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Sanitization of Automated Watering Systems

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Unless water contains a continuous biocide like chlorine, a biofilm will develop on wetted piping surfaces in an automated watering system and high numbers of bacteria could be present in animal drinking water. Regular flushing will limit bacterial accumulation in an automated watering system, but no amount of flushing alone will totally eliminate biofilm. Periodic sanitization with a chemical biocide may be necessary to remove and destroy biofilm.

This document provides information on common biocides used for sanitization in water systems. It also provides information about how to sanitize an automated watering system.

If you have any questions or comments about sanitization and drinking water quality, contact Edstrom Industries at 800-558-5913.

Definition of Sanitization

Sanitization is not an absolute phenomenon. It is a partial removal of organisms. Depending on the system, a sanitization operation should reduce the organism population by some 90%. In water, sanitization is frequently defined as a 3-logarithm (log) or 1,000-fold reduction in the number of bacteria.

Continuous Treatment or Periodic Sanitization?

There are two basic approaches for controlling bacterial growth in a potable water system. One is to maintain a constant residual level of biocide chemical within the system (continuous dosing). This is the technique that municipal water treatment facilities use when they inject enough chlorine to provide a residual throughout a citywide distribution system. Some research facilities continuously chlorinate or acidify their animal drinking water to control bacteria. For more information of continuous treatment, refer to these Edstrom Industries documents:

- *Drinking Water Chlorination* (MI 4230-4174)
- *Drinking Water Acidification* (MI 4230-4179)

The second approach is to periodically sanitize. If for some reason the research protocol prohibits the use of continuous chlorination, then periodic sanitization will be required. Most systems using continuous dosing will also need a regular, although less frequent, periodic sanitization regimen. For example: in an acidified water system, chlorine sanitization may be needed periodically to kill acid-resistant microorganisms in an automated watering system.

Chemicals Used For Sanitization

Chemical biocides can be divided into two major groups: oxidizing and non-oxidizing. Oxidizing biocides include chlorine, chlorine dioxide, and ozone. Non-oxidizing biocides include quaternary ammonium compounds, formaldehyde, and anionic and nonionic surface-active agents.

Table 1 provides some general information about biocides. The table includes recommended contact times for various concentrations, as well as factors to consider when choosing a biocide to use with automated watering systems. Note that some biocides are not recommended for use with automated watering systems at all.

Table 1. Common biocides and typical dosage levels.

Biocide	Concentration	Contact Time	Application to Automated Watering Systems
Chlorine	10–200 ppm (WQA)	1 minute @ 50 ppm (WQA)	Typical application is 20 ppm & 30–60 minute contact time. Chlorine is corrosive, so do not exceed 50 ppm or 2 hours contact.
	50–100 ppm (Mittelman)	1–2 minutes (Mittelman)	
	5–10 ppm (Gelman Sciences)	60 minutes (Gelman)	
Ozone	4 ppm (WQA)	1 minute (WQA)	Stronger biocide than chlorine at equal concentrations. Not commonly used. Must be generated on-site.
	1–2 ppm (Mittelman)	<1 minute (Mittelman)	
	0.5–1.0 ppm (Riedewald)		
Chlorine Dioxide	0–100 ppm (Mittelman)	1–2 minutes (Mittelman)	Biocidal activity similar to chlorine. Unstable, must be mixed on-site. Corrosive like chlorine. More expensive than chlorine.
Peracetic Acid	1% wt/wt (WQA)	30 minutes (WQA)	
Hydrogen Peroxide	30,000 ppm (WQA) 10% (v/v) (Mittelman)	180 minutes (WQA) 2–3 hours (Mittelman)	Not used. More expensive & less effective than chlorine.
Quaternary Ammonium Compounds	300–1,000 ppm (Mittelman)	2–3 hours (Mittelman)	Not commonly used in water systems. Requires exhaustive flushing to remove "suds"
Formaldehyde	1–2% (v/v) (Mittelman)	2–3 hours (Mittelman)	**NOT** used. Carcinogen!

Chlorine

The most common sanitizing agent is chlorine. Chlorine is the least expensive, most readily available, and is effective and easy to use. While ozone and chlorine dioxide are also effective biocides, there is little experience using these chemicals to sanitize automated watering systems.

This document will mainly address chlorine sanitization. For more information of the other sanitizing agents, refer to the Edstrom Industries paper on Biofilm. Since sanitizing chemicals are corrosive, contact Edstrom Industries for recommended concentrations and procedures for any other chemical agents.

The effectiveness of a sanitizing agent is a product of both concentration and contact time. Typical sanitization of an automated watering system is accomplished using 20 ppm chlorine for 30–60 minutes. Higher concentrations or longer soak times will increase effectiveness; however, do not use a sanitizing solution with a chlorine concentration higher than 50 ppm. Repeated sanitization at higher concentrations can cause corrosion of stainless steel wetted components in an automated watering system.

Hot-Water Sanitization

Heated water can be used to sanitize a system if it is held in the range above 70°C (158°F). The practical aspects of handling water at this temperature (the materials of construction and the energy used), plus the need to provide for animal and personnel safety normally preclude this method from serious consideration for the total automated watering system. It is applicable for components such as rack manifolds that can be sanitized with heat using rack-washers.

Sanitization Frequency

Since sanitization does not kill 100% of bacteria in a watering system, the remaining bacteria can regrow in the system. This means that the components of a drinking water system will need to be resanitized periodically. While monthly sanitization is typical, the frequency for your particular system will depend on its design, the frequency of both flushes and filter changes, the supply water quality, and the bacterial quality you are trying to maintain. To determine the sanitization frequency, establish a regular schedule for drawing samples and monitoring the total bacteria count levels. Increase or decrease the frequency of sanitization based on the measured bacterial quality.

To destroy an established biofilm, (for example: a watering system that has been in operation for some time and has never been sanitized) repetitive sanitizing cycles are usually required. The initial chlorine exposure may only kill the top layer of biofilm. Chlorine will also destroy the glycocalyx or slime which is the “glue” that holds biofilm bacteria together and to the pipe wall. This weakens the biofilm structure. For that reason, it is a good idea to follow chlorine exposure with a high-flow flush. Fresh chlorine is then reintroduced to the piping to kill the next bacterial layer. This chlorine sanitization/flush cycle may need to be repeated several times on consecutive days until the accumulated biofilm has been removed. For a well-established biofilm, 3-10 cycles may be needed (WQA, 1998).

Sanitization of an Automated Watering System

All the components in an automated watering system should be sanitized at regular intervals. This section describes how to sanitize these components. The components are listed in the order of the water flow – water purification components are listed first, drinking vales are listed last (see Figure 1).

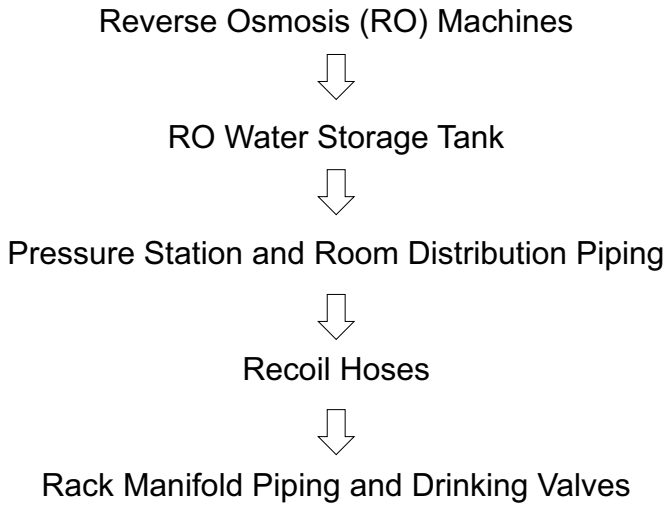

Figure 1. The components that make up an automated watering system. All components must be sanitized at regular intervals.

RO machines

Continuous chlorination. For reverse osmosis (RO) systems using cellulose acetate membranes, continuous chlorine pretreatment is used to prevent bacteria growth in the RO machine. Chlorine injection is adjusted to provide 0.5 – 2.0 ppm of free chlorine in the feedwater and a minimum of 0.3 ppm free chlorine in the RO product water. This low chlorine concentration in the product water is also beneficial for controlling bacteria growth within the storage tank and downstream in the room distribution system.

Clean-in-place cycle. Regular cleaning of the RO machine is necessary because contaminants can build up on membrane surfaces, reducing flow rate and quality of the product water. On most of the RO machines available from Edstrom Industries, cleaning is done automatically on a periodic basis. Low pH cleaners are used to remove precipitated salts and metals, and alkaline or neutral cleaners are used to remove dirt, silt, and organic foulants.

RO membranes can also become fouled with microorganisms. To minimize biofouling, it is best if the RO machine can operate continuously, or as many hours a day as possible, to minimize stagnant downtime. If a microbiological cleaner is needed, follow the membrane manufacturer's recommendations.

Storage tanks

In water purification systems by Edstrom Industries, the water in storage tanks will contain a continuous chlorine residual that helps prevent bacterial regrowth. If storage tank sanitization is required (based on water testing or once per year as preventative maintenance), refer to the RO system manual. Frequency is typically bi-annually or annually.

Room distribution piping

Automated watering systems should contain injection ports where a sanitizing solution can be introduced. These are typically located at the inlet to each pressure reducing station. The Edstrom Industries portable sanitizer is designed to inject chemical sanitizing solutions into the room distribution piping. Usually, animal racks are disconnected from the room piping during sanitization. Sanitization frequency is typically once every 1-12 months.

Recoil hoses

Recoil hoses can be chlorine-sanitized in the cage wash area using the Edstrom Industries Chlorine Injector Station and Recoil Hose Flush Station. Sanitization frequency is typically every 1–2 weeks.

Manifolds

Manifold piping on mobile animal racks can be chlorine-sanitized following the wash cycle in the cage wash area using the Edstrom Industries Chlori-Flush Station. Sanitization frequency is typically every 1-2 weeks (the same as the rack wash frequency).

Reference

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