University of California
Agriculture and Natural Resources
UC Cooperative Extension
TEHAMA, GLENN, COLUSA, AND SHASTA COUNTIES
1754 WALNUT ST, RED BLUFF, CA 96080
(530)-527-3101
Email: aefulton@ucanr.edu

Controlling Biological Clogging of Drip and Microsprinkler Irrigation Systems with Chlorination

Allan Fulton and Larry Schwankl, UCCE

Chlorine is often added to irrigation water to oxidize and destroy biological microorganisms such as algae, fungi, and bacteria. While these microorganisms may be present in any water source, they are most likely to exist at high levels in surface water from reservoirs, canals, and ponds. When water containing high levels of microorganisms is introduced into a drip or microsprinkler system, it may clog emitters and reduce irrigation uniformity and the average hourly rate of water application. In turn, this may influence the adequacy of an irrigation schedule if an irrigation system no longer performs as it was originally designed.

Using a good filter is the first line of defense to prevent clogging of irrigation systems but some biological organisms will pass through the filter into the irrigation system. If left unattended these organisms can multiply and lead to clogging. Chlorination or some other biocide will be needed to prevent biological clogging or recover a system that has already been affected.

HYPOCHLOROUS ACID. Adding chlorine to water mainly produces hypochlorous acid and hypochlorite, in combination referred to as free chlorine. Hypochlorous acid is the primary biocide agent. The concentration of hypochlorous acid that forms in a water supply is dependent on the pH of the water. Irrigation water supplies with pH less than 7.0 will have less or no effect on the availability of hypochlorous acid and will have the greatest reactivity on biological organisms. As the pH of the irrigation water increases the availability of hypochlorous acid and its reactivity declines. Table 1 below illustrates this effect in more detail. Water supplies with a pH above 7.0 require that either higher concentrations of chlorine be injected to account for the negating effect of high pH on hypochlorous acid reactivity or add acid to the water supply to reduce the water pH. If acid is used to adjust water pH, use a second injection system and port to inject the acid upstream of the port where the chlorine will be injected.

Table 1. The effect of water pH on the percentage of chlorine in the hypochlorous acid form.

pH of Irrigation Water Supply	Percent Hypochlorous Acid
5	99
5.5	98
6.0	97
6.5	88
7.0	75
7.5	44
8.0	24
8.5	10
9.0	4

FORMS OF CHLORINE. Common sources of chlorine include liquid sodium hypochlorite, granule or powder forms of calcium hypochlorite, and chlorine gas. Liquid sodium hypochlorite includes common household bleach and other more concentrated liquid formulations. Liquid sodium hypochlorite forms usually contain between 5.25 % (i.e. household bleach) and up to 15% available chlorine. Liquid formulations of chlorine are typically diluted in water to prepare a stock solution for injection. Granular or powder forms of calcium hypochlorite normally contain 65 to 70 % available chlorine and require that they be dissolved in water to prepare a stock solution. Note that typical forms of calcium hypochlorite require about 12.8 lbs of granules or powder per 100 gallons to prepare a 1% chlorine stock solution. Chlorine gas can be dissolved in water. It contains 100 percent available chlorine to react as a biocide because it lowers the pH of water to a level that results in hypochlorous acid and free chlorine

CHLORINATION APPROACHES. There are three approaches to injecting chlorine: 1) continuous injection; 2) periodic injection; and 3) superchlorination. Continuous injection of chlorine at a concentration of 1 to 2 ppm free chlorine at the end of the last lateral in the irrigation system is best suited for irrigation water that has high levels of algae and bacteria. Periodic injection of chlorine at concentrations of 10 to 20 ppm free chlorine at the end of the irrigation system may be appropriate for water supplies that have low or moderate levels of algae and bacteria. Superchlorination is an approach to recover irrigation systems that have been clogged by algae and bacteria, recommended concentrations of free chlorine range from 500 to 1000 ppm at the end of the irrigation system. Superchlorination requires special care to avoid damage to plants and irrigation equipment.

CHLORINE INJECTION RATES. Table 2 provides chloride injection rates using three different chloride stock solutions, for irrigation flow rates ranging from 100 to 2500 gpm, and for chlorine concentrations suitable for continuous or periodic injection. The basic equation used to calculate the chlorine injection rates in this table is:

$$IR = (0.006 \times Q \times C) \div S$$

Where,

IR = the injection rate in gallons per hour

Q = irrigation system flow rate in gallons per minute (gpm)

C = desired chlorine concentration in the irrigation water at the injection point (ppm)

S = the strength or concentration of the chlorine stock solution (%)

Table 2 shows a wide range in possible chlorine injection rates. As an example using Table 2, a stock chlorine solution of 1% (prepared by adding granular calcium hypochlorite to water in a storage tank) used for continuous injection of 2 ppm free chlorine into an irrigation system with a flow of 300 gpm requires an injection rate of 3.6 gph. As a second example applying Table 2, where the stock solution is 5.25 % chlorine, the irrigation system flow rate is 1200 gpm, and the desired concentration for periodic injection is 20 ppm free chlorine, the required injection rate is 27.4 gph. Table 2 also illustrates that some stock solutions and associated injection rates may not be practical for some needs. For example, using a 5.25 % percent stock solution for continuous injection to achieve a 2 ppm free chlorine concentration into irrigation flows of less than 500 gpm requires injection rates less than 1.0 gph, It will be difficult to accurately inject chlorine at these low rates and it is more appropriate to use a less concentrated stock solution, perhaps 1.0 % solution. At the other extreme, a 1% chlorine stock solution injected at 180.0 gph (3.0 gpm) into a 1500 gpm irrigation flow achieves a free chlorine concentration of 20 ppm at the point of injection. This injection rate may be too high for some injection equipment and a more concentrated stock solution of chlorine may be more appropriate. Chlorine gas, the most concentrated source of free chlorine may be better suited for irrigation systems with high flow and where superchlorination is desired. Chlorine gas is hazardous and requires professionally trained personnel to inject it. A different equation than provided on the previous page is used to calculate injection rates of chlorine gas.

INJECTION CONSIDERATIONS

- Chlorine should be injected upstream of the filter to help keep the filter clean and to remove precipitates that may form from the chlorine injection.
- Use a separate injection system if an acid is used to keep the water pH between 6 and 7. Do not use sulfur burners to adjust water pH. They produce sulfurous acid, which deactivates the chlorine.
- Understand the concentration of chlorine at the injection point will decline as the irrigation water travels through the irrigation system as a result of reacting with the algae and bacteria in the lines. As a general rule, expect the free chloride level in the irrigation lines at the end of the system to be approximately one-half of the concentration at the injection point. Use inexpensive chloride test strips available at any pool or spa supply store to check chloride concentrations at the end of the system to assure sufficient treatment. Injection rates may need to be adjusted accordingly.

<u>Table 2</u>. Chloride injection rates for different chlorine stock solutions and irrigation flow rates to attain desired concentrations of chlorine in drip and microirrigation systems

	1 % Chlorine Stock Solution (Add 12.8 lbs Calcium Hypochlorite granules per 100 gallons water, using 65 to 70 percent concentrated Calcium Hypochlorite granules)			1 % Chlorine Stock Solution (Add 12.8 lbs Calcium Hypochlorite granules per 100 gallons water, using 65 to 70 percent concentrated Calcium Hypochlorite granules)			15 % Chlorine Stock Solution (concentrated sodium Hypochlorite)		
Irrigation Flow (gpm)	Continuous Injection at 2 ppm	Periodic Injection at 20 ppm	Super chlorination at 1000 ppm	Continuous Injection at 2 ppm	Periodic Injection at 20 ppm	Super chlorination at 1000 ppm	Continuous Injection at 2 ppm	Periodic Injection at 20 ppm	Super chlorination at 1000 ppm
	Chlorine Injection Rate (gph or *gpm*)								
100	1.2	12.0	*10.0*	0.2	2.3	*1.9*	0.1	0.8	40.0
200	2.4	24.0	*20.0*	0.5	4.6	*3.8*	0.2	1.6	*1.3*
300	3.6	36.0	*30.0*	0.7	6.9	*5.8*	0.2	2.4	*2.0*
400	4.8	48.0	*40.0*	0.9	9.1	*7.6*	0.3	3.2	*2.6*
500	6.0	60.0	*50.0*	1.1	11.4	*9.6*	0.4	4.0	*3.4*
600	7.2	*1.2*	*60.0*	1.4	13.7	*11.4*	0.5	4.8	*4.0*
700	8.4	*1.4*	*70.0*	1.6	16.0	*13.4*	0.6	5.6	*4.6*
800	9.6	*1.6*	*80.0*	1.8	18.3	*15.2*	0.6	6.4	*5.4*
900	10.8	*1.8*	*90.0*	2.1	20.6	*17.2*	0.7	7.2	*6.0*
1000	12.0	*2.0*	*100.0*	2.3	22.9	*19.0*	0.8	8.0	*6.6*
1250	15.0	*2.5*	*125.0*	2.9	28.6	*23.8*	1.0	10.0	*8.4*
1500	18.0	*3.0*	*150.0*	3.4	34.3	*28.6*	1.2	12.0	*10.0*
1750	21.0	*3.5*	*175.0*	4.0	40.0	*33.4*	1.4	14.0	*11.6*
2000	24.0	*4.0*	*200.0*	4.6	45.7	*38.0*	1.6	16.0	*13.4*
2500	30.0	*5.0*	*250.0*	5.7	57.1	*47.6*	2.0	20.0	*16.6*

Chlorine Injection Rates in gph (white) — **Chlorine Injection Rates in gpm** (shaded)

CONTACT TIME AND FLUSHING

- At least 2 hours of contact time between the chlorinated water and the biological contamination is needed for the treatment to be effective. Longer contact times are preferable and chlorination can continue up to the time the irrigation stops, leaving chlorinated water in the lines.

- The drip or microsprinkler system should be flushed with untreated irrigation water preferably a day or two after periodic injections or superchlorination and certainly before the next irrigation. Flushing removes remaining biological contaminants in the line and any residual chlorine to make sure there is no interference with other products that may be injected.

SAFETY PRECAUTIONS

- When mixing chlorine stock solutions, use fiberglass storage tanks and always fill the storage tank with water first and then add the chlorine source (liquid or dry formulation), not vice-versa.
- Do not inject chlorine with other fertilizers and pesticides.
- Do not store chlorine compounds and acids in the same room.