MANUAL FOR CHLORINE TREATMENT OF DRIP IRRIGATION SYSTEMS

The practice of chlorination has been used for many decades as a mean of purifying water supplies. Chlorine is a powerful oxidizing agent and vigorously reacts with bacteria (destroys bacteria) fungi, algae and other forms of organic matter (moss, snails), then the reacted chlorine is chemically bound or "tied up" and it is no longer antibacterial. The chlorine that has not reacted remains as "free residual chlorine" to continue treatment of the system. Bacteria can grow in the absence of light inside pipelines and drip tubes, and oxidize iron, sulfur or manganese as energy source, and produce a mass of slime that combined with other materials can precipitate and clog emitters in drip irrigation systems. The nutrients required for their growth can be present in both well and surface water, and very small concentration of iron and manganese (0.1-0.3 ppm) in ground water can cause biological emitters clogging.

Chlorination is an effective and economical solution to the problem of orifice and emitter clogging, due to biological growth. When chlorine is dissolved in water, the chlorine molecules combine with water in a reaction called hydrolysis. The hydrolysis reaction produces hypochlorous acid (HOCl) as:

$$H_20 + Cl_2 = HOCl + H^+ + Cl^-$$

Following this reaction, hypochlorous acid then undergoes an ionization reaction to produce hypochlorite:

$$HOCl = H^+ + OCl^-$$

Hypochlorous acid (HOCl) and hypochlorite (OCl^-), which are together referred to as "free available chlorine", coexist in an equilibrium relationship which is influenced by temperature and pH. Where water is acidic (low pH) the above equilibrium shifts to the left and results in a high percentage of the free available chlorine being in the form of HOCl. Where the water is basic (high pH), a high percentage of the free available chlorine is in the form OCl^-.

The efficiency of Hypochlorous acid in killing microorganism is about 40 to 80 times greater than hypochlorite. The effectiveness of chlorination is highly dependent upon the pH of the water source, quantity of bacteria, algae and other organic matter. Thus, water having a low pH will result in a high concentration of HOCl which is the more potent biocide. At pH 8, only about 22% of the chlorine will be in the active HOCl form, at pH 7, 73% will be in the HOCl form, and at pH 6, about 96% of the chlorine will be in the HOCl form (Nakayama and Bucks, 1986). If water pH is above 7.5, may be necessary to add acid to lower the water pH.

Another relevant feature of chlorine chemistry that is negative to drip system, is that free available chlorine reacts strongly with oxidizable substances such as iron, manganese, and hydrogen sulfide, often producing insoluble compounds which may necessitate removal. Chlorine reacts with ammonia and urea; producing compounds called chloramines or "combined chlorine", and if nitrogen fertilizer is applied through micro-irrigation systems, ensure that the nitrogen and chlorine are applied at different times. At the injection point, acid and chlorine should be at least 2 to 3 feet apart down stream from filter station for drip systems. It is not recommended to combine acid and chlorine at the same container, and always add chlorine to water not vice versa.

Mauro Herrera

When iron is a problem in your irrigation water, there are to common treatments:

1. Pump water into a reservoir to settle and oxidize iron with air before entering the drip system.
2. Inject a strong oxidizing agent (chlorine) upstream of the filter station to filter ferric iron before entering the drip system, at a rate of 1ppm of chlorine per 0.7ppm of iron. The bacteria oxidize iron, ferrous iron (+2 charge) to form ferric iron (+3 charge) as energy source.

For chlorination to be effective, chlorine must be in contact with algae and bacteria for at least 30 minutes, so maintain 1 to 2 ppm of free residual chlorine in the system for 60 minutes to ensure that all parts in the system receive a minimum of 30 minutes of contact time. Usually an initial injection concentration of 5 to 6 ppm of chlorine is required in order to maintain 1 to 2 ppm of free residual chlorine in the system. For effective chlorine treatment, the water should be acidified to a pH of 6.5, so that hypochlorous acid predominates. For pH of irrigation water of 7.5 or less, 1 ppm of free chlorine at the farthest end from the injection point is sufficient, and for pH above 7.5 of the irrigation water, 2 ppm of free residual chlorine at the farthest end will be enough. However, chlorine has no effect on scale deposits (lime or calcium carbonate).

Warning:

Active chlorine solutions are dangerous to human beings and animals. Follow very carefully the manufacturer's instructions. When using chlorine, proper protection to the eyes, hands, and body parts must be worn, i.e. glasses, gloves, shoes, etc. Chlorine contact with the skin can cause serious burns; contacts with eyes can cause blindness, and swallowing may be fatal.

Objectives:

1. Prevent clogging of emitters due to organic and biological growth.
2. Destroy and decompose sulfur and iron bacteria and accumulated bacterial slime in the system.
3. Improve performance of filtration system while reducing back flush water.
4. Clean the drip irrigation system of organic sediments.

Material:

Liquid sodium hypochlorite (NaOCl) is the easiest, and the safest form of chlorine or bleach most often used and labeled for treatment in drip irrigation systems. Chlorine solutions can be bought in concentrations of 5.25%, 10%, 12.5% and 15% available chlorine.

Gas chlorine is the most stable, pure and effective chlorine source for injection. However, it is very dangerous, poisonous and corrosive; it requires specialized controllers, and equipment. Refer to the Material Safety Data Sheet (MSDS) for chlorine.

Calcium hypochlorite not recommended for injection into drip irrigation, calcium may form precipitates.

Storage and transportation:

Sodium hypochlorite is transported by tanks. It should be stored in a clean tank without fertilizer residues. Direct contact of chlorine and fertilizer will create a thermo-reaction, which can be explosive. The tank should be painted white, placed in a shaded area, and it should not be stored for more then 20 days, because chlorine degrades over time.

Methods of application:

In general, there are three methods recommended:

1. **Continuous treatment** for water with high biological growth, to prevent growth of algae and bacteria. Continuously add 1-2 ppm of chlorine during irrigation or at the last hour of every irrigation cycle.
2. **Intermittent treatment** or **intervals** for water with slight to moderate biological load, to kill a build-up of algae and bacteria. Inject chlorine at a higher concentration (5- 20 ppm) at the end of the growing season.
3. **Super chlorination** or **shock treatment** to dissolve organic material restricting emitter flow. Apply chlorine at a very high concentration (>50 ppm), and leave the chlorine inside the system for 24 hours before flushing. This method is used on annual basis, end of the season or when clogging and build-up is severe. Frequency and duration of shock treatment is determined by the severity of the problem.

PROCEDURE FOR CHLORINATION

1. Before you start the chlorination procedure, decide the method that you are going to use: Continuous, intermittent or shock treatment.

Shock treatment:

2. Calculate the amount of chlorine to inject using the following formula: your may need to know the well flow rate, the chlorine strength, and the desired chlorine concentration to treat the system.

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

IR: Chlorine injection rate (gal/hr)
Q: System flow rate (gpm)
C: Desired chlorine concentration (ppm)
S: Strength of chlorine (in percentage, not fraction)

IR = 500gpm x 5 ppm x 0.006 = 15 ÷ 5.25 = **2.85 gal/hr** of chlorine

3. The procedure should be started by turning the well pump on, of the irrigation system.

4. The system should be operating and pressurized, check the pressure gages, if there are leaks in the field repair them before chlorination.

5. Before injecting the chlorine, flush the entire system: filter station, main, sub main and manifold lines.

6. Calibrate your injection pump to deliver the chlorine needed to treat the system.

7. Chlorine should be injected at a point upstream of the filter station, to prevent growth of bacteria and algae in the filter station, and removal of any precipitates caused by chlorination.

8. If you decide not to treat the filter station, you may inject the chlorine at a point downstream of the filter station. However, if iron or manganese precipitates due to chlorination, clogging problems to emitters may occur.

.

9. Start the chlorine injection at the calculated rate.

10. Use the recommended chlorine tester, color test kit that measures only the "free residual chlorine": D.P.D. (N, N Diethyl-P (-Phenylenediamine). Otherwise, you may use your experience and check the water until you can smell the chlorine at the farthest end from the injection point.

11. 10-15 minutes after injection is initiated, at the farthest emitter or flush-out valve from the Injection point, test the water and measure the free residual chlorine concentration.

12. Using the chlorine tester, you should be reading 1-2 ppm of free residual chlorine in the water.

13. Adjust the injection rate if necessary. Allow sufficient time to achieve a steady reading.

14. Once you reach the chlorine level desired, run the chlorine injection system for 1 hour, then stop the chlorine injection.

15. Switch to the next block, and follow the same procedure until you chlorinate all the blocks that you want to treat, and leave the chlorine in the system for 24 hours.

16. After 24 hours, with clean water proceed to flush out the filter station, main, sub-main and manifold lines of the drip irrigation system, until all the blocks are completely clean. Then you may shut everything off.

17. It may be necessary to repeat the chlorination process several times, until you unclog the system. In some cases it may be needed to increase the chlorination rate. Compare the pressure gages before and after. It should be the same pressure or less.

    For **continuous and intermittent treatment**, use the same formula at lower chlorine concentration (2-20 ppm), following the same procedure from 2-16 and you may flush the blocks as soon as you finish the chlorination.

References

Brian Benham, Assistant Professor and Extension Specialist; and Blake Ross, Professor and Extension Specialist. 2002. Filtration, Treatment, and Maintenance Considerations for Micro-Irrigation Systems. Virginia Tech. Publication Number 442-757, March 2002.

Charles M. Burt, P.E., Ph.D and Strart W. Styles, P.E. 1999. Drip and Micro Irrigation for Trees, Vines, and Row Crops. 148-149p. Irrigation Training and Resource Center (ITRC). BioResource and Agricultural Engineering Dept. California Polytechnic State University. San Luis Obispo, California 93407.

Darbie M. Granberry, et al., Chlorination to Control Algae and Bacteria. Extension Horticulturist. The University of Georgia College of Agricultural & Environmental Sciences Cooperative Extension Service.

Gary A. Clark et al., 1996. Maintaining Drip Irrigation Systems. Kansas State University. Agricultural Experiment Station and Cooperative Extension Service.

James Hardie. 1984. Micro-Irrigation DesignManual. 8-13p. First Edition.
Treatment of drip irrigation systems with chlorine. 2008. www.netafimusa.com

Mahbub Alam et al., 2002. *Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems*, Kansas State University, January 2002.

Nakayama. F.S. and D.A. Bucks. 1986. Trickle irrigation for crop production: Design, Operation, and management. Elsevier Science Publishers. 383p.Amsterdam, Netherlands.

Pitts, D.J., D.Z. Haman and A.G. Smajstrla. 1990. Causes and prevention of emitter plugging in microirrigation systems, Bulletin 258. University of Florida, Gainesville, FL.

Treating Irrigation Systems with Chlorine. University of Florida. IFAS Extension.
http://edis,ifas.ufl.edu/AE080

William Lamont, Professor of Vegetable Crops. 2005. Maintaining drip irrigation systems. Associate Department of Horticulture, Pennsylvania State University.
www.fruit.cornell.edu/Berries/genprodpdf/dripirrigationsystems.pdf