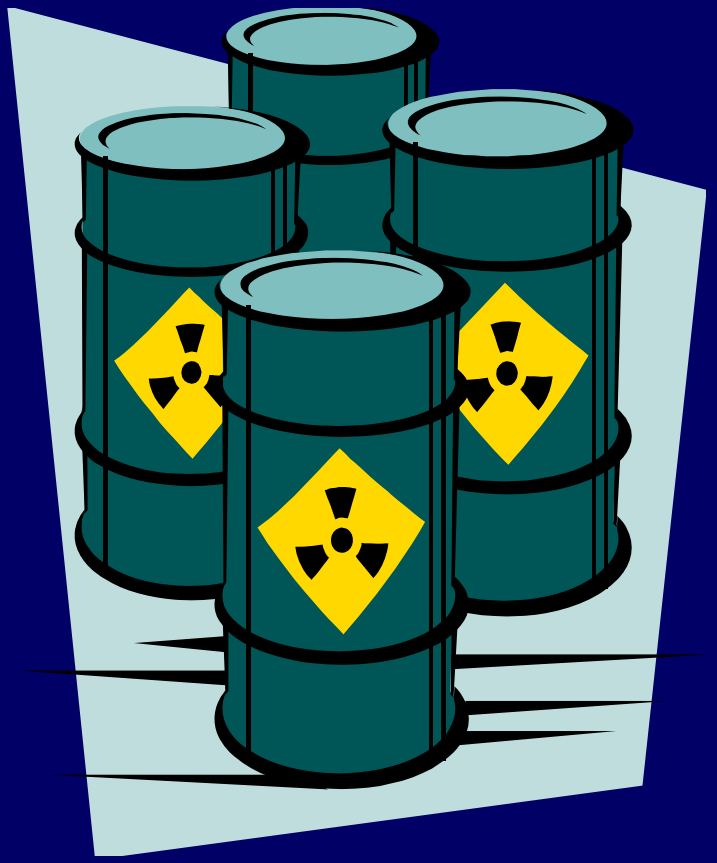


ALL ARE CARCINOGENS or MUTAGENS

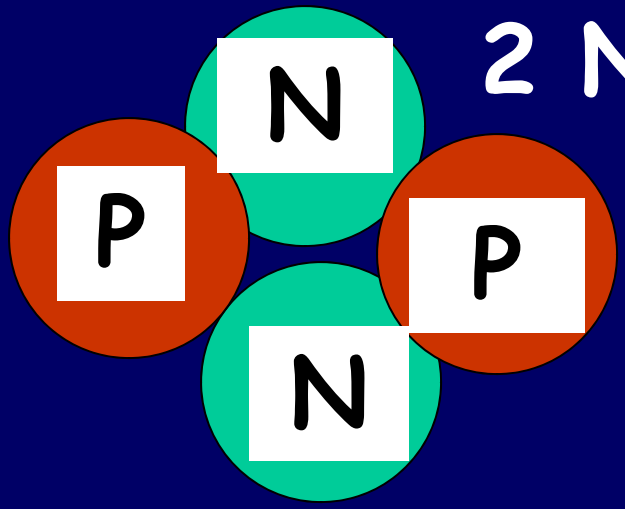
MOST MEASURED AS pCi/L (picocuries per liter)

ALPHA & BETA EMITTERS

COME FROM MINING & NUCLEAR WASTES



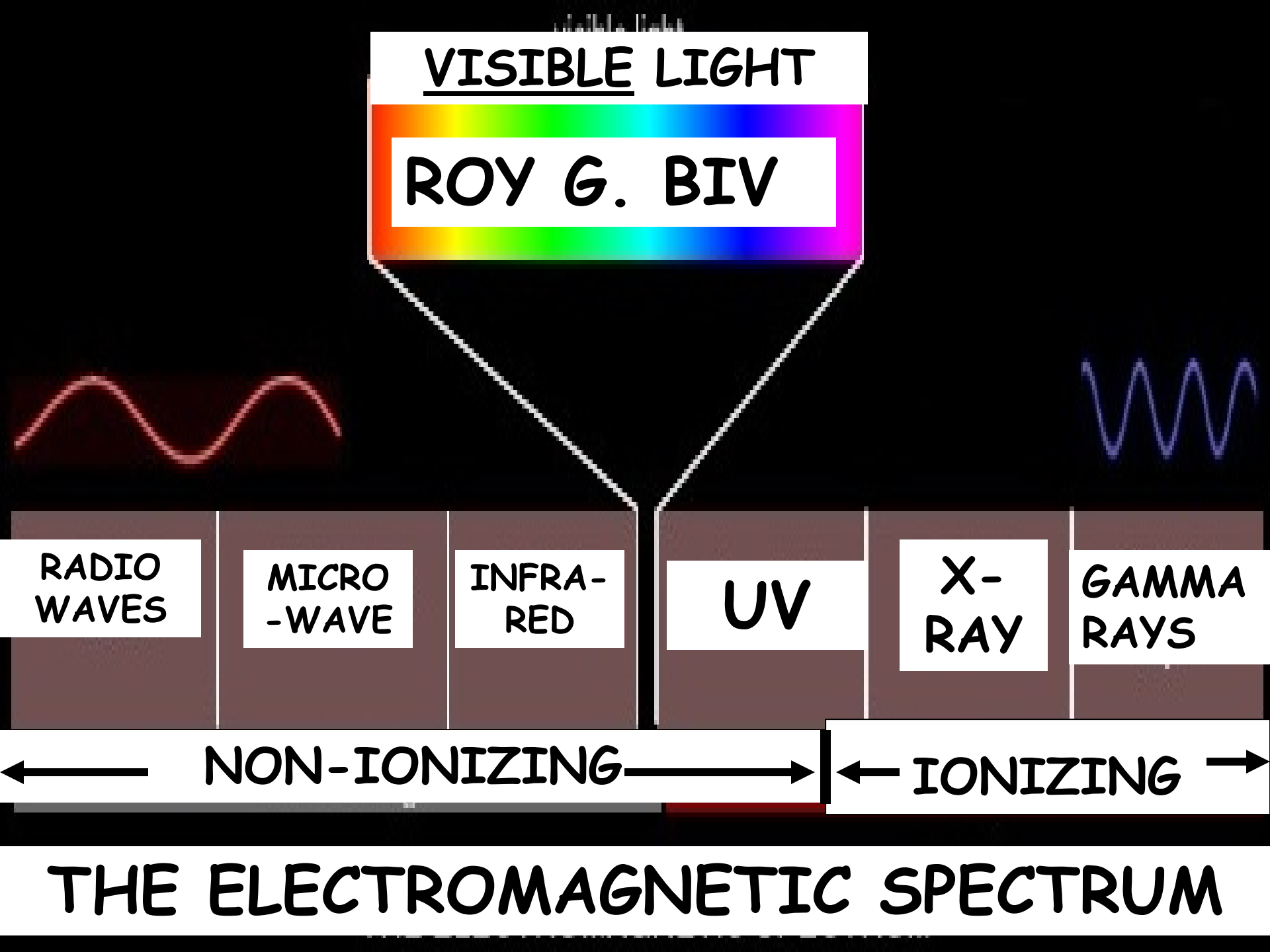
HELIUM NEUCLUS: 2 PROTONS + 2 NEUTRONS



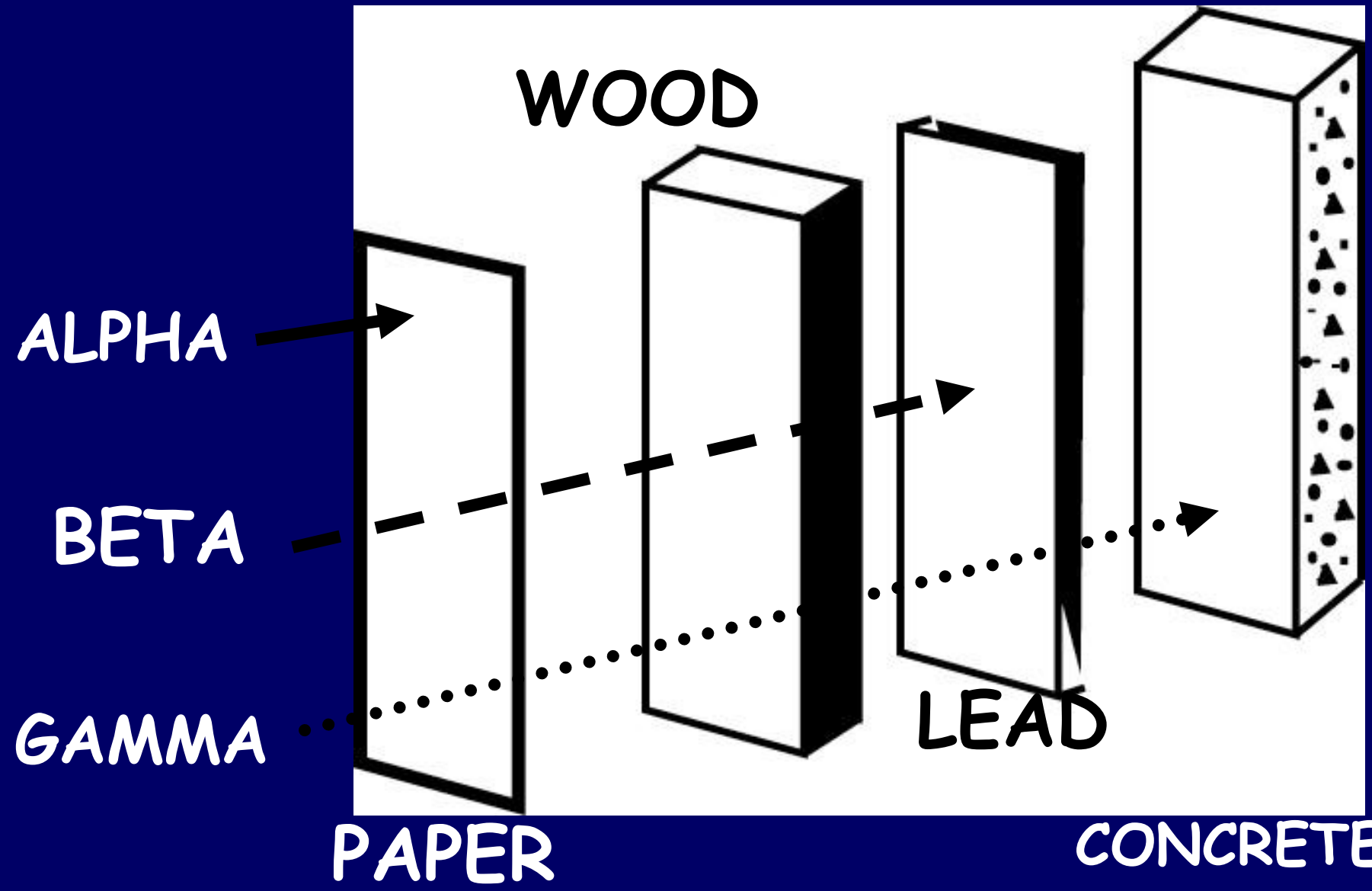
ALPHA PARTICLE

BETA PARTICLE: a high speed electron

GAMMA RAY



THE ELECTROMAGNETIC SPECTRUM



RELATIVE PENETRATING POWER

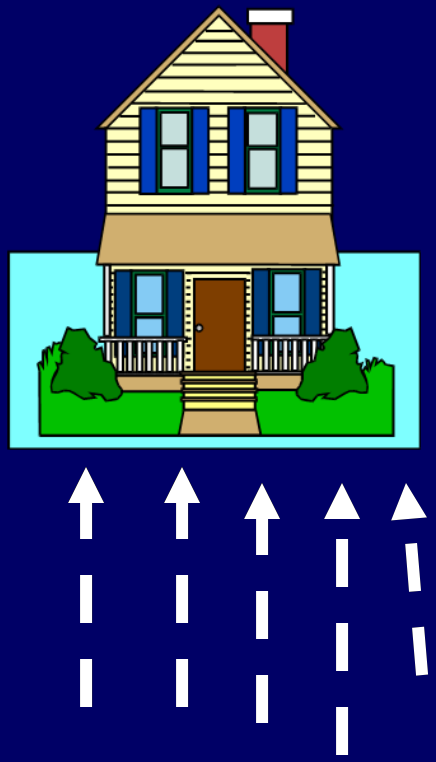
RADIOACTIVE MATERIAL IS CONSTANTLY DISINTEGRATING

RADIOLOGICAL MEASUREMENTS ARE MADE BY INSTRUMENTS THAT COUNT DISINTEGRATIONS

1 pCi/L = 2.2 disintegrations/min

ANOTHER RADIOLOGICAL CONCERN IS RADON

RADON GAS ENTERS HOMES FROM SOIL



HOUSEHOLD RADON CAN BE A PROBLEM IN PARTS OF NEW MEXICO AND COLORADO

RADON

URANIUM → RADIUM

Biological Characteristics of Water

Disease-causing organisms are called Pathogens. Water-borne pathogens include:

- Bacteria
- Protozoa
- Viruses

Biological Characteristics of Water

Bacteria:

Single celled organisms Range in size from 0.5 – 2 microns wide and 1-10 microns long

(micron = metric unit of measurement equal to 1 thousandth of a millimeter)

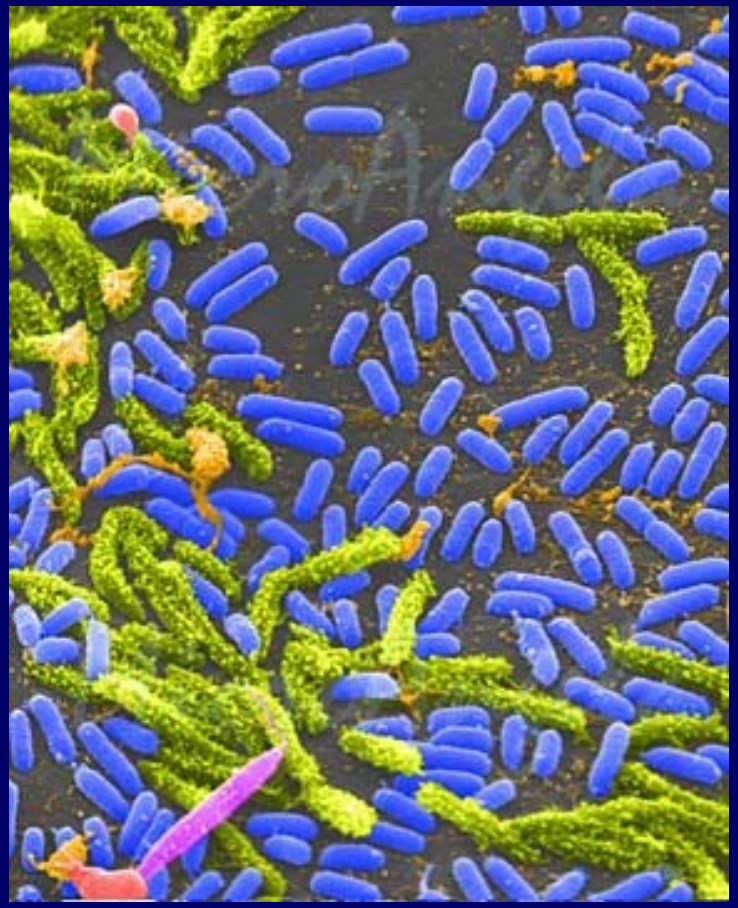
It would take one thousand bacteria lying side by side to reach across the head of a straight pin

Bacteria are the most common microorganism in water.

Diseases caused by Bacteria

- Typhoid fever
- Cholera

- 0.5 – 2 microns in diameter
- 1 – 10 microns long
- 1000 bacteria side to side across head of pin



Biological Characteristics of Water

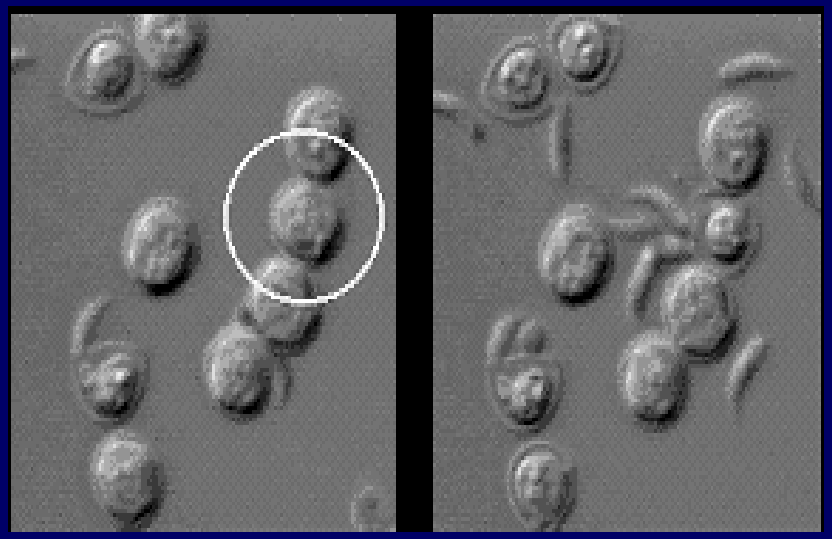
Diseases caused by Bacteria

- Typhoid Fever
- Gastroenteritis
- Cholera
- Tetanus
- Botulism

Biological Characteristics of Water

Protozoa:

- Size
  - Giants of the microbial world
  - One celled animal-like organism
  - From 10μ to 20 , to 400 to 500 μ
  - Grouped by locomotion system



Cryptosporidium

Protozoa go through a life cycle, in which one phase they are in the resting or cyst phase, which makes them hard to kill with Chlorine.

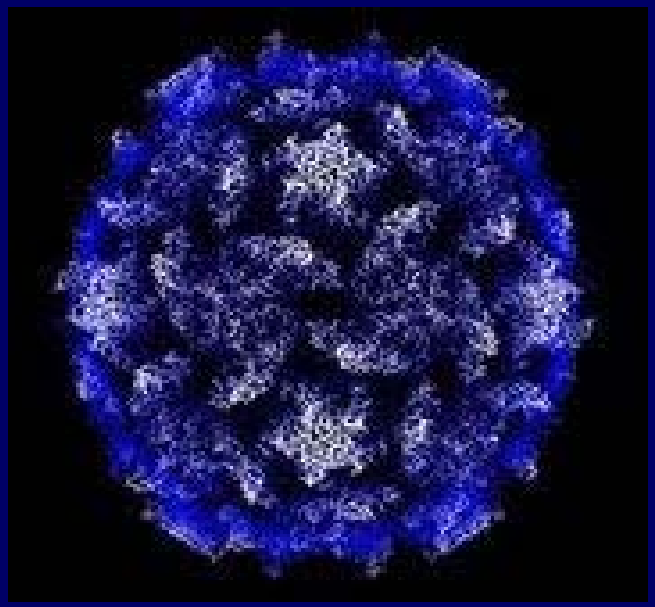
Biological Characteristics of Water

Diseases Caused by Protozoa:

- Giardia
- Cryptosporidium
- Amoebic Dysentery

Biological Characteristics of Water

Viruses:



Polio virus

- Size – 0.02 to 0.25 microns in diameter
  - Midgets of the microbial world
- Difficult to destroy by normal disinfection practices
- Need a Host

Biological Characteristics of Water

Diseases caused by Viruses

- Viral Gastroenteritis
- Small Pox
- Poliomyelitis
- Infectious Hepatitis
- SARS

Indicator Organisms

Coliform Bacteria

Hearty organism that provides the first “clue” of possible presence of pathogens in water supply

Fecal Coliform

Originates from the intestinal tracts of warm-blooded animals

Indicates presence of contamination from fecal matter

National Secondary Drinking Water Regulations 40 CFR 143

Secondary Maximum Contaminant Level Goals (SMCLGs) - examples:

Secondary Contaminants	SMCLG (mg/L)
Total Dissolved Solids	500
Chloride	250
Sulfate	250
Iron	0.3
Manganese	0.05
pH	6.5-8.5

Monitoring

- *Not Enforceable*
- *Goals or Guidelines for the States*

Taste and Odor

- Can be caused by area geology (gases such as hydrogen sulfide), algae (earthy/musty), Fe/Mn (rusty)

- Difficult to quantify
  - usually determined by a panel
  - subjective testing

- Generate many of your customer's complaints

- Odor reported as TON – Threshold Odor Number

- Is it the garbage disposal?

Color

- True Color = dissolved or suspended organic material caused by once living plants or animals
- Apparent Color = suspended colloidal oxidized Fe and Mn
- aesthetically displeasing
- can react with disinfectants to form DBPs
- determined by comparing water to color standards and reported as color units

Color Removal

- reduce pH to between 3.5 and 5.5 (before other processes that require higher pH)
- causes color compounds to settle out as gelatin-like (slimy) solid
- oxidation with Cl, O_3, $KMnO_4$

pH – Power of Hydrogen

- **pH is the measurement of the hydrogen ion, H+ or acid concentration of a fluid.**
- **Water is considered to be acidic when it has more hydrogen ions (H+) than hydroxide ions (OH-)**
  - **Water is considered to be basic when there are more hydroxide ions (OH-) than hydrogen (H+)**
- **Chemicals that add hydrogen ions (H+) are:**

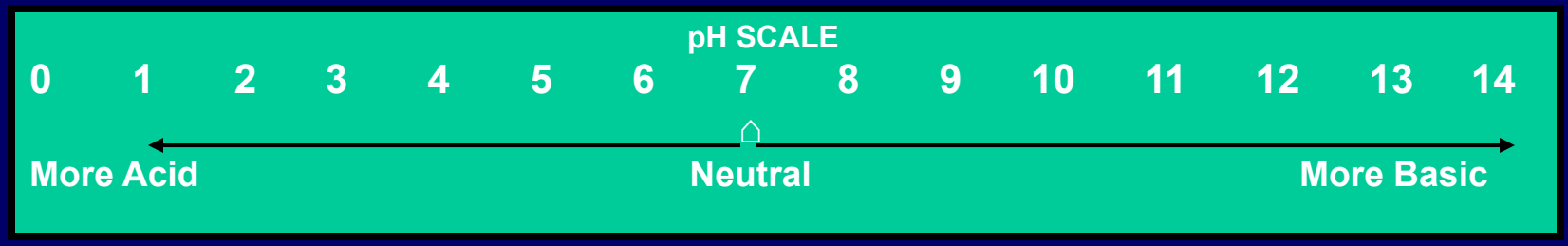
  hydrochloric acid, (HCl), sulfuric acid, (H_2SO_4), nitric acid, (HNO_3), and carbonic acid, ($H_2 CO_3$)

- **Chemicals that add hydroxide ions (OH-) are:**

  sodium hydroxide, (NaOH), calcium hydroxide, ($Ca(OH)_2$), and magnesium hydroxide, ($Mg(OH)_2$)

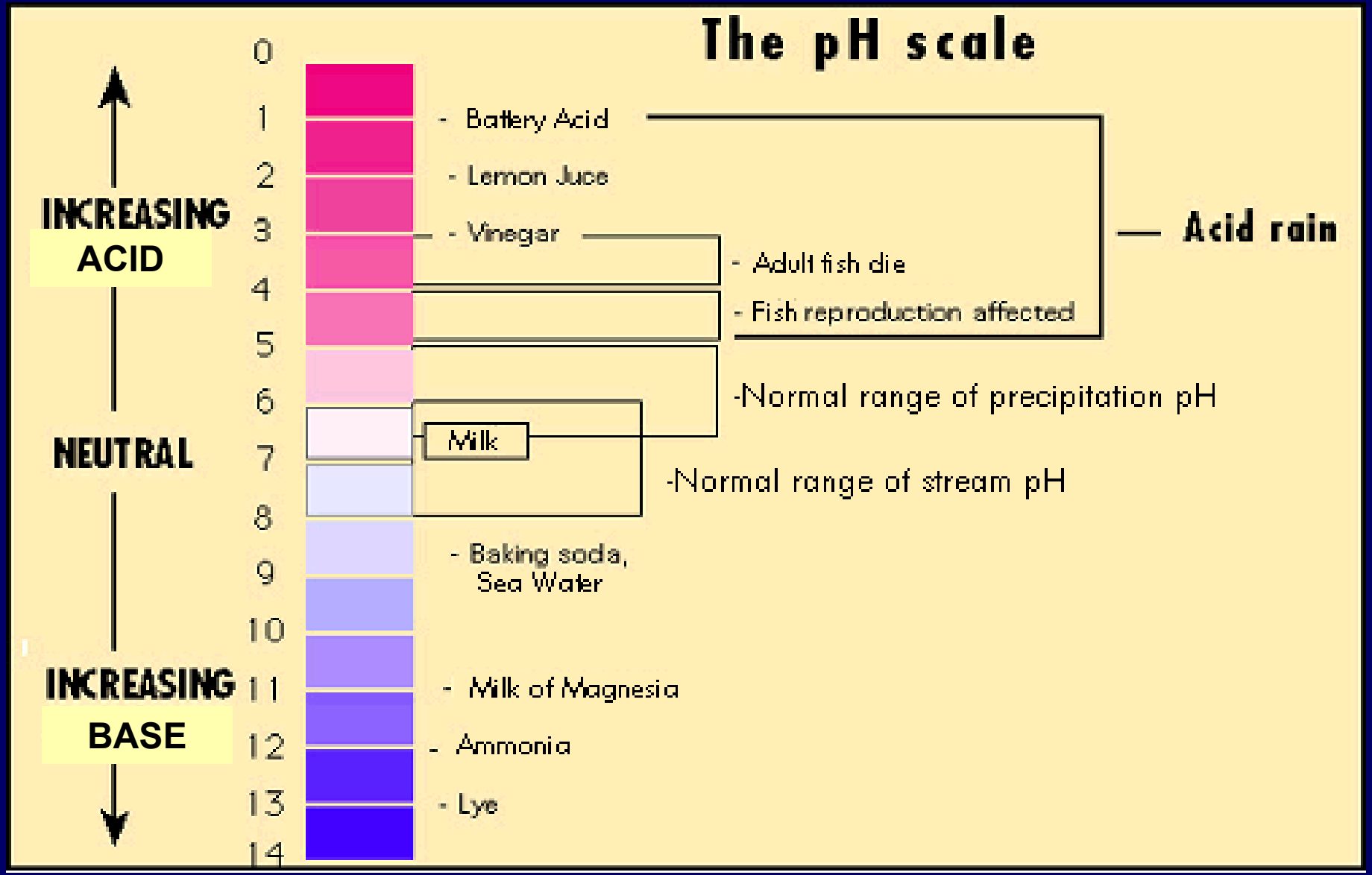
pH – Power of Hydrogen

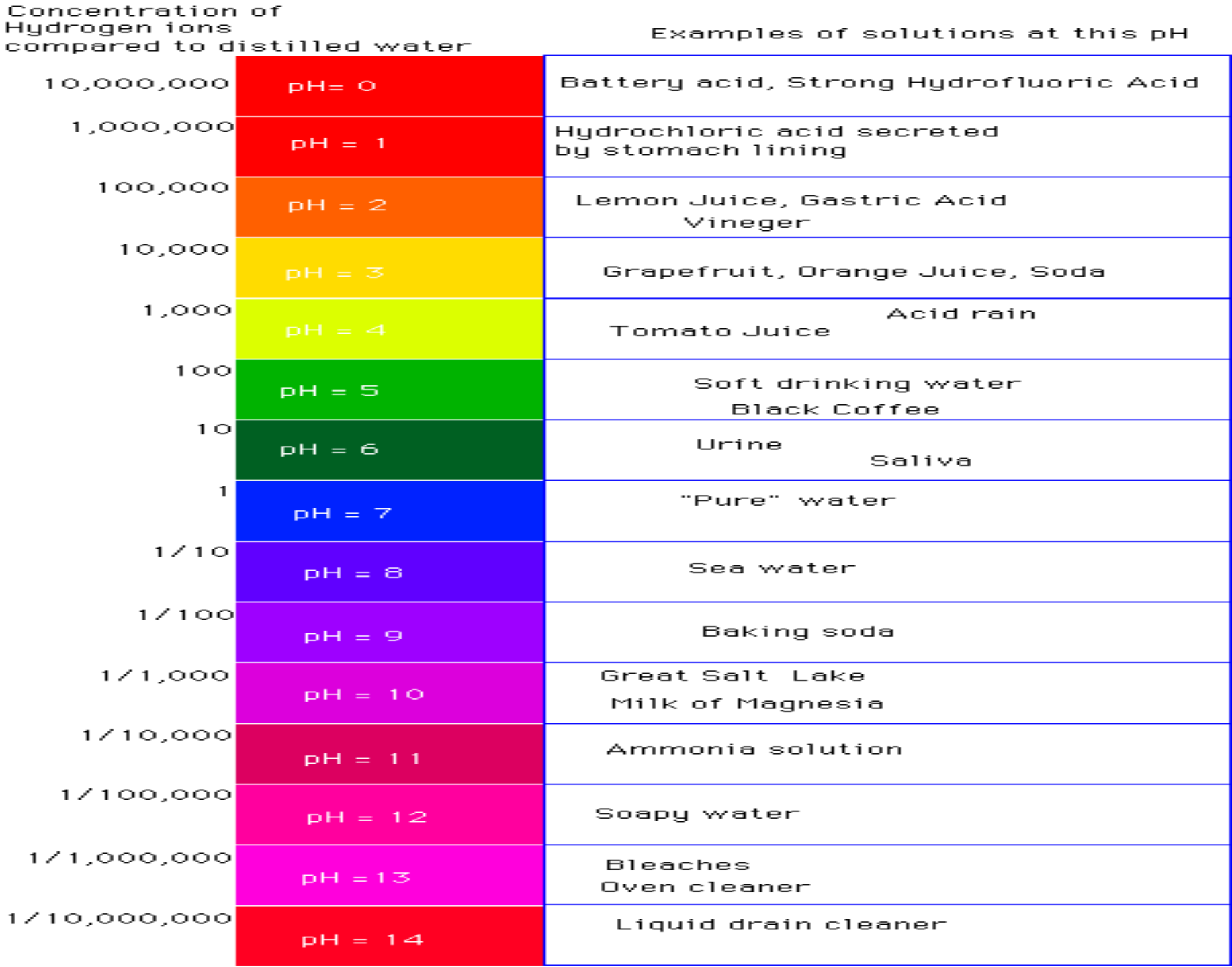
The pH of water is measured on a scale that reads from 0 to 14, where 7 is neutral



- For every whole number that the pH changes the strength of the acid or base properties of the fluid will change by a factor of ten
  - pH of 9 to a pH of 10 becomes 10 times more basic
  - pH of 5 is 10 times more acid than water at a pH of 6

pH – power of Hydrogen




Concentration of Hydrogen ions compared to distilled water
Examples of solutions at this pH
10,000,000
pH= 0
Battery acid, Strong Hydrofluoric Acid
1,000,000
pH = 1
Hydrochloric acid secreted by stomach lining
100,000
pH = 2
Lemon Juice, Gastric Acid
Vineger
10,000
pH = 3
Grapefruit, Orange Juice, Soda
1,000
pH = 4
Acid rain
Tomato Juice
100
pH = 5
Soft drinking water
Black Coffee
10
pH = 6
Urine
Saliva
1
pH = 7
"Pure" water
1/10
pH = 8
Sea water
1/100
pH = 9
Baking soda
1/1,000
pH = 10
Great Salt Lake
Milk of Magnesia
1/10,000
pH = 11
Ammonia solution
1/100,000
pH = 12
Soapy water
1/1,000,000
pH =13
Bleaches
Oven cleaner
1/10,000,000
pH = 14
Liquid drain cleaner

Hardness

- Calcium
- Magnesium

Hard water:

Water that requires lots of soap to get any suds.

Soft water:

Water that reacts with soap to produce a slimy residue.

Soft water = 0 – 75 mg/l
Moderate = 75 –150 mg/l
Hard = 150 – 300 mg/l
Very hard = Over 300 mg/l

What are the major problems associated with hard water?

Calcium carbonate build up in pipes and plumbing fixtures

What is the major problem with soft water?

With no hardness pipes have no coating leaving them at risk for Corrosion.

Corrositivity:

Tendency of water to dissolve metal.

Corrosive water can bring metals into solution such as lead and copper.

Corrosive water is based on:

- ✓ pH
- ✓ Hardness
- ✓ Alkalinity
- ✓ Temperature
- ✓ Total dissolved solids

Iron and manganese

Iron:

Reddish brown color, can stain clothes and plumbing fixtures.

Manganese:

Brownish, blackish color, also stains clothes and plumbing fixtures.

Iron and manganese are considered nuisance constituents in water. They can also cause some taste and odor problems.

Iron and Manganese Removal Methods

- ✓ Aeration
- ✓ Ion exchange
- ✓ Sequestering agents – polyphosphates such as sodium hexametaphosphate (Calgon)
- ✓ Potassium permanganate/greensand
- ✓ Cartridge filters
- ✓ Addition of chlorine followed by cartridge filtration

Dissolved gases found in water may include:

- ✓ Oxygen = bubbles in the water
- ✓ Carbon dioxide
- ✓ Methane gas = Tastes like garlic, explosive
- ✓ Hydrogen sulfide = Smells like rotten eggs
- ✓ Radon = Suspected carcinogen

What are some pollutants and contaminates you may find in your Surface water source?

- Wastewater treatment effluent
- Animal wastes
- Industrial discharges
- Recreational contaminates (boats, wave runners)
- Surface water runoff flowing into the water source can pick up many types of contaminates.

Surface water requires more complex treatment processes to make it safe for public consumption.

Drinking Water Protection Program (DWPP)

Source Water Assessments

A report or study that identifies those factors that can affect the source water quality and how to mitigate them.

Groundwater Protection

Establishes min separation distances between drinking water sources and potential sources of contamination.

Wellhead Protection

Program designed to prevent contamination in and around the area of the well.

What are some protective measures that can be taken for surface water?

- Educate people

- Try to keep potential contaminants out of the surface water.
  - Fence off
  - Zoning laws