

Taste and Odor Control,
Aeration,
Iron Removal and Basic
Stabilization

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Taste and Odor Control Problems

- Taste and odors in drinking water is a common problem faced by the operator
- Consumer evaluates water on three senses: sight, smell, and taste
- Effects of taste and odor problems
 - Complaints by customers
 - Consumer may switch to unsafe water
 - Loss of confidence in utility to produce a safe water
- Secret to successful taste and odor control is to PREVENT TASTES AND ODORS FROM EVER DEVELOPING

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Causes of Tastes and Odors

Can be the result of natural or manmade conditions that exist within the total water supply system

- Raw water sources
- Conveyance facilities
- Treatment plants
- Chlorination stations
- Finished storage facilities
- Distribution systems
- Consumer plumbing

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Types of Pollutant Sources

- Municipal wastewaters
- Domestic wastes
- Industrial discharges (requires NPDES permit)
- Chemical spills (primary concern is health related effects)
- Urban runoff
- Agricultural wastes
- Irrigation runoff
- Distribution system maintenance
- Consumer plumbing

 Note: If taste and odor problems and organic loadings are controlled, the need for activated carbon treatment at the plant may be reduced or eliminated.

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 What is the first step in determining the cause of taste and odor problems in a water system?

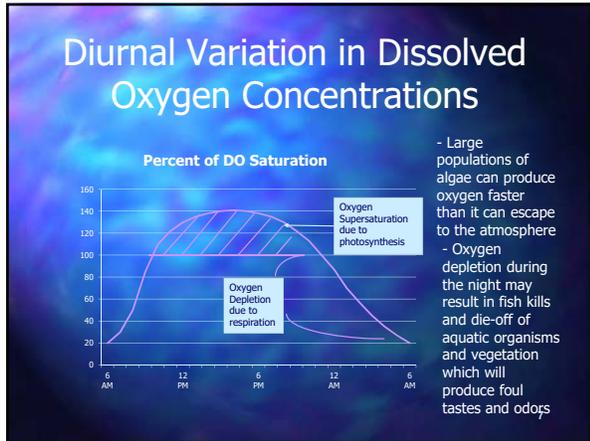
- a. Flush the system
- b. Change the coagulant dosage
- c. Do a taste test
- d. Locate where in the system the problem is originating

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Environmental Conditions

- Organisms (bacteria, algae, diatoms, or fungi) that grow in water or in the sediments of lakes, reservoirs, and rivers are significant contributors to tastes and odors.
- If organic matter decays when there is no oxygen present (anaerobic conditions) undesirable tastes and odors are produced.
- When sulfate is reduced to sulfide in the anaerobic bottom sediments of a lake or reservoir the result can be a strong odor of rotten eggs.
- The diurnal variation in dissolved oxygen concentrations may have significant effect on taste and odor.

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Importance of Diurnal Oxygen Fluctuations

- Significantly different conditions can and do exist from day to night
- Oxygen depletion at night may result in fish kills and die-off of aquatic organisms and vegetation which will produce foul tastes and odors
- During darkness anaerobic organisms may become established and contribute to the aesthetic qualities of the water

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Operations Impact

- Significant dissolved oxygen fluctuations caused by algae in raw water will also be accompanied by changes in the pH.
 - During daylight hours when algae produces oxygen, carbon dioxide (CO_2) is removed and the pH will increase
 - At night during the respiration process, algae will consume oxygen and release carbon dioxide which will lower the pH
 - These changes will influence the chemical doses required to effectively treat the water.
-  Tastes and odors caused by algae are best removed through improved coagulation and sedimentation.
 - Allows longer filter runs
 - If chlorine is used upstream of filtration it will reduce the reaction of chlorine on algae cells that would be release cellular materials into the water.

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Taste and Odor Control by Aeration

- Effective in removing gases and organic compounds which are relatively volatile, this is known as DEGASIFICATION
- Can also destroy some compounds by OXIDATION, such as ferrous iron and manganous manganese.
- Aeration may also reduce the chemical dosage needed.

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Taste and Odor Control Through Adsorption

- Adsorption is the process of removing materials from water by adding a material to the water to which taste-and-odor-producing compounds will attach themselves
 - Addition of powdered activated carbon; usually at the influent
 - Use of granular activated carbon as a filter medium

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Iron and Manganese Problems

- Dissolved ferrous iron (Fe^{+2}) gives water a disagreeable taste and will encourage the growth of iron bacteria in the water distribution system .
- Iron combined with tea, coffee and other beverages, produces an inky, black appearance and a harsh, unacceptable taste.
- Vegetables cooked in water containing excessive iron turn dark and look unappealing.
- Concentrations of iron as low as 0.3 mg/l will leave reddish brown stains on fixtures, tableware and laundry that are very hard to remove.
- Precipitates will form in the distribution system
- When these deposits break loose from water piping, rusty water will flow through the faucet.

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Forms of Iron Found in Water Treatment

- Soluble Iron or Clear Water Iron (Fe^{+2})
- Precipitant Iron or Red Water Iron (Rust, Fe^{+3} , settles out)
- Organically Bound Iron Soluble Iron
- Iron Bacteria (Slime or biogrowth)

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Iron and Manganese Facts

Regulated SMCL	Problem Types
Iron < 0.30 mg/l	Red Water
Manganese < 0.05 mg/l	Black Particles

- Weathering processes release the elements into waters.
- Iron dissolved by reaction with CO_2 . Reduces insoluble iron (Fe^{+3}) & Manganese (Mn^{+3}) to soluble Fe^{+2} & Mn^{+2} only under anaerobic conditions.
- Ground waters that contain Iron and Manganese are devoid of Oxygen otherwise they would settle out.
- When exposed to O_2 precipitants forms insoluble hydroxides in water.
- Visible as red and brown color. Will stain fixtures and clothes. Imparts taste and odor to water.

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Iron Bacteria in Water Supply System



Iron Bacteria Cells



Bacterial Growth



Iron Problem

- Iron and manganese are most frequently found in water systems supplied by wells and springs.
- Iron and manganese react with oxygen to promote the growth of iron bacteria.
- These bacteria form thick slime growths on the walls of the piping system and on well screens.
- The growth can be controlled by chlorination

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Iron and Manganese Control

- Alternate source
- Ion exchange
- Oxidation
- Phosphate treatment
- Lime softening

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Soluble Iron (Fe^{+2}) and Manganese (Mn^{+2}) Can be Removed by Aeration

- Water with Fe + Mn > 0.3 PPM will have disagreeable taste and odor.
- Removal of Fe/Mn by aeration is dependent on pH, contact time, temperature and presence of organic material.
- By maintaining pH above 7, contact time can be significantly reduced.
- pH can be adjusted by adding lime (increases pH and speeds oxidation).
- It will be necessary to periodically chlorinate the aeration system to control slime growths.

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What effect does pH have on the reaction?
Accelerates it

Plot of pH vs. Time for Iron Removal at 90% Efficiency (min 30 minutes detention)

Temperature (°F)	pH 5.5	pH 6.0	pH 6.5	pH 7.0	pH 7.5	pH 8.0	pH 8.5
70	10000	1000	100	10	1	0.5	0.2
40	10000	1000	100	10	1	0.5	0.2

(by Hem, Jnl. AWWA, February 1961)

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Treatment Methods to Remove Iron and Manganese

Comparison of Oxidants Required to Oxidize 1mg/l of Ferrous Iron or Manganous Manganese

Oxidant	Iron	Manganese
Oxygen	0.14	0.29
Chlorine	0.62	1.30
Chlorine Dioxide	1.21	2.45
Ozone	0.86	0.87
Potassium Permanganate	0.91	1.92

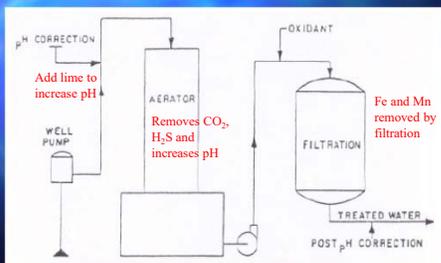
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Aeration Processes

- Aeration works in two different ways to remove the undesirable compounds from the water, oxidation and volatilization (degasification.)
- Volatilization removes undesirable gases such as Hydrogen Sulfide or Carbon Dioxide by forcing them to escape into the air.
- Removal of iron and manganese is accomplished by chemical oxidation. Once oxidized, these new compounds can be removed by sedimentation or filtration.
- Aeration also facilitates the oxidation reaction by removing CO₂ which raises pH.

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Schematic of Typical Fe Removal Aeration System



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Results of Aeration

- Taste and odors caused by Fe, Mn, H₂S, and any volatile compounds are removed.
- Reduces corrosive constituents, i.e. CO₂ (to 5 ppm) and H₂S.
- Supersaturated water is corrosive and stability must be adjusted.
- Aeration will not remove tastes and odors caused by organic sources such as algae.

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Types of Aeration Systems

- Water into Air. This method produces small drops of water that fall through the air.
- Air into Water. This method creates small bubbles of air that rise through the water being aerated. (less common in small systems).

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Cascade Tray Aerator



- Termed to be a waterfall device; passes water through the air
- Even distribution of water over top tray
- Loading Rates of 1 to 5 GPM for each sqft. of tray area.
- Trays 1/2" openings perforated bottoms
- Protect from insects with 24 mesh screen
- May encourage biological growths which may cause taste and odor problems
- Evaporation losses are a disadvantage

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Forced Draft Aeration System (Air Stripping)



- Combines elements of both air blowers and waterfall devices
- Includes weatherproof blower in housing
- Counter air through aerator column
- Includes 24 mesh screened downturned inlet/outlet
- Discharges over 5 or more trays



Blower

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Packed Tower Odor Removal System



- Uses Henry's Law constants for mass transfer
- Usually requires pilot testing
- Used to Remove VOCs below MCL
- Col to Packing >7:1 ratio
- Air to water at pk >25:1 with max 80:1
- Susceptible to Fouling from $\text{CaCO}_3 > 40 \text{ PPM}$

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Protection of Aerations Systems from Insect, Vermin and Slime

- Growth of Insects
- Contamination from Bird Droppings
- Contamination from Animals
- Growth of Slime

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Chemical Oxidation of Fe and Mn Using Chlorine

- The main advantage of chlorine over aeration is the requirement for much shorter reaction times
- Chlorine is frequently used instead of aeration when iron concentrations exceed 5 PPM
- When levels of iron and manganese exceed 5 PPM, sedimentation may also be necessary prior to filtration
- The higher the amount of chlorine fed, the more rapid the reaction
- After filtration, water may need to be dechlorinated by addition of sodium bisulfide or sulfur dioxide to prevent TTHMs
- Chlorine residual concentration after a contact tank should never be allowed to drop below 0.5 PPM
- The Chlorine concentration that is most effective is determined by the use of a jar test

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Clarification Requirements for Iron and Manganese

- Oxidized particles must be removed
- Anthracite filters are frequently employed
- With high Fe/Mn concentrations in source water (> 6 PPM) a clarifier may be necessary

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Use of Potassium Permanganate

- Oxidizes iron and manganese to insoluble oxides
- Sulfides and color are also removed
- Potassium permanganate is added upstream of filters
- Permanganate is a reactive, fast-acting oxidizer
- Dose must be exact
 - Too little will not oxidize the manganese in the water
 - Too large a dose will allow permanganate to enter the system and may produce a pink color in the water
 - Bench scale tests required to determine the proper dosage
- It is a poor disinfectant



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Filter Considerations Using Permanganate

- Filtration is used as the final step in Fe and Mn treatment
- Gravity and pressure filters are typically used
- The normally-used filter media will work if the combined concentration is below 1 ppm.
- Higher concentrations require different type of filter materials and different methods of operation
 - Use of manganese greensand filter
 - Charged with potassium permanganate after the backwashing process
 - This method allows the oxidation process to be completed in the filter

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Stabilization of Iron and Manganese using Phosphates

- Phosphates are used keep Fe and Mn in a dissolved state. The effect is called sequestration.
- Reduces the layer of scale that forms on the pipe.
- Very small quantity are required to inhibit precipitation in water distribution lines.
- Sequestering agents bind with the mineral (Fe, Mn, Ca, Mg) to keep them in suspension. This prohibits (delays) them from falling out and causing buildup, stains, discoloration, etc.
- At high mineral levels, the agents are not very effective. With long detention times in your storage, they are also not very effective.
- Testing should be performed to determine if they work.

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Some Benefits Attributed to Phosphate Addition

■ Control of Iron and Manganese Color and Staining	■ Disinfectant By-Product Reduction
■ Scale Reduction	■ Increased Life of Iron Pipelines
■ Corrosion Inhibition	■ Increased Life of Water Heating Elements
■ Hydrogen Sulfide Oxidation	■ Improved Taste of Water
■ Chlorine Demand Reduction	■ Water Color Enhancement
■ Bacterial (MPN) Reduction	

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Considerations in the Use of Polyphosphates for Sequestering

- Polyphosphates are effective for low concentrations of iron and manganese
- Polyphosphate sequestering agents can start to degrade to orthophosphate after about 2 days
- Polyphosphate sequestering does not work under stagnant conditions (slow moving water or dead end conditions)
- Over feeding Polyphosphate can contribute phosphorus as a nutrient that favors the growth of slime bacteria

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Considerations in the Use of Polyphosphates for Sequestering (cont.)

- The Polyphosphate, Hexametaphosphate is commonly used for Sequestering Soluble Iron and Manganese
- Large doses (>5 mg/l) will soften rust deposits in pipelines which are transported into homes
- Proper dose is to keep soluble iron and/or manganese tied up for 4 days so deposits won't build up on the pipe walls
- Chlorine usually must be fed along with the polyphosphate to prevent the growth of iron bacteria



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Use of Orthophosphates for Sequestering

- Orthophosphate is used to sequester iron ions at pipe surfaces
- The sequestering forms a protective coating that prevents further iron migration
- Ortho/Poly Blends provide both sequestering of soluble iron and manganese movement from pipelines under corrosive conditions

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DEP Limitations in Sequestering Iron and Manganese

- Sequestering with polyphosphates may be used when the combination of (Fe + Mn) < 1 mg/l
- Polyphosphate may not exceed 10 mg/l
- Sequestering with sodium silicates may be used when combination of (Fe + Mn) < 2 mg/l
- Sodium Silicate can not exceed 20 mg/l
- Sodium Silicate is applicable prior to air contact only!



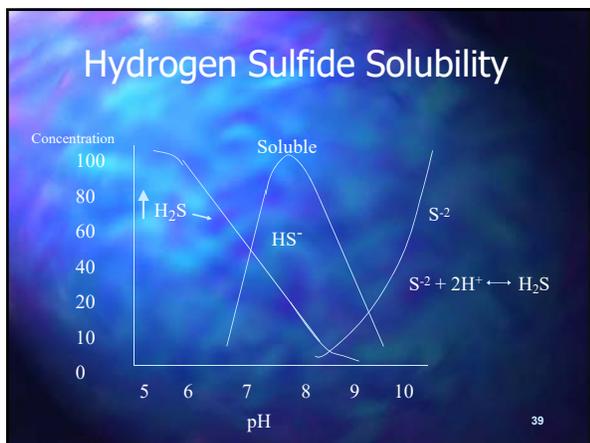
Polyphosphate Dosing System³⁷



Taste and Odor from Hydrogen Sulfide

- Not uncommon in Florida well waters
- Typical concentrations not a health risk but do affect the taste of water; Detected in concentrations as low as 0.05 mg/l
- Presence of sulfate-reducing bacteria causes rotten egg odor of hydrogen sulfide.
- Free hydrogen sulfide (H₂S) can react with water forming sulfuric acid (H₂SO₄) which is extremely corrosive to metals.
- Removed by aeration, greensand/ potassium permanganate, and chlorination

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Hydrogen Sulfide Removal Techniques (DEP)

Sulfide (mg/l)	Recommended Treatment Process	Achievable Range of Removal
<0.3	Direct Chlorination	100%
>0.3	Direct Chlorination (requires filtration)	100%
0.3 to 0.6	Conventional Aeration	50%
0.6 to 3.0	Forced Draft Aeration	90%
>3.0	Packed Tower Aeration	>90%

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Distribution System Maintenance

- Flushing alone does not provide an adequate level of protection against tastes and odors in a distribution system
- Routine collection of samples for tastes and odor tests can provide an early warning of quality deterioration
- The location of flushing stations and the frequency at which they are flushed is determined from records of complaints and water quality tests. Records can be used to:
 - evaluate the effectiveness of these spot flushing's
 - the frequency of flushing
 - the need to add or rotate stations during the year.

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Determining if Dissolved Iron is Present

- Draw a sample from the well and allow it to stand for 30 minutes
- Water should be clear and colorless turning to a slight yellow haze color after contact with air
- If allowed to stand it will finally form a yellowish brown color
- If aerated and allowed to stand it will form reddish brown deposits in bottom of container

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