

Water Basics

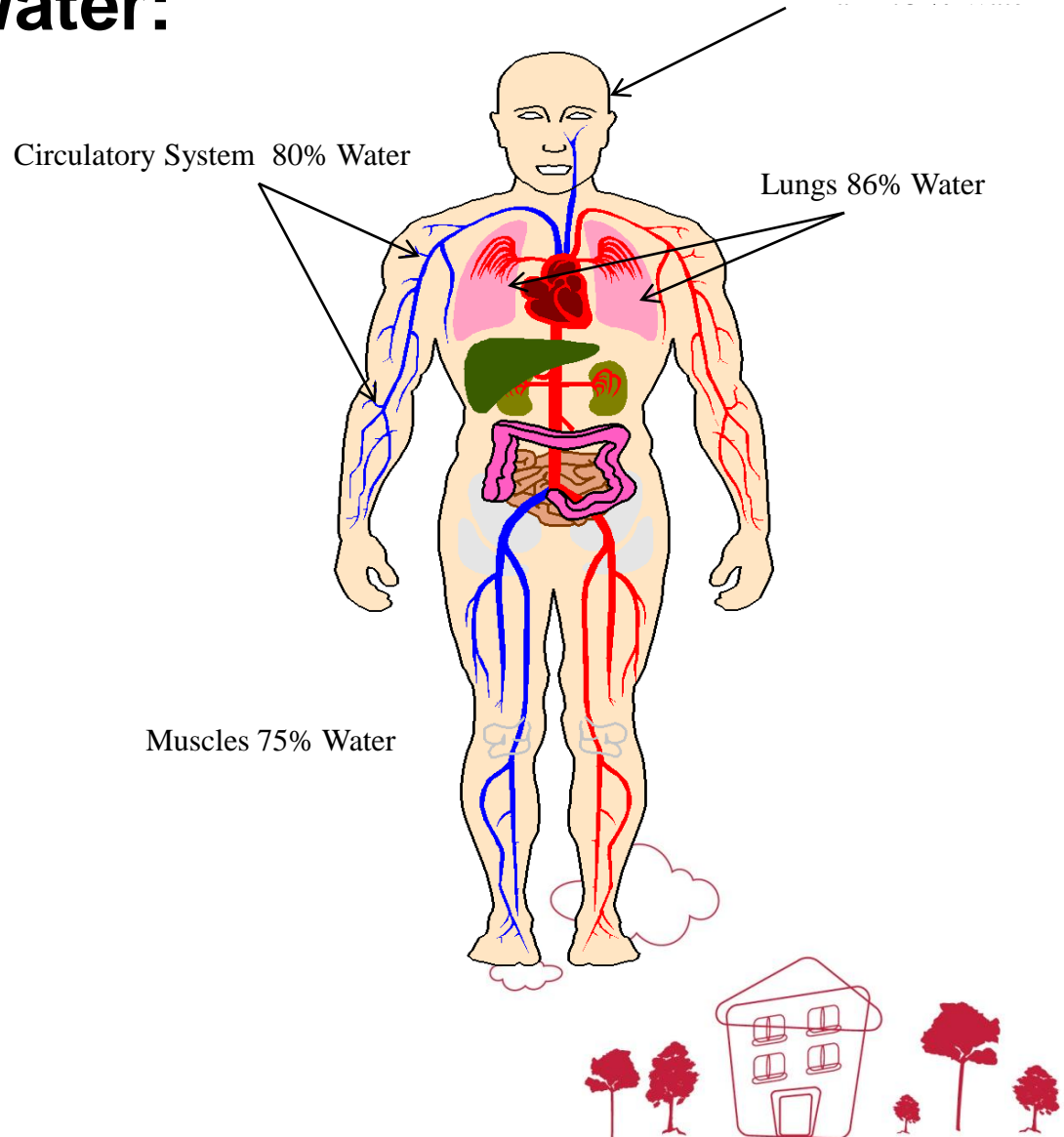
- Importance of water: The Human Body
- Basic Water Chemistry: Measurable Properties
- Fundamentals of Water Technology: Hydrologic Cycle
- Nature of Water: Environmental Factors
- Contamination: Origin & Potential Problems



Water Basics

The Importance of Water:

- Human body is made up of approximately 70% water; therefore water is vital to all systems
- 'Clean' water is essential for the human body
- Contaminants present in water can bio-accumulate in the body causing health issues – i.e. carcinogens like THM's can bio-accumulate possibly causing cancer in the future

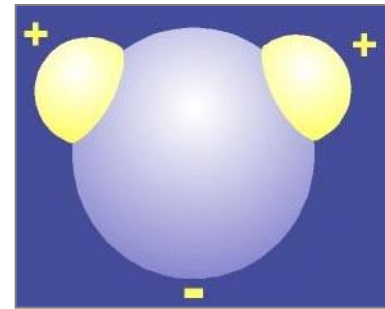


Water Basics

Water Chemistry

- Water is an extremely stable compound composed of Hydrogen & Oxygen atoms
- It is referred to as the universal solvent as it dissolves more substances than any other liquid
- Water is unique as it is only natural substance that is found in three states – liquid, solid, gas
- Water is very rarely in pure 'distilled' form
- Water will always contain salts, nutrients & particulates depending on local conditions

Water Molecule:
2 Hydrogen atoms
1 Oxygen atom



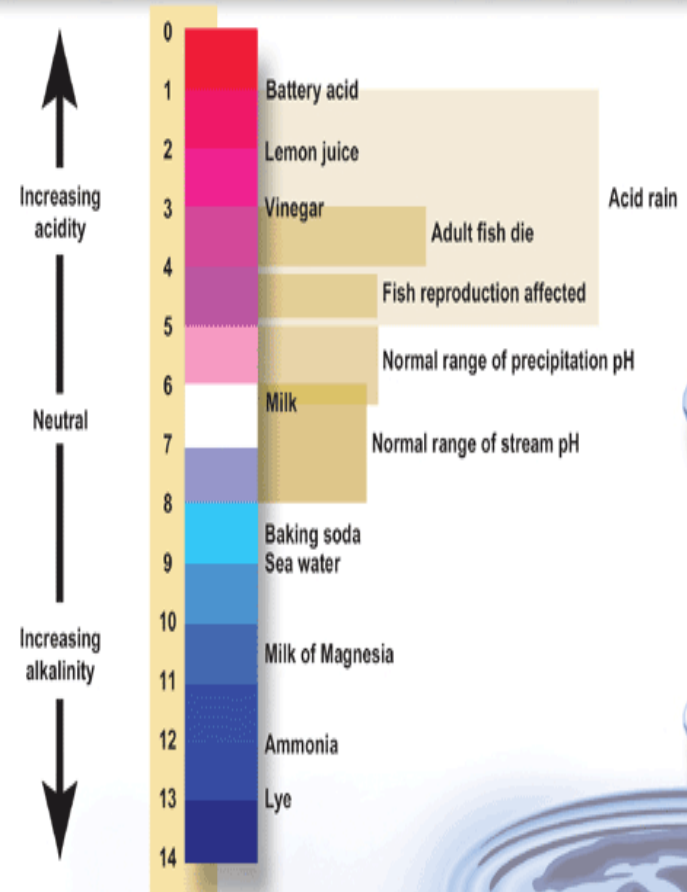
Water Basics

Measurable Properties of Water: pH

pH: refers to water being acidic, basic or neutral; pH is affected by chemicals therefore is a good indication that water may be changing chemically

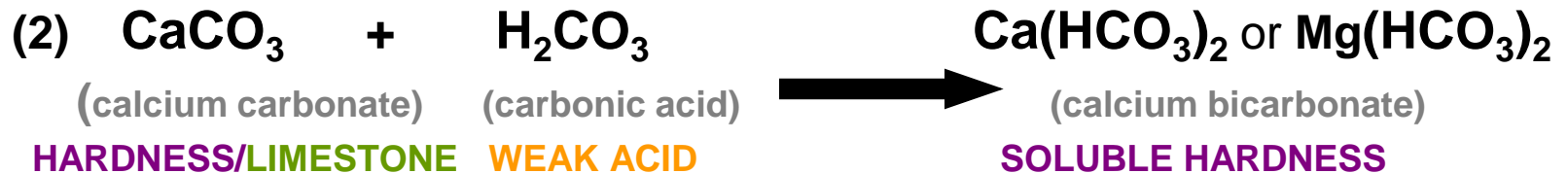
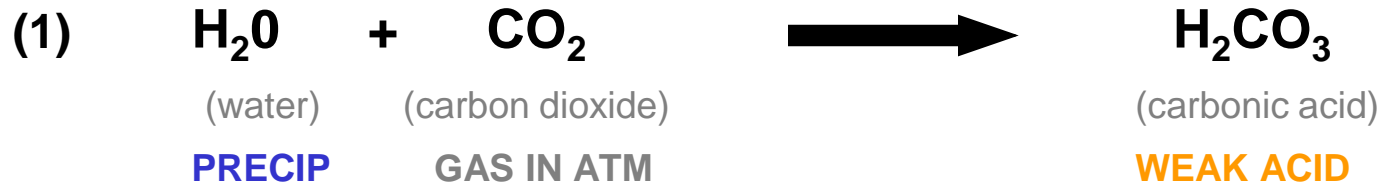
- pH stands for the potential of hydrogen
- The neutral point of 7 indicates the presence of equal concentrations of free hydrogen & hydroxide ions
- Each decrease in pH by one pH unit means a tenfold increase in concentration of hydrogen ions – therefore more acidic

The pH scale



Water Basics

Measurable Properties of Water: Hardness



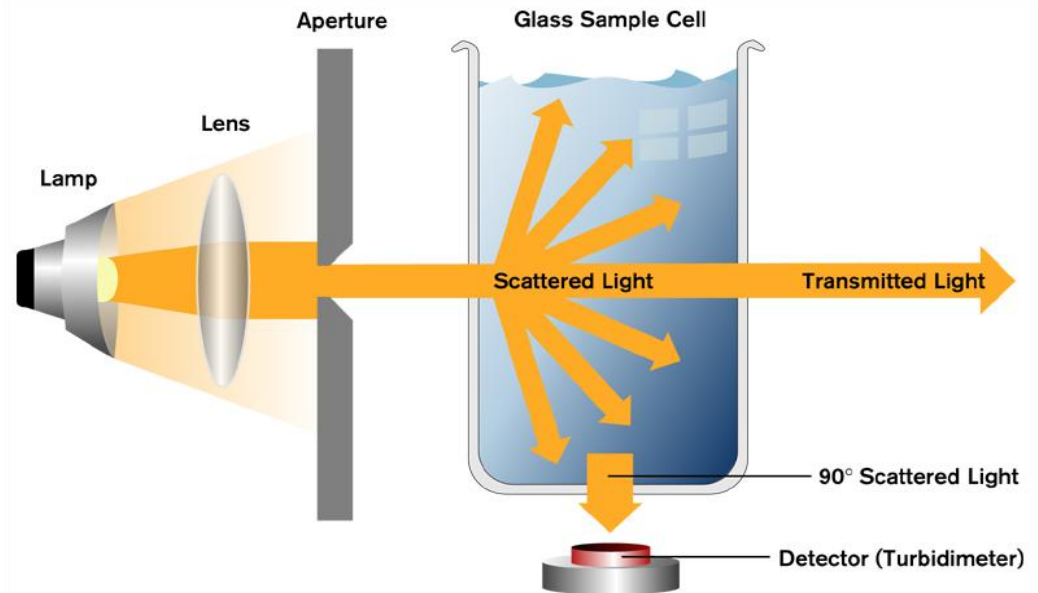
- As moisture falls through atmosphere, it absorbs amounts of CO_2
- When CO_2 dissolves in water, some of it forms a weak acid called carbonic acid
- This carbonic acid then comes into contact with limestone (carbonate) on the earth's surface, dissolving it thereby producing calcium & magnesium bicarbonates
- Bicarbonates are known as 'Temporary Hardness'
- These bicarbonates are highly soluble; when heated bicarbonates will release CO_2 & revert back to carbonates or an 'insoluble state' = HARDNESS



Water Basics

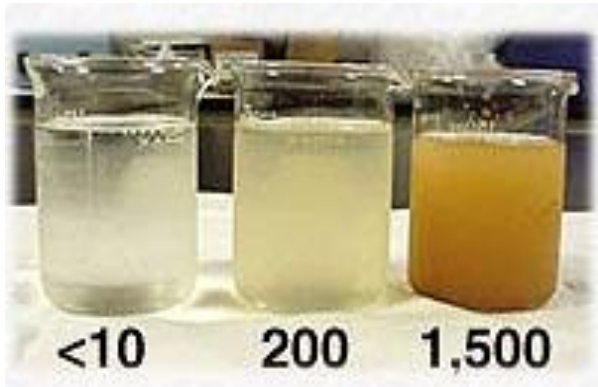
Measurable Properties of Water: Turbidity

- Turbidity is amount of small particles of solid matter suspended in water
- Turbidity is measured with a Turbidimeter
- Turbidimeter reads sample by amount of scattering & absorption of light rays caused by particles present in sample
- Turbidity blocks light rays and can make a water sample appear cloudy
- Turbidity CANNOT be directly equated to suspended solids (TSS) as white particles will reflect more light than dark colored particles & many small particles will reflect more light than an equivalent large particle
- Turbidity CANNOT be directly equated to UVT levels



Water Basics

Measurable Properties of Water: Turbidity



- Turbidity can make water either cloudy or opaque depending on what makes up turbidity
- Turbidity is measured in NTU's (Nephelometric turbidity units)
- the higher the NTU value, the higher the intensity of scattered light

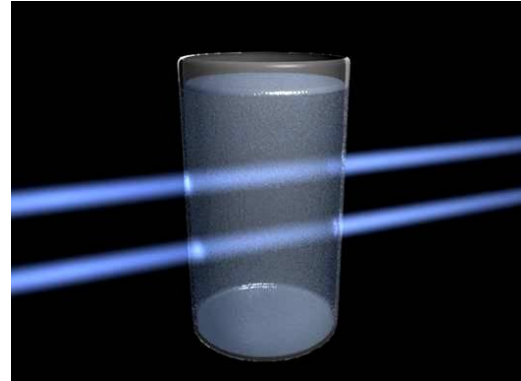
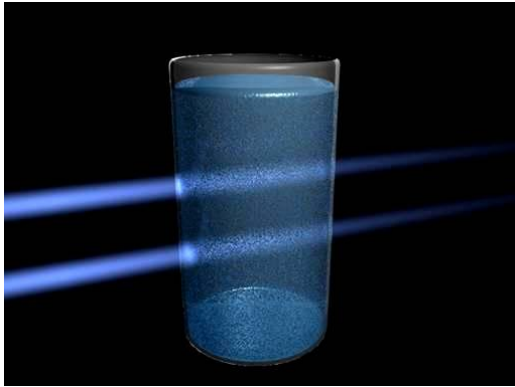


- Turbidity is measured with a turbidimeter
- Turbidimeter is calibrated using vials of solution which contain different NTU levels



Water Basics

Measurable Properties of Water: UV Transmittance (UVT)



Less UV light getting through the water



- UVT is a measure of how well water is able to transmit UV light
- If the UV light cannot penetrate the water then it cannot penetrate the microorganisms present in the water
- As the UVT drops UV dose also drops dramatically
- UVT (%) is the most important water quality property to be considered when looking at UV as a piece of water treatment equipment
- Keep in mind that low UVT levels are not always detectable with the naked eye
- Tannins are visual in water but there are many other organics that can drop the UVT with no colour at all

Low UVT = Low Dose

High UVT = High Dose



Water Basics

Measurable Properties of Water: Iron (Fe)

- One of earth's most plentiful resources (5% of earth's crust)
- Rainfall seeping through soil dissolves iron in crust & carries it into almost every kind of water supply, mostly well water
- Iron is seldom found at concentrations greater than 10 ppm
- Iron is not hazardous to human health, it is considered a secondary aesthetic contaminant
- At levels of 0.3 ppm staining of household fixtures can occur
- Iron can be present in water in either a clear soluble (ferrous iron or clear water iron) or insoluble (ferric iron) state; is often associated with iron bacteria problems
- When considering iron removal (i.e. with a softener) ensure that the outdoor taps are being treated....what could happen you ask?



Iron staining in toilet



Water Basics

Measurable Properties of Water: Manganese (Mn)

- This element is usually found in groundwater
- Usually present in combination with iron (but in lower concentrations)
- At levels of 0.05 ppm Mn can cause staining of a black-yellow color
- Both Fe & Mn can be present in well water & water can appear clear when first drawn
- Upon exposure to air both soluble Fe & Mn will quickly become oxidized changing to their insoluble state (a precipitate)



Water Basics

Measurable Properties of Water: Tannins

- Tannins are water soluble, organic phenolic compounds formed in the decomposition of vegetation
- Tannins occur in water or in almost any location where large quantities of vegetation have decayed
- Cannot simply be filtered out of water as tannins consist of microscopic, unseparable, colloidal particles that carry a negative charge
- Due to the materials that have decayed, tannins create a yellowish color in water
- This may not be visible in a glass of water, however a tubful of water will appear slightly yellow (or Styrofoam cup)
- Above a pH of 6 tannins must be removed by anion exchange; below 5 they may be removed by activated carbon depending on tannin concentration

Clean & tannin water comparison



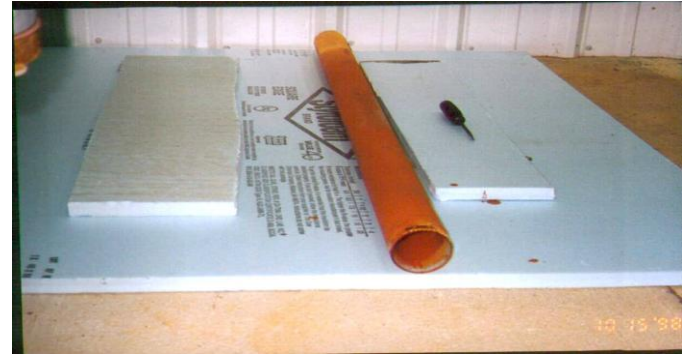
Tubful of tannin water



Water Basics

What can these parameters do to a UV system?

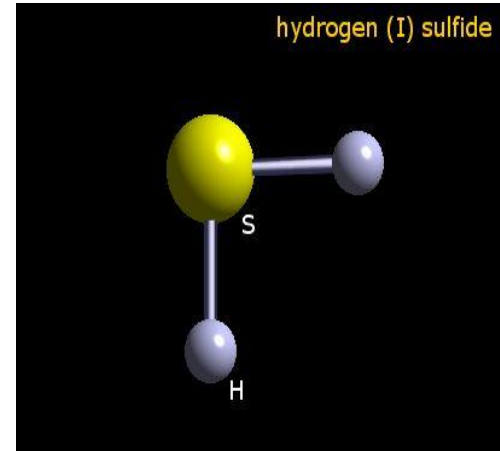
- Hardness, iron, manganese & tannins can all inhibit UV light from penetrating microorganisms in water
- This is done either by absorption or scaling
- If the sleeve is coated then UV light is trapped & cannot reach the water
- A non-monitored system needs to have water that is pre-treated or is of a known quality



Water Basics

Measurable Properties of Water: Hydrogen Sulphide (H₂S)

- H₂S is a corrosive, flammable & toxic gas often found dissolved in well water, accompanied by iron & low pH
- Develops from decaying organic matter or sulphate-reducing bacteria (SRB)
- SRB produces enzymes which accelerates reduction of sulphur compounds thereby producing H₂S
- Produces rotten egg smell, can corrode piping & turn water black
- In some cases H₂S may only be present in household hot water
- This condition is caused by a biochemical reaction between sulphates in water, sulphate reducing bacteria or organic matter



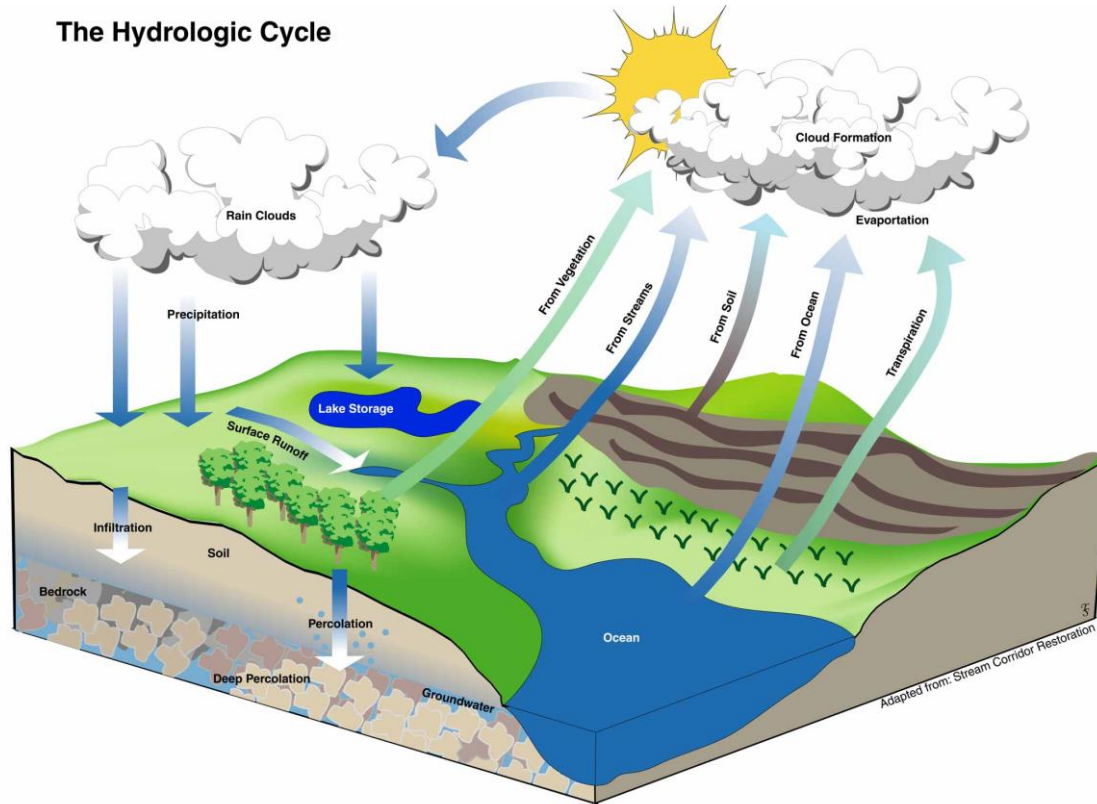
Structure model of Hydrogen Sulfide



Water Basics

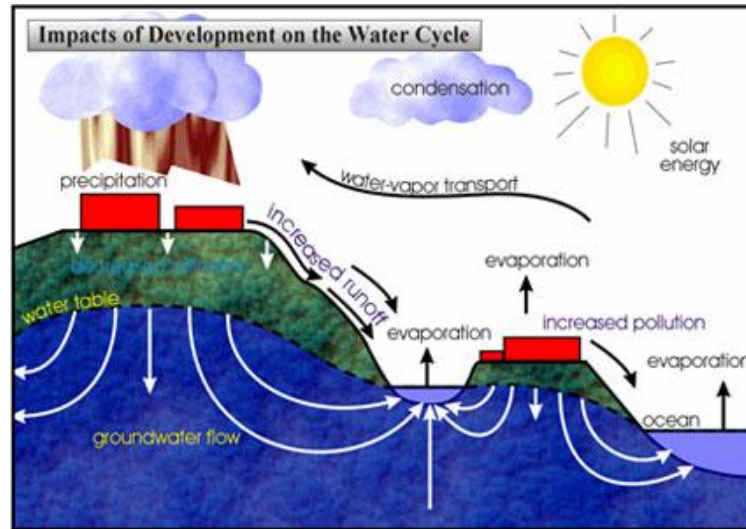
Fundamentals of Water Technology:

The Hydrologic Cycle



Water Basics

The Nature of Water – Environmental Factors



Water is a product of the environment, absorbing & dissolving a part of everything it touches in both air & water



Water Basics

The Nature of Water – Environmental Factors

AIR: As water falls to earth the rain serves to cleanse air
Rain will absorb solid matter, gases, odors & other impurities that pollute air
Carbon dioxide gases in atmosphere can penetrate precipitation as it falls, causing rainfall to become slightly acidic (carbonic acid)
Rainwater can also encounter sulfuric acid & some types of bacteria

SURFACE: Surface properties have a great impact on water reaching earth
As water percolates into ground it loses some of its impurities it absorbed from air BUT while the soil filters out impurities it also allows water to dissolve large amounts of earth's minerals etc.

- I. Vegetated Areas: O_2 is consumed & CO_2 is produced through decay of vegetation
- II. Limestone Areas: H_2O containing H_2CO_3 reacts with stone becoming hard; Ca, Mg bicarbonates are formed
- III. Granite/Sandy Areas: H_2O holds H_2CO_3 but does not become hard due to absence of limestone



Water Basics

Contamination:

- Contamination in drinking water can exist in many different forms:

- Particulate Matter
- Colloidal Matter
- Dissolved Solids
- Radioactive contaminants
- Microorganisms (protozoan cysts, viruses, pyrogens)
- Pesticides and herbicides
- Heavy Organic Molecules

- These exist either naturally or are man made.



Water Basics

Contaminants & their origin:

Naturally Occurring

Dirt
Rust
Sediment
Roots
Leaves
Algae
mold,
Iron (Fe)
Calcium (Ca)
Magnesium (Mg)
Manganese (Mn)
hydrogen sulfide
Microorganisms
Cysts (*Cryptosporidium*, *Giardia*)

MAN-MADE

Agricultural

Fertilizer
herbicide
Pesticide
Nitrate
Fungicide

Industrial

Detergent
Solvent
Radio-active waste
Acids
Hydrocarbon
Carbon monoxide
Lead based contaminants
Chlorine
Chloramines
THM's
etc...



Water Basics

Potential Problems with Contaminants:

PROBLEM	SYMPTOM	CAUSE
Hardness	White build-up on fixtures; difficult to generate soap suds	Dissolved calcium and magnesium
Iron, Manganese	Staining on household fixtures	Dissolved iron (ferrous) or precipitated (ferric) iron
Acid/Corrosion	Green stains on fixtures	Low pH from excess acidity
Hydrogen sulphide	Rotten egg smell	H ₂ S gas from sulphate reducing bacteria
Lead	Cannot detect	Contaminated water supply; lead solder in pipes
Cysts	Cannot detect	<i>Giardia</i> or <i>Cryptosporidium</i> cysts
Chemicals	Cannot detect	VOC's - benzene, THM, PCB's

