Filtration-101

MINNESOTA WATER QUALITY ASSOCIATION
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- *This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying 2 hours of Non-Code credit toward Water Conditioning and Plumbing continuing education requirements.*

Fundamentals of Filtration

- Purpose is to remove suspended solids-sand, silt, organics, precipitated (not soluble) iron, algae and bacteria
- Fibrous medias-paper-cloth-synthetic membranes

Fundamentals of Filtration-Factors

- Pore size of filtering media
- Total filtering area
- Capacity of filter
- Quality of water to be filtered
- Required flow rate
- Construction/design of filter

Filtration-Surface vs Depth Filters

- Surface filters-use sieves or screens to reject particles
- Formation of surface layer or film composed of removed particles
- Surface layer is what does the actual filtering
- Surface filters tend to clog quickly

Basics Filtration Methods

- Disposable Cartridge Filters: Replaceable
- Surface Filters: Screens-Sieves-Strainers
- Depth Filters: Single Media
- Depth Filters: Multi-Layered

Depth Filters-Deep Bed

- Trap particles deep within the medium
- Particles get trapped at the top, and additional particles travel deeper into the bed
- Some particles get strained and some are attracted by electrostatic and intermolecular forces
- Can be a single medium sand or multiple medias either stratified layers or mixed

Factors that affect filtration

- Pore size compared to particle size
- Chemical characteristics of the water
- Characteristics of the solid particles in the water
- Amount of particles in the water

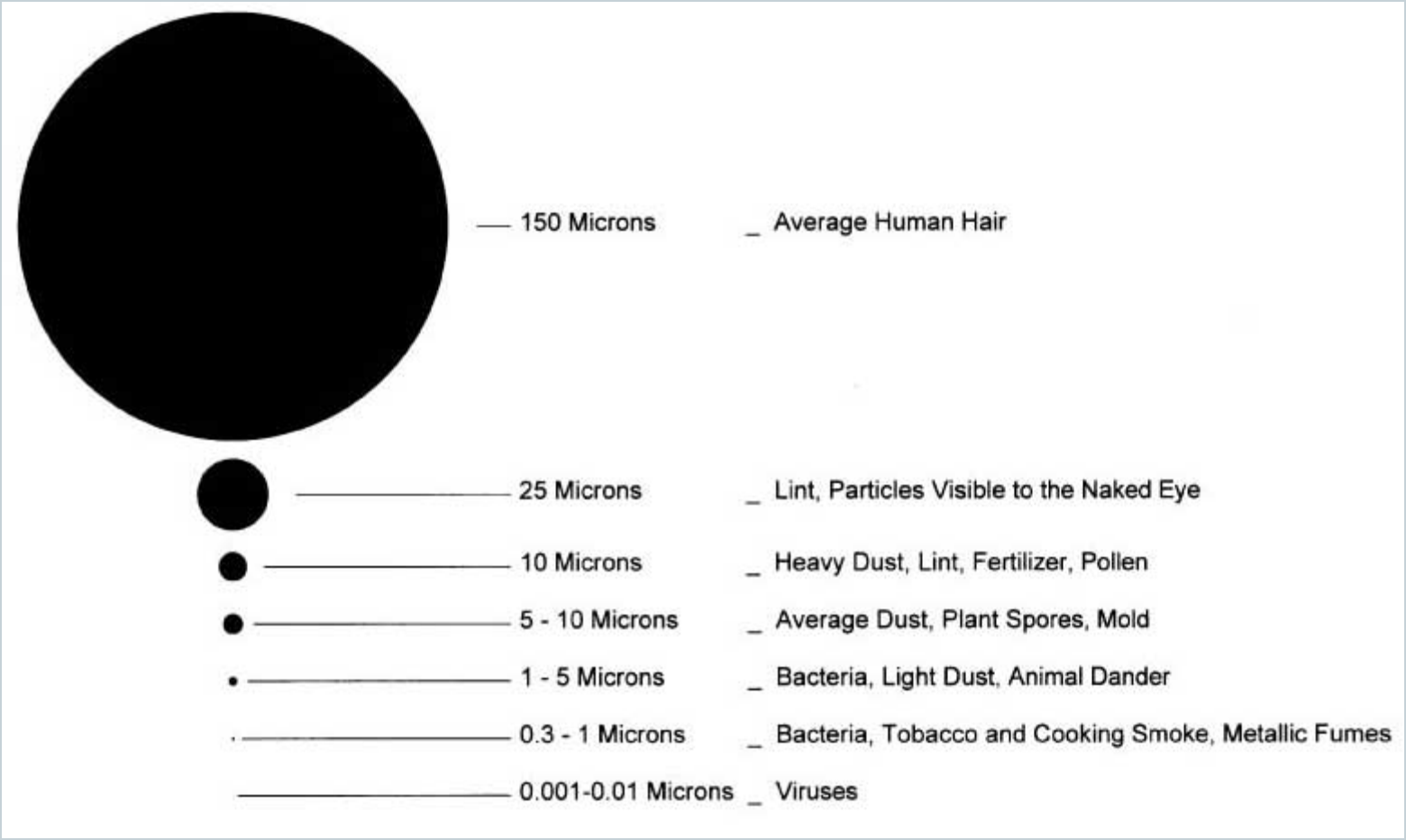
Factors that affect filtration-Water Temp

- The colder water gets it becomes more viscous (dense)
- Take more pressure to move cold water than warm water
- Filter bed will expand more if backwashed with cold water
- Higher backwash rate is needed with warm water than and a lower rate is needed with cold
- Particles settle back slower in cold water

Particle Size

- Mechanical Filtration removes clay, bacteria, asbestos fibers, cysts and algae
- 25,000 microns to 1 inch
- Water molecule is 0.0004 microns
- Calcium and Magnesium are in the same size range
- Diatomaceous earth filters are good for asbestos and silt
- Granular filters are not good for bacteria, cyst and viruses

Particle Sizes



Granular Media Filtration

- Used for reduction of suspended particles, turbidity, such as clay, mud and as a pre-filter for oxidized iron
- Commonly used for producing water that is good for drinking, laundry cooking

Filter Medias

- Sand and special grades of coal
- Sand needs very high rate backwash rates-10-15 gpm
- Anthracite is used in industrial applications uses ½ as much backwash water as sand
- Trend in residential is to use lighter materials to accommodate lower backwash rates-also multi media's

Filter Media

- Dual Function Media- may be a combination of calcite for acid reduction
- Manganese greensand for iron and manganese
- Activated carbon for taste and odor

Surface Charge

- Small particles in water carry a electrical charge
- Particles with the same charge will for a stable "colloidal" suspension
- Clay has a strong negative charge and will keep water cloudy
- Treatment of water with a surface charge can be done with coagulation method
- Neutralize the particles with alum or a polyelectrolyte to form larger particles and then filter them out

Effects of time

- A filter will not deliver the same quality of water thru it's life
- Pores get smaller and the resistance to water increases
- Pressure will begin to drop
- If not changed the water may form channels or cracks for the water to pass

Elements of Granular Bed Filter

- Housing-contains the filter media
- Filter media-dah
- Underdrain/Media Support-keeps media in place
- Backwashing System-forces water backwards
- Raw Water Feed-forces water thru the media to service
- Control System-controls rate and direction of water flow

Filter Selection and Sizing

- Must figure out the water problem FIRST
- Determine the customers flow requirements
- Don’t ever undersize a filter
- Backwash-requires water flow in reverse at a higher rate
- Is the flow and time adequate
- If there is low backwash flow, YOU WILL HAVE ISSUES
- Multiple small parallel filters can be used where volume/flow is a issue

Multi-Layered Media Beds

- Coarse and lighter particle backwash to the top
- Finer and heavier particles stay on the bottom
- Typically there are 3 layers- total depth 26-40 in.
- Top layer: large and lightweight/coal 15-18 in.
- Middle layer: 8-15 in. heavier/smaller calcined aluminum silicate or sand
- Bottom layer: 3-6 in. of heavy garnet, semiprecious red silicate is 50%-60% heavier than sand
- This design is can clarify water at a higher flow rate

Underdrain-Media Supports

- It collects the filtered water
- It retains the media, keeps it from the filtered water
- Evenly distributes the backwash water

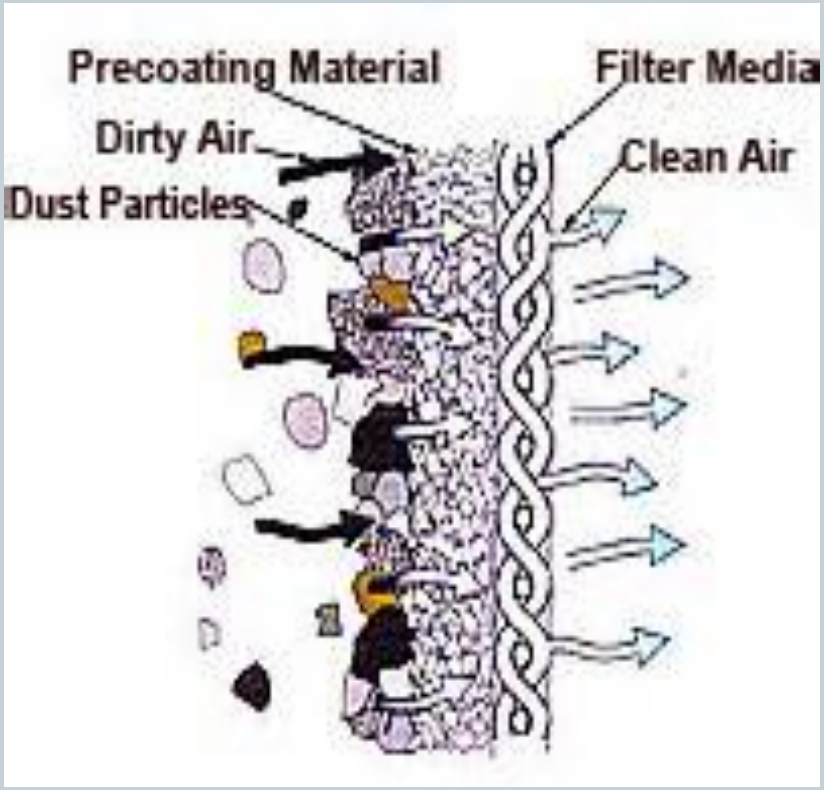
Series Filtration

- Almost the same as multi-media
- Two or more filters directly following one another
- Great when there is lower flow rate for backwashing a single unit

Precoat Filtration

- Combination of a depth filter and a surface filter
- Almost always use a finely powered filter media
- Medium consist of “precoat and body feed”
- Precoat is diatomaceous earth or perlite
- Regeneration does not imply backwashing-its completely removing the precoat media
- Can remove Giardia lamblia cysts and asbestos fibers

Precoat Filter example



Precoat Filter Construction

- Vacuum filters and pressure filters
- Vacuum housings are visible to the operator
- Pressure housings are closed and not visible to the operator
- Both operate the same but pressure filters are less expensive to operate and vacuum filters cost less upfront and easier to maintain

Microfiltration

- Microfiltration is one of 3 common types
- Membrane separation falls into 3 categories:
- 1. Microfiltration MF
- 2. Ultrafiltration UF
- 3. Reverse Osmosis RO

- The main difference is the size of what these 3 pressure driven methods will remove from the water

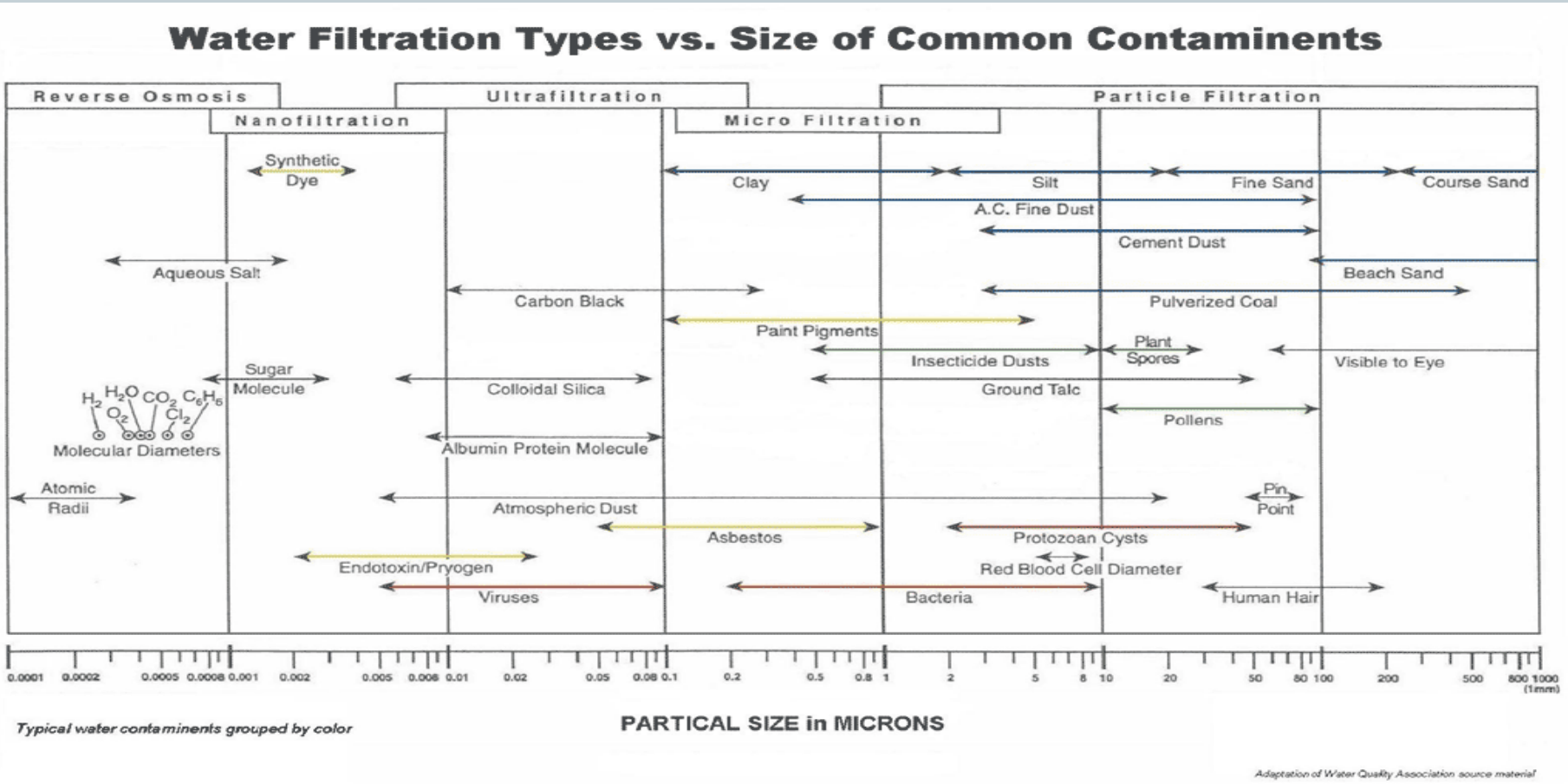
Ultrafiltration UF

- Removes non-ionized, dissolved material such as large organic macromolecules
- Removes most matter as small as 0.003 microns
- Removes most colloidal matter
- Removes most microorganisms including bacteria and virus
- Most organic molecular with (MW) >1000 like oil, proteins and cysts
- 300 to 300,000 molecular weight (MW) range

Reverse Osmosis RO

- The most sophisticated separation process
- Removes ionized materials or dissolved mineral salts (total dissolved solids TDS)
- Sediment, rust, asbestos, bacteria, virus, cysts, pyrogen can not penetrate a RO membrane
- Water easily passes thru a RO membrane
- RO and UF have one stream into it and two leaving
- MF has one stream in and one stream out

Comparative Size of Small Particles



Microfiltration

- There are two main uses for MF
- 1. remove very fine material from water for aesthetic and heath reasons
- 2. pretreatment for industrial RO or UF

- Its not a good barrier for microbial contamination
- Its good pretreatment for disinfection
- Sometimes called a sieving process
- Great example of surface filtration

MF Materials

- Made of expanded plastic polymers such as:
- 1. cellulose acetate
- 2. cellulose nitrate
- 3. nylon
- 4. teflon

- Most are very porous about 80% voids
- .10 mm to .15mm thick

Pore Size & Particle Removal

- MF will remove 0.1-5.0 micron size particles

Applications MF

- Common application is a cartridge filter
- Individual sheet membranes and cartridge filters
- Sheet membranes are used for:
- 1. bacterial analysis
- 2. suspended solids analysis
- 3. soluble metals analysis
- Many cartridge filters are pleated simply to increase the surface area

Strainers and Microstrainers

- Strainers commonly used in POU to remove large debris
- Use blow down fittings to divert solids
- Applications for strainers could be:
- 1. protecting chemical lines from grit and scale
- 2. protecting chemical feed tanks
- 3. protecting residential systems from grit and sand

Microstrainers

- Not used commonly for POU
- Commonly used for industrial water in between treatment systems
- Small scale example is removing all debris from a irrigation system
- Constructed as static and rotating models
- Usually made from woven fabrics or stainless steel

Cartridge Filters-Type

- Deep Bed
- Pre-coat
- Sorption
- Sheet filter
- Membrane filter

Cartridge Filter Elements

- Membrane-flat or pleated
- Fabric-flat or pleated
- Fiber filters
- String-wound fiber filters
- Resin-bonded filter units
- Sintered media-ceramic, stone, bronze, or stainless
- Diatomaceous earth
- Oxidizing filter
- Activated carbon filter

Cartridge Filter Applications

- Can be used singularly or in combination
- Very versatile
- Can be used to treat whole house water supply
- Ideal for single streams of water for specific needs

Cartridge Filter Types

- Membrane: polishing or pre-treatment 1-10 micron
- Fabric: pleated more surface area 20-25 micron
- Fiber: remove course materials-nominal ratings
- String-Wound Fiber: nominal ratings 0.5-100 micron
- Spun-Bonded: synthetic fiber, good for cellulose eating bacteria
- Resin-Bonded: fibers covered in resin, inexpensive-10-100 micron
- Sintered Ceramic: particles down to 1um, easy to clean with a brush, but very fragile
- Diatomaceous Earth: used for pre-coat, 1-2 micron

Cartridge Filter Types-Cont.

- Activated Carbon: taste and odor control, chlorine and organic reduction-granular, powered and block carbon, can have high pressure drops 4-5 psi
- Bag Filters: water flows into the bag and then filtered outward, not good for bacteria and viruses
- Coarse: 50 micron
- Medium: 20-30 micron
- Fine: 5-10 micron

Cartridge Questions

- How often should it be replaced? Follow manufacturers guidelines, bacteria can attack cellulose filters and cause a smell, replace ASAP
- Will cartridge filters purify the water? Disinfection must occur first, so chemicals must be added
- Can I filter out Giardia cyst? Yes, they are large organisms and can be filtered out

Chemical Conditioning with Filtration

- Some filter medias have dual abilities
- Manganese greensand, activated carbon and calcite are examples of dual-function medias
- Reasons to induce chemical change to water:
- 1. conditioning of particles make them easier to remove
- 2. convert soluble to insoluble such as oxidizing iron
- 3. removal of soluble by absorption-chlorine with carbon
- 4. change the water character-pH adjustment-acid neutralization

Chemical Feed Systems-Types

- Dry Powder: rotating table feeds dry chemicals
- Pellets: Feed when certain amounts of water have passed a meter
- Liquids: feed with small positive displacement pumps
- Gaseous: chlorine, ozone or atmospheric air, can be drawn with an ejector for feed out of a pressurized cylinder

Multi-Functional Filter Media

Media Type	**Function As**			
	pH Control	Absorption	Oxidizer	Filter per se
Calcite	X			X
Activate Carbon		X		X
Magnesia	X			X
Manganese Greensand			X	X
Manganese coated Pumicite			X	X

Reactive Media for pH Modification

- Acid water has low pH values is very corrosive-below 7.0
- Alkaline water has a high pH value, can cause scaling, above 7.0
- Orange juice is a acid with a value of 4.0
- Ammonia and bleach are alkaline with values over 11.0
- pH is driven by carbon dioxide (CO_2) when dissolved in water forms carbonic acid

pH Charter

Concentration of Hydrogen ions compared to distilled water			Examples of solutions and their respective pH
1/10,000,000	14	Liquid drain cleaner, Caustic soda	
1/1,000,000	13	bleaches, oven cleaner	
1/100,000	12	Soapy water	
1/10,000	11	Household Ammonia (11.9)	
1/1,000	10	Milk of magnesium (10.5)	
1/100	9	Toothpaste (9.9)	
1/10	8	Baking soda (8.4), Seawater, Eggs	
0	7	"Pure" water (7)	
10	6	Urine (6) Milk (6.6)	
100	5	Acid rain (5.6) Black coffee (5)	
1,000	4	Tomato juice (4.1)	
10,000	3	Grapefruit & Orange juice, Soft drink	
100,000	2	Lemon juice (2.3) Vinegar (2.9)	
1,000,000	1	Hydrochloric acid secreted from the stomach lining (1)	
10,000,000	0	Battery Acid	

Activated Carbon Filters

- Used for taste, odor control and chlorine reduction, organics and hazardous organic chemical control
- Absorption is when something adheres to the surface of activated carbon-like herbicides, pesticides and solvents
- Surface looks like a sponge, a teaspoon of carbon will have surface area equal to a football field

Activated Carbon Medias

- Coal-bituminous or lignite
- Coconut shells
- Nutshells
- Peat
- Wood
- Fruit Pits

Activated Carbon Applications

- Musty, earthy, wood or fishy smells
- Chlorine smell or taste
- Gasoline or hydrocarbons
- Pesticides and herbicides
- Volatile organic compounds
- Radon
- Detergents
- Phenol smell

Oxidizing Filters

- Mainly used for removal of iron, manganese and hydrogen sulfide
- A term means the process which oxidize soluble forms to insoluble forms
- Cation resins can be used to reduce iron and manganese but have limits
- Oxidation/Filtration has 3 steps, oxidation, precipitation and mechanical filtration

Oxidizing-1st Step

- Water has contact with a strong oxidizing agent:
- 1. Oxygen (O_2) air
- 2. Chlorine (Cl_2)
- 3. Manganese oxide (MnO_4) results when regen greensand or manganese zeolite with potassium permanganate
- 4. Ozone (O_3)
- The goal is to convert the dissolved element like iron or manganese to non soluble and then filter out

Oxidizing- 2nd Step

- Provide adequate contact time or retention time
- This allows the particles time to grow to a filterable size
- The higher the pH the faster this will happen, the lower the pH the contact time must be longer

Oxidizing-Applications-Troublesome Trio

- Dissolved Iron-Dissolved Manganese-Hydrogen Sulfide
- Red-Black Water
- Red-Black stained porcelain fixtures
- Red-Black laundry stains
- Scaling inside pipes and tanks
- Iron Bacteria
- Taste and Odor
- Tarnishing of silverware

Drinking Water Standards

- Fe < less than 0.3 mg/l
- Mn < less than 0.05 mg/l

Maintenance

- Critical areas depend on:
- 1. media regeneration cycle
- 2. filtration rates
- 3. backwash rates