What Your Chlorine Residual is Trying to Tell You

How Active Mixing Improves Water Quality and Lowers Chemical Costs

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Introduction

Health organizations around the world recognize the importance of chlorination of drinking water to public health. In the U.S., before the widespread introduction of chlorine disinfection in the early 1900s, cholera, typhoid fever, dysentery, and hepatitis A killed thousands of people every year.

In addition to killing bacteria, viruses, and parasites, chlorine reduces unpleasant tastes and odors in water. Chlorine eliminates slime bacteria, molds, and algae that grow on the walls of pipes and water tanks.

Chlorine is so important for maintaining healthy drinking water supplies, the U.S. EPA requires treated drinking water to contain a detectable level of chlorine – **a chlorine residual** - to help protect against germs all the way to the consumer's tap. The loss of chlorine residual makes distribution systems vulnerable to microbial contamination.

Water utilities understand the importance of monitoring chlorine residuals in their distribution and storage systems. However, understanding what that monitoring data is telling you is not straight forward. In this post, we look at what your chlorine residual monitoring data is trying to tell you - and provide brief explanations on the subject.

Chlorine Residuals and Water Quality

In general, drinking water must be treated before disinfection. Coagulation, filtration, and clarification are common treatments. Disinfection comes after treatment in the clear water tank. Because chlorine can be easily applied, measured, and controlled, it is one of the most widely used disinfectants. It is relatively cheap and very effective for the deactivation of pathogenic microorganisms.

Being very reactive, when added to water, chlorine immediately starts reacting with any contaminants present after treatment. Those reactions are predictable:

1. Chlorine begins by oxidizing any organic matter left in the water after treatment. This is termed the ***chlorine demand*** of the water.
2. Chlorine then combines with any nitrogen compounds. This is called ***combined chlorine*** and is unavailable for disinfection.
3. What remains is ***free chlorine***, which kills any remaining microbial contaminants in the water.

After reactions with organic matter, combining with nitrogen, and disinfection, what chlorine remains is ***chlorine residual***.

Chlorine Residuals in Distribution Systems

After disinfection, the water enters the distribution system with chlorine residual. What happens to chlorine residuals in a system depends on in-coming water quality, distribution system interactions, and system operation.

In-coming Water Quality

High Organic Loads

Chlorine reacts rapidly with any organic matter left in the incoming water, using up residuals. Organic sediments entrained in the water from pipes and tanks can add a further chlorine demand to the water.

Stratification, Temperature, and Water Age

In warm weather, water in un-mixed aboveground tanks often stratifies. Warm water collects at the top of the tank, while cold fresh incoming water remains at the bottom. Water drawn from the bottom will not impact the top layer, which gets warmer and older over time. Warmer temperatures also increase the rate of chlorine decay.

Distribution System Interactions

Metallic Tanks / Pipes

In metal tanks and pipes, chlorine reacts with reduced iron to form metal oxides. These reactions remove chlorine from the system and cause buildups in pipes; restricting flow.

Biofilms and Sediments

Difficult to eliminate, biofilms on pipe and tank walls exert a demand on chlorine residuals. Sediments in tanks tend to be organic in nature, reducing residuals further.

System Operation

Multifunction, Floating and Isolated Tanks

Water tanks in distribution systems are often designed to address peak water demands, equalize pressures, and provide reserves for fire-fighting and other emergencies. If tanks are kept full but underutilized, the stored water ages and water quality deteriorates. Residual drops as chlorine degrades over time.

Inlet / Outlet arrangements

In many municipal water tanks, the same pipe is used to fill and drain the tank. This leads to short-circuiting in un-mixed tanks as the colder incoming water remains on the bottom and is drained first.

Maintaining chlorine residuals

Optimize Treatment Upstream

Chlorine demand can be reduced by improving upstream organics removal. Treatments applied depend on the character of the organic material in the water and include:

- optimizing coagulation
- addition of carbon adsorption
- biological treatment

Tank Maintenance

Maintenance and Cleaning

Regular maintenance and cleaning of tanks and flushing of pipes reduce chlorine demand in a system. AWWA has produced a standard for steel water tanks*. The standard recommends that every three years at a minimum, tanks are to be drained, washed out, and professionally inspected. Inspections should assess obvious sanitary concerns such as biofilm and sediment build-up.

Biofilm Growth Reduced in Well-Mixed Tanks

Biofilms add to the chlorine demand in a system and flourish when chlorine residuals drop. Biofilms tend to develop at the top of tanks where the water level rises and falls during daily operations.

As discussed, water at the top of un-mixed tanks tends to be older and warmer, with low chlorine residuals. Increasing circulation, either passively through cycling and pumping or actively with mixers, allows chlorine access to biofilms, eliminating them.

Tank operation

Reducing Water Age

Operators reduce water age by forcing a high turnover and by changing water levels in water tanks. Some utilities must pump water into and out of tanks that ‘float’ on the system to maintain adequate residuals.

To increase passive mixing, tanks can be designed or retrofitted with a separate inlet and outlet. The inlet is set higher in the tank to encourage mixing of fresher, colder influent water with older, warmer water in the tank.

Some passive mixing systems use a complex series of pipes and nozzles to inject the infilling water throughout the tank.

Chlorine Dosing

Some distribution systems required additional chlorine dosing at certain points. The system may be extensive, or tanks may be isolated. In these cases, more chlorine must be added to maintain residuals.

Maintaining Chlorine Residuals with Active Mixing

Active mixing in water tanks helps maintain chlorine residuals by preventing stratification and eliminating short circuiting that leads to high water ages. Active mixing provides a complete mix of the water, resulting in consistent chlorine residuals throughout the tank.

In situations that require supplemental dosing of chlorine into tanks, an active mixer allows for a complete mix of the added chemicals.

Kasco provides an NSF-61 approved cost-effective solution to your tank mixing requirements. Superior design, outstanding effectiveness, and ease of installation put Kasco's CertiSafe™ Municipal Mixer for potable water at the top of the list.

Conclusion

Chlorination of water supplies is one of the greatest advances in public health. However, chlorinating water supplies is not a set-and-forget activity. Monitoring chlorine residuals throughout the distribution system provides an understanding of system dynamics.

An active mixing system installed in your water tank helps maintain a chlorine residual throughout the tank. Maintaining adequate chlorine residuals eliminates biofilm growth and reduces organic contamination. This, in turn, reduces the chlorine demand of the water.

The best active mixing systems for potable water tanks are designed for effectiveness, safety, and durability. To solve problems in your water tanks, learn more about Kasco's CertiSafe Tank Mixer.

About the Author – Lucy Allen

Lucy Allen is the Municipal Business Development Manager at Kasco. With more than 12 years of experience in the water and wastewater industry, she has a strong technical background and extensive field experience, along with relationship building skills that enhance market presence within the water utility market. Lucy holds a Bachelor of Science degree from Michigan State University.