

Distribution Water Quality



Workshop developed by RCAP/AWWA and funded by the USEPA

Learning Objectives

- Be able to describe what different water quality parameters tell us about distribution system health
- Be able to describe and apply key practices for managing water age and quality during storage



Why water quality parameters are important

- Protect public health
- Comply with regulations
- Impact distribution system operation
- Impact aesthetics (taste, odor, color)



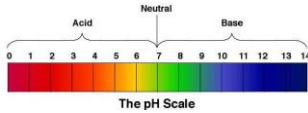
Water quality parameters we will discuss

- pH
- Chlorine residual
- Water age
- Temperature
- Heterotrophic plate count
- Taste and odor



pH

- Measurement of H⁺ concentration
- lower pH → more acidic
- EPA secondary standard - 6.5 to 8.5
 - pH 7.0 is neutral – neither acidic nor basic



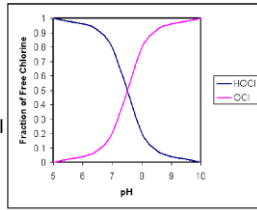
Impacts of pH

- pH Too High:
 - May precipitate excessive calcium carbonate in distribution system
 - Restrict water flow in pipe
- pH Too Low:
 - May corrode water pipes
 - Red water issue (iron particulates)
 - Pipe failure and rupture
 - Lead and copper issues



Impacts of pH

- pH impacts the form of Chlorine
- Chlorine is most effective between pH 5.5 – 7.5
- pH impacts TOC removal
 - Lower pH = better removal
- pH affects DBP formation
 - Higher pH = more TTHMs



Chlorine Residual

- Maintaining a chlorine residual in the distribution system is critical to ensure pathogen-free water
- The maximum Cl_2 level is limited to 4.0 ppm under the Maximum Disinfectant Residual Level (MDRL)
 - Unpleasant chlorine taste
 - Excessive disinfection byproduct formation
- Other disinfectants (such as chlorine dioxide) also have MRDLs



Chlorine Decay

- Chlorine degrades in the distribution system
 - Reaction with natural organic matters (NOM) and/or pipe materials
 - Booster chlorination may be needed to maintain an acceptable chlorine residual
- Rapid decay can be an indicator of a distribution system problem



Decay of Chlorine Residual

- Rate of decay can be affected by
 - Water age
 - Temperature
 - Biological growth/nitrification
 - Amount and type of chlorine-demanding compounds (organic and inorganic)



Water Age

- The residence time of water in the distribution before reaching the customers
- Factors affecting water age:
 - Water production rate
 - Water demand
 - Pipeline and storage tank operations
- Measure using tracer studies (fluoride)



Water Age

- High water age:
 - Loss of chlorine residual
 - Increased risk of bacterial regrowth
 - Increased DBP formation
 - Higher chance of contamination
- AWWA recommends water age of less than 7 days



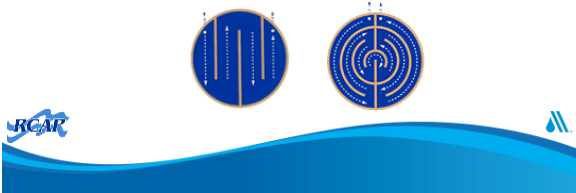
Managing Water Age and Quality

- Manage Hydraulics in Storage Facilities
 - Inlet/outlet configuration, baffling
 - Increase turnover rate
 - Pumping schedules (deep cycling)
 - Mixing
- Manage chemistry
 - Increase chlorine residual
 - Shock chlorination
 - Aeration (radon, TTHM , hydrogen sulfide, etc)



Baffling Systems

- Adding baffle walls in the storage facility
 - Make the interior “channel-like” to enhance a “plug-flow” condition
 - Make water age more uniform and reduce short circuiting



Turnover Rate

- Achieved by:
 - Decreasing storage volume
 - Partially draining and refilling
 - Account for seasonal water usage variations
 - Close down some facilities during cold seasons or operate with lower volumes
- Important to ensure a certain minimum storage at all time for emergency purposes (e.g. fire flow)
- Set a minimum water level to prevent re-suspending any sediments



Pumping (Deep Cycling)

- Large water level fluctuations facilitate mixing and help increase turnover rates
- Pumping water when the tank is unusually low can cause scour and sediment release
- May not provide mixing of upper layers in a stratified tank



Tank Mixing

- Even a storage facility that has a high turnover, older water zones can still occur
 - Thermo stratification
 - Short circuiting
- Adequate tank mixing can break up stratification and promote consistent water quality



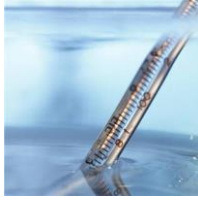
Questions

- Do you know the typical / average water age of your distribution system?
- Where is your water age the highest?



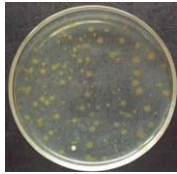
Temperature

- Water temperature can vary daily, and seasonally
- High water temperature:
 - Quicker loss of chlorine residual
 - More bacterial regrowth
 - Higher disinfection byproduct formation
 - Nitrification



Heterotrophic Plate Count

- An estimation of the number of live bacteria
- Quantified as the number of colony forming units (cfu) per 100 mL of water
- Indicator of system health
- Excellent indicator for nitrification in chloraminated system
- To identify causes of low chlorine residual



Taste and Odor

- Chlorine taste and smell
 - Chlorinated organic from sourcewater
 - Di-and trichloramine
 - Excess residual concentration
- Earthy-musty odor
 - Natural Algae products (MIB and Geosmin)
 - Algae under chlorine exposure
- Swampy or rotten egg odor
 - Hydrogen sulfide
- Others (e.g. gasoline, metallic)
 - From contaminations of various sources



Customers are a great source of water quality information

- Taste and odor issues can be a symptom pointing to other problems in the system, for example:
 - Excessive chlorine taste may indicate chlorine overfeed
 - Back flow through cross connections may be first noticed by change in taste/odor



Use Customer Information

- Track customer complaints
- Investigate the origin of the problem



Discussion: Aesthetic Issues

You received several complaints from customers. How do you respond?

1. Swimming pool smelling water
2. Red water coming out of the tap



Other Storage Related Issues

- Corrosion
- Sedimentation
- Leaching
- Hydrogen sulfide release
- Biological issues
 - Regrowth
 - Nitrification
 - Birds, insects, rodents, reptiles, etc.....



Bacteria Regrowth

- Storage and piping often create an environment prone to regrowth
 - Decreased chlorine residual
 - Increased temperatures
 - Build-up of nutrients
 - High surface to volume in pipes
 - Low velocity



Bacteria Regrowth

- A public health and compliance concern
 - May contain total coliform which leads to TCR compliance issues downstream
 - May contain amoeba
 - Loss of chlorine residual
 - Nitrification



Discussion – Water Quality Changes

- What interesting water quality issues have you seen in storage facilities