

# ***MICRO IRRIGATION SYSTEM MAINTENANCE***

by

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## **Introduction**

Timely maintenance is a prerequisite for long-term successful micro irrigation system operation. Proper maintenance will extend the life, improve the performance, and reduce operating costs. A well-planned preventative maintenance program will minimize shut-down time and reduce the likelihood of non-uniform water and fertilizer applications due to emitter plugging. Micro irrigation systems are typically automated and require little attention to perform the irrigation. However, because of the higher level of technology as compared to conventional irrigation, these systems often require significant maintenance to ensure that they are operating at maximum efficiency. Maintenance includes checking for leaks, backwashing and cleaning filters, periodic line flushing, chlorinating, acidifying, cleaning or replacing plugged emitters, and evaluating and monitoring system performance.

## **Routine Maintenance**

The irrigation water pump is essential to the irrigation system. Manufacturer's recommended maintenance procedures should be followed. Most micro irrigation systems that use ground water have submersed turbine pumps, which require very little maintenance. If failure does occur, however, repair requires the removal of the pump which is expensive. Micro systems using surface water typically employ above-ground centrifugal pumps. During the irrigation season, pumps should be checked at each visit for excessive or unusual noise or vibration, water leakage and proper flow rate and pressure. The pumping level should be observed to ensure the required net positive

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suction head (NPSH) and the intake screen should be observed to ensure that it is not obstructed.

In Florida, most pumps are diesel powered and are installed with safety controls that will shut the unit off if sensors indicate a potential problem. However, during the irrigation season, the diesel unit should be visually checked at each site visit for proper oil pressure and coolant temperature, and excessive noise or vibration. The oil level should also be checked regularly with the system off. Oil, coolant, and filters should be changed based on manufacturer's recommendation. Engine tune-up and other preventative measures should be performed annually or as the manufacturer recommends.

Proper filter performance is critical to minimize emitter plugging. Filters must be periodically cleared or backflushed of accumulated particles and debris. A partially clogged filter may reduce system pressure, resulting in non-uniform and reduced water application. Additionally, clogged filters increase pump head and consume additional energy. Backwashing may be manual or scheduled automatically based on time interval or pressure differential. If filters are backflushed manually, the operator needs to calculate flushing frequency based on the time of operation for particle accumulation. Since this can change as the water source changes, automatic backflushing is preferred. Automatic backwash is typically set to operate on a **4-6** psi pressure differential. During irrigation periods the filter should be inspected monthly in the following manner: the cover should be removed and the filter element examined (if screen filter, check for tears or extruded material in the screen; if disk filters, check for accumulated organic material on the outside of the disks and check for sand or other particles that may have become wedged between disks rendering them ineffective). Sand media filters should be checked at least twice a year to insure the appropriate sand level (look for caked material in the media, ensure that the media hasn't been flushed out in the backwash process, and that cavities have not been created). Inspect all automatic components such as hydraulic tubing, pressure regulators, pressure gauges, and control valves.

Chemigation is typically practiced with micro irrigation. Routine maintenance of chemical injection equipment includes a visual inspection of the hoses, valves, pumps, and injector at each **chemigation event**. Be sure to flush the injection system following each chemigation, so that corrosive materials will not remain in the equipment.

Automatic diaphragm valves are an essential component of larger systems. These valves are relatively reliable but require periodic inspection to insure proper operation. Some controllers are able to detect if a valve is malfunctioning; however, if a valve failure goes undetected, pump or power unit damage could occur or water could be applied where it is not needed. The control line filter may become plugged, and thus the valve may not operate properly. It is recommended that diaphragm valves be inspected and cleaned once a year. This can usually be accomplished without removing the valve from the line. It is important to clean any deposits that may have developed on the valve stem. Deposits may cause the valve to bind and not perform normally. Encrustation may be removed with a wire brush, weak acid (e.g. vinegar), or very fine sand paper. When the valve is opened, the diaphragm, seat, and o-ring seals should be inspected and replaced if signs of wear or degradation are apparent. Adjustable pressure regulating valves should be inspected periodically to ensure correct setting. If regulating valves are pre-set, they should be checked with a pressure gauge mounted at the regulator, or by attaching a portable pressure gauge to a Schrader valve.

Pressure gauges can become damaged or wear out. Liquid-filled pressure gauges are generally of higher quality and are recommended. Pressure gauges can be checked by comparing them with a new gauge or a standard test gauge. Be sure to determine that gauge range is appropriate for the application.

Micro irrigation systems should be visually inspected regularly (at each site visit during irrigation periods) to insure that leaks have not developed. In some areas, animals (rabbits, rats, and field mice) chewing plastic spaghetti lines to micro sprayers can be a very common problem. With vegetable production under plastic mulch, insects and rodents may also damage the drip tape. To detect this problem it is often

necessary to spend considerable time walking the fields while the system is operating and listening for leaks (water discharging against the plastic mulch). One possible solution to this problem is to encourage natural predators of the pest that is causing the damage. Leaks can also occur in hardware such as pipe fittings, emitters, and hose adapters. Farm equipment and workers also are a frequent cause of damage. When micro sprayer stakes are often knocked over by numerous causes, and the result is the improper application of water. Regular observation of the emitters while they are operating is important to detect this problem.

### **Line Flushing**

Some particulate matter will not be removed by filters and may accumulate in the irrigation pipes. Chemical precipitation may occur after the irrigation system is shut down and water is standing in pipe lines. Suspended materials will be carried with the irrigation water, but as the water velocity decreases near the end of lines, particles will settle. If these sediments are allowed to build-up, they can be a serious cause of emitter plugging.

All micro irrigation systems should be designed so that mainlines, submains, headers, manifolds and laterals can be flushed. Lateral lines are sometimes fitted with automatic flushing valves which open under low pressure. Although these valves have some benefits, manual flushing is still required. With automatic flush valves, all or many laterals are open at the same time, so that the flushing velocity's often too low. Manual flushing should be done by opening only a few laterals at a time, so the flushing water velocity is at least 2.0 ft/s at the end of the line.

Use the following procedure to determine flushing velocity. With the lateral line open, catch a volume of water for a known time period. Determine the flushing velocity as follows:

$$V = Q / A$$

where,

V = velocity (ft/s),  
Q = flow (ft<sup>3</sup>/s),  
A = inside cross-sectional area of the pipe of later line (ft<sup>2</sup>).

An examination of the flushed material can be a good indicator of potential plugging problems. A **nylon sock** can be held over the end of the lateral line to catch the first slug of debris as it leaves the pipe. Also a jar sample can provide useful indicators of potential problems. The flushing frequency should be determined based on observation of the flushed materials. If there is only a small amount of suspended particles being flushed from the pipe, then the flushing interval can be increased. On the other hand, if large amounts of material are flushed, the flushing interval should be reduced.

The entire irrigation system should be flushed following chemical injection to insure that all the fertilizer is purged from the irrigation system (some chemicals such as chlorine, should be left in the line to prevent organic growths between irrigation). If fertilizer chemical is left in the line, it may harbor bacteria or other organisms.

Occasionally the irrigation piping system must be open for repairs. Plastic cutting originating from PVC pipe have frequently been observed as a source of plugging. When possible use tube cutters rather than saws for repairs. If a saw must be used, clean and flush the repaired section before reconnecting to the remainder of the irrigation system.

## **Emitter Maintenance and Reclamation**

In the event of severe plugging, emitters may need to be replaced or reclaimed by acid treatment. Before new emitters are installed or old ones retrofitted after reclamation, the irrigation water should be analyzed to identify the causes of the severe potential sources of emitter plugging. Table 11.1 can be used to classify irrigation water based on its potential for emitter plugging or hazard rating. The prevention of emitter plugging is usually more cost-effective than high concentrated chemical treatment for reclamation. Reclaiming plugged emitters by chemical treatment is not

always successful because most of, the injected chemical flows through the open emitters and not through the plugged ones. Thus, field reclamation by chemical treatment should be considered only as a last resort. Primary efforts should be directed at effective system maintenance.

Table 11.1 Hazard rating for emitter plugging based on water quality analysis.

Plugging Factor	Hazard Rating		
	Minor	Moderate	Severe
Suspended Solids (ppm)	<50	50-100	>100
pH	<7.0	7.0-8.0	>8.0
TDS	<500	500-2000	>2000
Iron	<0.2	0.2-1.5	>1.5
Hardness (Ca)	< 100	100 to 200	> 200
Alkalinity <sup>1</sup>	< 150	150 to 300	> 300
Hydrogen Sulfide	<0.2	0.2-2.0	>2.0
Bacteria (#/ml)	<10000	10000-50000	>50000

Ca = Hardness (Ca) x 0.4

Before attempting to unplug emitters by injecting chemicals, the material plugging the emitter should be identified. In most cases, plugging will be caused by a combination of physical, chemical, and/or biological sources. A quantity (perhaps a dozen) of the plugged emitters can be sent in a zip-lock baggy to: Emitter Diagnostics, in care of Don Pitts, University of Florida - Southwest Florida Research and Education Center, P.O. Box 5127, Immokalee, FL, 34143. An analysis will be performed to determine the source of the plugging material. If the plugged material is calcium carbonate, the chance of reclamation without removing emitters from the field is good, but if the primary cation is iron, removal and treatment or replacement is likely the only solution. Iron compounds found in plugged emitters in southern Florida have proven to be very difficult to unplug in the field. In fact, dissolving the iron compounds in the

laboratory is often difficult. Iron fouled emitters can be cleared by physically removing and soaking in a strong (pH = 2.5) citric acid solution for 48-hours.

Mechanical cleaning of the plugged emitter is not recommended since this often distorts the emitter orifice and introduces another source of non-uniformity in irrigation water application. It is also very time consuming and, thus, expensive. Clearly, the best approach is proper water treatment to minimize plugging potential.

Calcium scale can be removed by chemical acidification of the irrigation water to pH 2.0 - 3.0. Care must be taken to minimize the duration of the treatment. Prolonged acidification may cause damage to the irrigation system or the plant. Hydrochloric acid (sold commercially under the name of muratic acid) is one of the most effective acids for removing mineral scale. Hydrochloric acid can be ordered with an inhibitor that minimizes its corrosive effect on metal parts. Sulfamic acid is a dry, white, granular material that produces a strong acid when mixed with water. Although it is more expensive than hydrochloric acid and is less aggressive, sulfamic acid offers a number of advantages. In its dry form, it is relatively safe to handle. Sulfamic acid is particularly useful in treating calcium scale but is less effective when iron is present. Another acid, hydroxyacetic acid, has been reported to be effective in treating iron scale in wells (Driscoll, 1986). Its effectiveness in reclaiming micro irrigation system is not know.

## **Chlorination**

Chlorine is injected into irrigation water to destroy microorganisms such as algae and bacterial slime. These organisms are most commonly found in surface water, but they may also be present in ground water. Biological plugging is common and the most effective control is chlorine.

Chlorination is the most widely used chemical treatment of irrigation water to control emitter plugging. The chlorine source may be gas, liquid, or solid. Chlorine gas is the most effective and economical source, but there is some resistance to its use due to high toxicity. Sodium hypochlorite (NaOCl) solution (household bleach) is readily available and is relatively safe to handle. Calcium hypochlorite ( $\text{Ca}(\text{OCl})_2$ ) is a powder

or pellets which must be dissolved in water to form a stock solution. Calcium hypochlorite may cause calcium precipitation in alkaline irrigation water. Table 11.2. gives other potential sources of chlorine and the available chlorine equivalent compared to chlorine gas.

Table 11.2. Quantities of various chlorine compounds required to provide as much available chlorine as one lb of chlorine gas.

Source	Available Chlorine (%)	Number of lbs. Equivalent to one lb. Cl (gas)
Chlorine Gas	100	1
Calcium Hypochlorite	65	1.5
Lithium Hypochlorite	36	2.8
Sodium Hypochlorite	10	10
Trichloroisocyanuric Acid	90	1.1
Sodium Dichloroisocyanurate	63	1.6
Potassium Dichloroisocyanurate	60	1.7
Chlorine Dioxide	4	25

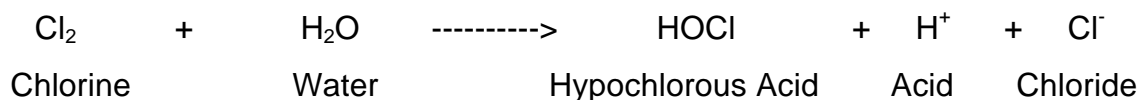
***Recently, commercial equipment has become available to make potassium hypochlorite in the field by electrolyzing KCl solution to produce hypochlorite solution.***

If the irrigation water has high levels of algae or bacteria, continuous chlorination may be necessary. Injection at low levels, resulting in 1 ppm of 'free' chlorine at the end of the farthest lateral line is recommended. No evidence has been reported of damage to plants from using water with low chlorine concentrations. Any active chlorine present will be rapidly and completely deactivated by the soil. Plant damage has been reported from irrigation with swimming pool water. This damage, however, is primarily caused by the high salt concentration of some pool water rather than from active chlorine (Nakayama and Bucks, 1991)

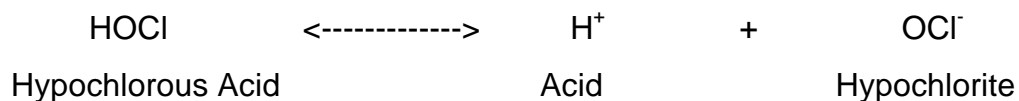
If the supply water contains low amounts of microorganisms, periodic (weekly) injection at a higher concentrations is usually effective. To reclaim systems that have bacterial-plugged emitters may require superchlorination with concentration levels as high as 500 ppm. However, superchlorination may damage plants and irrigation

system components. Chlorine has different effects, depending on its concentration. At low concentrations (1 - 5 ppm), chlorine acts as a bactericide and an oxidizer of iron, while at high concentrations (100 - 500 ppm) it can effectively oxidize organic materials, and can be used to disintegrate organic materials that may have accumulated to plug emitters (Abbott, 1985). **Caution:** If emitters have components made of silicon or other materials that may be sensitive to chlorine treatment, contact the emitter manufacturer to verify emitter resistance to superchlorination.

When chlorine is injected into water, the *free chlorine* is composed of two compounds: hypochlorous acid (HOCl) and hypochlorite (OCl<sup>-</sup>). The reaction is shown below for chlorine gas.



The HOCl dissociates in a pH-dependent equilibrium as follows:



The concentration of hypochlorous acid versus hypochlorite varies with the water pH. At low pH, more of the chlorine is present in the HOCl form. Hypochlorous acid (HOCl) is approximately 60 times more powerful as a biocide than hypochlorite (Boswell, 1990). For more economical chlorine treatment, alkaline water should be acidified, so that hypochlorous acid (HOCl) predominates.

*Example Problem 11.2:* At a pH of 7.5 it was determined that a chlorine injection rate of 10 ppm was required to maintain 1 ppm 'free' chlorine at the end of the last lateral. Estimate the liquid chlorine injection rate required following acidification which lowered the irrigation water pH to 6.5.

*Answer:* HOCl concentration at pH 7.5 = 45 % and at pH 6.5 HOCl = 90%.

$$0.45 \times 10 \text{ ppm} = 0.90 \times M, M = 5 \text{ ppm}$$

Chlorine concentration can be measured with test kits. The analysis should be for free chlorine; total chlorine test results are not as meaningful as those measuring 'free chlorine'. Achieving a specific free residual chlorine level must be done by trial and error. The reason is most water has an inherent chlorine demand. Chlorine will react with suspended organic matter, soil particles, and other dissolved constituents. For example, hydrogen sulfide will use approximately 2 ppm chlorine for each ppm of sulfide, while iron will use approximately 0.7 ppm chlorine for each ppm of iron (McGowan, 1988).

For establishing the starting point for liquid sodium hypochlorite injection, use the following formula:

$$I_{Cl(\text{liquid})} = (0.006 \times P \times Q) / m \quad \text{Eq. 11.1}$$

where,

- I = gallons of liquid sodium hypochlorite injected per hour,
- P = parts per million desired,
- Q = system flow rate in gpm,
- m = percent chlorine in the source, normally 5.25% or 10%.

*Example Problem 11.3.* Determine the liquid chlorine injection rate given the following conditions: 1) chlorine source is 10 percent solution, 2) system flow rate is 500 gpm, 3) desired concentration is 5 ppm.

*Answer:*  $(0.006 \times 5 \times 500) / 10 = 1.5 \text{ gph}$

When injecting chlorine gas, use the following formula:

$$I_{Cl(\text{gas})} = (0.012 \times P \times Q) \quad \text{Eq. 11.2}$$

where:

- I = chlorine gas injection rate (lbs/day),
- P = parts per million desired,
- Q = system flow rate in gpm,

*Example Problem 11.4.* Determine the gas chlorine injection rate given the following conditions: 1) system flow rate is 500 gpm and 2) desired concentration is 5 ppm.

*Answer:*  $0.012 \times 5 \times 500 = 30 \text{ lb/day}$

***Notes of precaution for chlorine injection include:***

1. The water acidification and chlorine injection should be done at two different injection ports; mixing acid and liquid chlorine in the same tank will produce highly toxic chlorine gas. *Never store acids and chlorine together.*
2. Because the chlorine may attack the organic composition of some herbicides and pesticides, these chemicals should not be injected when chlorine is being injected.
3. *Always add chlorine to water, not vice versa.*
4. Inject chlorine upstream of the filter to help keep the filter clean and so the filter can remove precipitates that may be caused by the chlorine injection.
5. Liquid chlorine tends to deteriorate with time. Storage tanks for the solution should be shielded from the sun to reduce such degradation and the chloric should be used as soon as possible.

Gas chlorination is an economical method of controlling bacterial slime deposits in micro irrigation systems where continuous chlorination is required. Gas chlorine is contained in steel cylinders and does not lose its strength in storage, whereas liquid sodium hypochlorite loses its effectiveness in storage. The newer gas injection systems only allow chlorine to be delivered under a vacuum. The gas is drawn from the tank by a venturi, which is driven by water flow. If the vacuum line breaks or if any part of the vacuum system is damaged, gas shuts off immediately (Chlorinators Inc., 1993). Figure 11.2 shows a chlorine gas injection system.

**Acids**

***As previously noted, acid treatments enhance the effectiveness of chlorine. In some cases, acids may be sufficient by themselves to eliminate small slimy bacteria. Typical acids are:***

Sulfuric acid

Phosphoric acid

Muratic (Hydrochloric) acid

Urea-sulfuric (e.g., N-pHURIC®)

Citric acid

As previously noted, acid treatment, or pH adjustment, is an effective way to control the precipitation of calcium carbonate. Calcium solubility is temperature and pH dependent. The Langelier Saturation Index (see Appendix L - Module 6) is a method for determining the tendency for  $\text{CaCO}_3$  scale to form. By measuring the TDS, alkalinity, and Ca level of a water, the saturation (calcium) pH can be predicted. If the saturation pH is lower than the measured pH, then  $\text{CaCO}_3$  precipitation would be expected to occur. Changes in pH can occur spontaneously, especially if ground water, under high hydrostatic pressure, is pumped to the surface and exposed to the atmosphere. The release of  $\text{CO}_2$  will cause the pH of the water to rise and increase the potential for  $\text{CaCO}_3$  precipitation.

***Long-term use of acidic nitrogen fertilizer for bacterial control must be done with caution because nitrogen should not be applied to some crops near harvest. Also the pH of the soil may be lowered with time by adding acid.***

The use of phosphoric acid is not recommended if the irrigation water has a high calcium content because of the possibility of calcium phosphate precipitation. Calcium phosphate is very insoluble and not readily dissolved with subsequent acid injections. In general, if there is more than 50 ppm calcium in the irrigation water, phosphoric acid should not be injected (Burt et al. 1994). Phosphoric acid injections which lowers the irrigation water to pH 3.0 for line purging can be employed. The low pH minimizes calcium phosphate precipitation. Problems may still occur during addition of acid and purging of system because of higher pH due to mixing at the interface.

The amount of acid required to drop the pH must be determined through titration tests with samples of the irrigation water. A titration curve (relationship between water pH and the amount of acid added) is unique for each water source and type of acid. Since water quality can change over time, titration should be run occasionally. At least

1 gallon of irrigation water should be used, along with an eye dropper. The irrigation water should be stirred to ensure complete mixing of the acid before the pH is measured. An estimate of the amount of N-pHURIC acid required to neutralize excess bicarbonate can be obtained from Table 11.3.

Acids require special filters and injection pump gaskets. Check with the manufacturer of the equipment before acid treatment to ensure compatibility. Chemical injection ports should be designed to protrude into the center of the pipeline to ensure adequate mixing of the acids with the water. **CAUTION: Always add acid to water; do not add water to acid. Adding water to acid can cause a violent reaction, causing the acid to splash on the person pouring the water. Also, be sure that adequate safety devices are provided, including a shower and eyewash.**

Table. 11.3. The quantity of N-pHURIC acid fertilizer required to neutralize **50 %** of the bicarbonate in 1000 gallons of water at various alkalinity levels.

Alkalinity (as CaCO <sub>3</sub> )	N-pHURIC 28/27 (oz /1000 gal)	N-pHURIC 15/49 (oz /1000 gal)	N-pHURIC 10/55 (oz /1000 gal)
50	7	4	3
100	13	7	6
150	20	11	9
200	27	14	12
250	33	17	15
300	40	21	18
350	47	24	21
400	53	27	24

(Unocal, 1996: N-pHURIC reference manual).

### Synthetic Compounds

Compounds such as polyphosphates, phosphonates, polymaleic acid (PMA), and polyacrylic acid (referred to as PAA or PAM) have been used for many years in

municipal and cooling tower applications. Some of these compounds are noted for their scale removing properties, while others prevent scale formation by sequestering iron. It is well documented that these compounds have been successful in various applications for preventing scale buildup, and some are currently sold for prevention of scale and sequestration of iron in micro irrigation systems. Sequestration is a process that keeps the metal ions in suspension without removing them from the water. This is commonly accomplished by neutralizing the particle's electrical charge. These compounds can offer some substantial benefits due to their safety and ease of handling (as opposed to acid, for example) and the lack of registration problems (they are often registered for drinking water applications). However, the water chemistry in drip systems may differ significantly from that of a cooling tower or municipal treatment systems, so direct adoption of the technology for micro irrigation systems may not be successful (Burt et al. 1994). There is still uncertainty regarding exactly which compounds should be used, for what conditions, and at what concentrations. There has been almost no documented independent research that confirms manufacturer or vendor claims as to the effectiveness of these products in micro irrigation systems.

Based on limited experience, the best anti-plugging formulations may well be a mixture of various polymers and compounds, each with a different function. Such a broad-spectrum formulation might be satisfactory for the three major clogging problems: slimy bacterial growth, iron and manganese, and calcium and magnesium precipitation. Such commercial broad-spectrum formulations have already been developed.

The following is a discussion of some of the water amendments commonly used by vendors providing water treatment materials for micro irrigation systems in Florida.

#### Polyphosphates

Polyphosphates have been used in municipal water treatment for over 60 years. They usually contain a range of linear chain polyphosphates with different numbers of orthophosphate ( $\text{PO}_4$ ) groups that are held together by P-O-P linkages. The average chain length, as measured by the number of phosphorus atoms per chain ranges from 4.5 upwards to 18 in commercial polyphosphates (Holm and Schock, 1991). Thus,

there are significant difference between the various compounds known as polyphosphates.

For reasons relating to the structure of the molecule, polyphosphate ions vary in complex strength formed with different metals. One compound might bind metals in the order  $\text{Ca} > \text{Mg} > \text{Fe}$  (strongest first), whereas another compound might bind in the order  $\text{Fe} > \text{Ca} > \text{Mg}$ . The complex concentration formed in solution is a function of the metal ion and the polyphosphate concentrations, as well as the stability constant of the complex. Therefore comparisons of chemical efficiencies are somewhat complicated and depend on specific water chemistry (Burt et al., 1994).

One of the earliest polyphosphates to be developed was Calgon® ("Calcium-be-gone"), which is sodium hexametaphosphate, a short chain polyphosphate. Arceneaux (1974) reported that polyphosphates were used effectively 20 years ago in the chemical treatment of wells to disperse iron hydroxide, iron oxide, and manganese, and that the chemicals were safe to handle. Dart (1983) noted that typically polyphosphates cannot sequester more than 1 to 2 mg/L of iron concentration, and the dosage should be 2 to 5 times the iron concentration.

Robinson et al. (1990) reported on a study of polyphosphates effectiveness in sequestering iron and manganese. Their conclusions were pertinent to micro irrigation system maintenance and were as follows:

1. Polyphosphates prevent the oxidation of manganese by chlorine. No significant differences were seen between several polyphosphates tested, in their performance for sequestering manganese.
2. Polyphosphates sequestered iron. Significant differences were found between the sequestering ability of different polyphosphates for iron.
3. Some polyphosphates lose their potency with long storage times.
4. Different water suppliers report quite different successes from polyphosphate use.
5. Iron is oxidized from the ferrous ( $\text{Fe}^{2+}$ ) to the ferric ( $\text{Fe}^{3+}$ ) form during sequestration, but manganese is not oxidized by the polyphosphates.

### Phosphonates and Polyelectrolytes

Phosphonates have also been used in municipal water industries as a scale inhibitor. Structurally, phosphonates differ from polyphosphates in that they are formed by direct bonds between phosphorous and carbon in contrast to the oxygen-phosphorus linkage (Burt et al., 1994). A specific brand of phosphonate, ESI-50, was reported by Schwankl and Prichard (1990) to reduce calcium precipitation problems in drip systems if applied continuously or during the last 2 hours of irrigation.

A polymaleic anhydride anionic, terpolymer, is currently sold for the purpose of sequestering iron and manganese. Iron and manganese ions attach to this polymer and pass through the irrigation system rather than oxidizing and precipitating in the lines and emitters (Burt et al., 1994). Manufacturers claim these compounds provide de-scaling of certain precipitates, including calcium phosphates and calcium carbonates.

### Copper Sulfate

Copper sulfate is occasionally used to prevent bacterial growth in micro irrigation systems. Chlorine has been found to be more effective, less expensive, and to cause fewer plant toxicity and aluminum corrosion problems. However, copper sulfate is now included in some commercial drip line cleaning mixtures together with citric acid to reduce slimy bacterial growth. Copper sulfate is commonly used for pond treatment to suppress algae. However, even at high concentrations (30 ppm), copper sulfate will not be completely effective because algal spores can exclude the copper sulfate (Burt et al., 1994).

### Iron and Manganese

Emitter plugging from iron precipitates and iron-reducing bacteria is especially difficult to control. In southern Florida, these iron problems cause very serious emitter plugging problems. The presence of dissolved iron in irrigation water is usually caused by microbial activity (Nakayama and Bucks, 1991). Even very small iron and manganese concentrations (less than 0.2 ppm) are sufficient to provide enough bacterial growth to cause problems. Iron bacterial growth generally appears reddish, whereas manganese bacterial growth is more black in color. These bacteria oxidize

iron or manganese from the irrigation water as an energy source. Precipitation of the iron and rapid growth of the bacteria create a large volume of material that can completely plug a drip system in a matter of a few weeks. These bacteria are notoriously difficult to kill, partly because they may live in the irrigation well. Periodic acid or chlorine treatments of the well are sometimes effective.

It is unclear whether iron bacteria exist in groundwater before well construction and simply multiply as the amount of iron increases due to pumping, or whether they are introduced into the aquifer from the subsoil during well construction (Driscoll, 1986).

Water well drillers should use great care to avoid introduction of iron bacteria into the aquifer during the well drilling process. All drilling fluid should be mixed with chlorinated water at a 10 ppm free chlorine residual (Driscoll, 1986).

Polyphosphates and polymaleic acid can effectively sequester iron and manganese so that they remain suspended and move through the irrigation system. If the iron concentration is less than 3.0 ppm, this is the most common and likely the most economical treatment. However, at higher concentrations of iron, polyphosphates are not always effective nor likely the most economical solution. Economics will dictate alternative treatments.

Since chlorine compounds are effective oxidizing agents, they can be used to precipitate iron or manganese. This can be an effective means of removing these troublesome elements from the irrigation water. Chlorine gas injection prior to a fine media or disc filter to precipitate the iron has been demonstrated to be effective (Barr, 1995). It is essential that the mixing be thorough. Chlorine will also kill the bacteria that oxidize iron and manganese, thus eliminating these growths. However, as mentioned above, the iron will precipitate out of the water with the chlorine injection, so it must be removed with filtration.

Another solution is to pump well water into a reservoir and aerate (i.e., oxidize) it. The iron and manganese then precipitate out in the reservoir before the water is picked up by a booster pump for irrigation. Chlorination is still required since the reservoir water now has characteristics of surface water.

Iron and manganese oxides can form without bacterial action. This generally occurs after the irrigation system has shut down and the contact with air causes the iron to precipitate from the water left in the line.

#### Iron and Manganese Sulfides

Dissolved iron and manganese in the presence of sulfides can form a black, insoluble ***precipitant***. A combination of greater than 0.6 ppm iron and greater than 2.0 ppm total sulfides present in the water will generally create an iron sulfide sludge (Huntmacker et al., 1994). Iron is a major problem for emitter plugging. While manganese is toxic to many crops at very low concentrations and may damage the crops by toxicity before plugging becomes a problem. The problem with sulfides is almost exclusively associated with well water, and the well casing can become clogged rapidly. Wells which draw water from two formations, one high in sulfides and the other high in iron, are candidates for this type of problem. Treatment for iron sulfide includes a combination of aeration, acidification, and chlorination.

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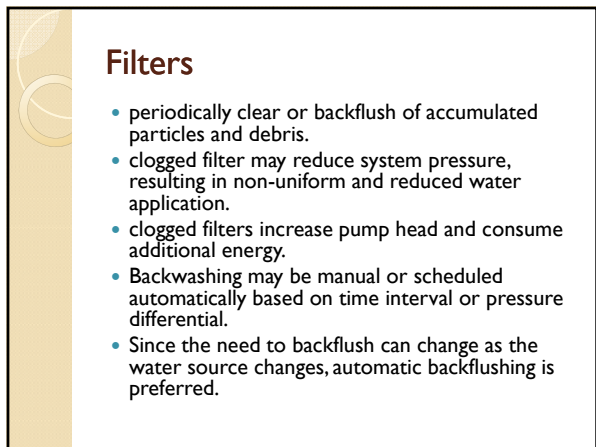
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### Injection

- All systems should be designed with injection in mind.
- Reasons for chemical injection
  - Emitter plugging
  - Enhancing water infiltration into soil
  - Fertigation
  - Pesticides
  - Soil pH modification

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- Chemicals may be injected into pressurized drip systems via a variety of methods including positive displacement pumps, differential pressure tanks, and venturi-type suction devices.

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- Injection should occur upstream of the filter
- BEFORE INJECTING ANY CHEMICAL, OR BEFORE MIXING AND CHEMICALS, A "JAR" TEST SHOULD ALWAYS BE PERFORMED.

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### Jar test



These pictures show the results of a 24-hour test. An alternative fertilizer was chosen rather than this one.  
... courtesy of Torro Irrigation

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### Other considerations

- Chemical compatibility, if more than one chemical is injected at the same time,
- Some chemicals are best applied at the beginning of the irrigation event, others towards the end.
- When scheduling chemigation events, the duration of operation must exceed the chemical travel time in order for all emitters to receive chemical.

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- The system operated with clean water after a chemical application
- The following guidelines may be used as a rule of thumb (Schwankl, 2001):
  - Trees and vines – injections should last at least 1 hour, and at least 1 hour (longer is better) of clean water irrigation should follow it.
  - Row crop drip – injections should be at least 2 hours in length, and there should be at least 2 hours (longer is better) of clean water irrigation following injection

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### Safety Considerations

- Regardless of the injection system type, proper safety equipment must be employed to prevent chemicals from contaminating the water source or the surrounding environment, and to prevent chemicals from being injected without water being pumped.

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## Emitter plugging

- Clogging can occur by chemical precipitation of minerals, non-filtered particulate or organic matter, root intrusion and sometimes the combination of these
- Clogging effects discharge, uniformity and plant productivity

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PHYSICAL FACTORS (Suspended solids)	CHEMICAL FACTORS (Precipitates & others)	BIOLOGICAL FACTORS (Bacterial growth)
Inorganic particles Sand Silt Clay Plastic Metal	Calcium &/or magnesium carbonates Calcium sulfate Heavy metals Hydroxides Carbonates Silicates Sulfates	Filaments
Organic Particles (Aquatic organisms) Zooplankton Snail Fish	Oil and other lubricants	Slimes
Organic Particles (Non-aquatic organisms) Insect larva Ant Fish Spider	Fertilizers Phosphate Aqueous Ammonia Iron, copper, zinc Manganese	Microbial ochres Iron Sulfur Manganese

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## • Chemical precipitation

### ◦ Iron and Manganese

- Options
  - Aeration – discharge into a pond sit 12 -24 hrs
  - Inject oxidizer upstream of filter, most is chlorine
  - Inject a polymer to sequester and keep in solution, (polyphosphates)
  - Use special sand called “green sand”, in a deep media filter

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## Calcium and Magnesium Carbonate



- Prevention/treatment
  - Acid injection
  - Gas injection ( $\text{SO}_2$ )
  - Polymer injection (safe to handle)

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## Root intrusion



- Prevention
  - Keep irrigations frequent and avoid deficit irrigation
  - Minimized if acidic fertilizers are used
  - Chemical injections to stop roots or lower pH
- Once emitters have become plugged about the only option is to replace the tape.

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## • Biological

- Slimy Bacteria
  - Bacteria growing on interior walls of hose and emitters. Clay particles attach to the bacteria compounding the problem.
- Prevention
  - Chlorine – liquid or gas

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## Chlorine Treatment

- **Continuous**
  - To precipitate iron or manganese oxides prior to the filtration system
  - Where organic loading of the water source is very high
  - For controlling bacterial and algae growths that are excessive
  - For continuous chlorination a residual level of 0.5 – 1 mg/L should be sufficient.
- **Intermittent Chlorine Treatment**
  - chlorination level should be 10 - 20 mg/L and held for at least one hour.
    - If the free chlorine level at the ends of the laterals are well below the original concentration more frequent chlorination may be required.
    - If the free chlorine levels at the end of the lateral are close to the concentration at the injection point, fewer treatments can be applied over the course of the irrigation season.

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- **Superchlorination**
- Used if emitters are totally plugged by organic matter.
  - The chlorination levels from 200 - 500 mg/L.
  - chlorine levels should be kept in the system for 24 hours.

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### Recommendations for a chlorination program

- The duration of chlorine application is as important as the concentration. Treatments of 10 mg/L for 4 hours may be more effective than 40 mg/L for 2 hours. Exceeding 4 hours appears to give no further improvement in system performance.
- 
- The maximum chlorine concentration injected should not exceed 40 mg/L. Concentrations exceeding 40 mg/L may enhance the precipitation of calcium or magnesium carbonate.
- 
- Chlorine should not be injected continuously unless specifically used to precipitate ferric oxide.
- 
- If plugged emitters cannot be cleared with a chlorination treatment of 40 mg/L for 4 hours, Superchlorination, an acid treatment or manual cleaning may be necessary.
- 
- Lateral line flushing should always be done in conjunction with chlorination programs. The chlorine will kill living organisms but not dissolve them. Flushing is required to remove the material from the trickle system.

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### Water Quality Guide

TYPE OF FACTOR	MINOR	MODERATE	SEVERE
<b>Physical</b>			
Suspended solids <sup>a</sup>	50	50-100	>100
<b>Chemical</b>			
pH	7.0	7.0-8.0	>8.0
Dissolved solids <sup>a</sup>	500	500-2,000	>2000
Manganese <sup>a</sup>	0.1	0.1-1.5	>1.5
Total iron <sup>a</sup>	0.2	0.2-1.5	>1.5
Hydrogen sulfide <sup>a</sup>	0.2	0.2-2.0	>2.0
Carbonate+bicarbonate <sup>a</sup>	50.0	50-100	>100
<b>Biological</b>			
Bacterial population <sup>b</sup>	10,000	10,000-50,000	>50,000

<sup>a</sup>Maximum measured concentration from a representative number of water samples using standard analytical procedures for analysis in ppm (mg/L).

<sup>b</sup>Maximum number of bacteria per milliliters can be obtained from a portable field sampler using standard analytical procedures for analysis.

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## Handout Kansas Water Quality Guide

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## Practice problem



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## Microsprinkler Emitter Wear

- Wear on emitter orifices over long periods of operation can significantly increase the orifice diameter and therefore flow rates and wetting patterns, especially if the water contains sand.
  - OC and VC emitters, flow rates start to increase after about 2,000 hours of operation, in the range of 8-11%
  - PC emitters, after 2,000 hours of operation, the flow rate starts to decrease in the range of 8% less than initial values.

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### Rodents

- Rodents and insects are known to chew polyethylene laterals
  - Rigid pipe
  - Alternative water sources
  - Burial depth
  - Maintain wet soil along entire lateral (emitter spacing)

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### Hand out O & M Flowcharts

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## Hand out Diagnosing and avoiding...



Diagnosing and Avoiding Damage to Drip Tape

Drip-Micro CIG of The Irrigation Association

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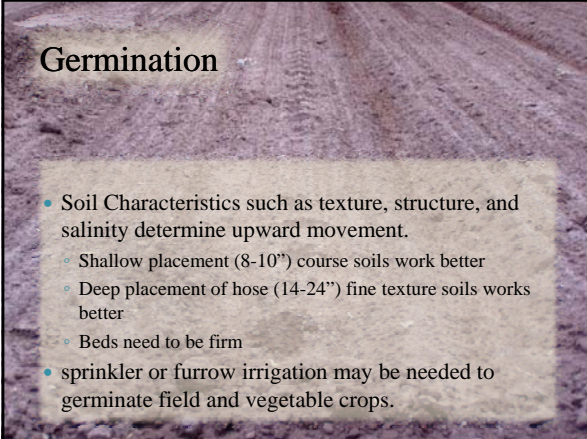
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## Germination

- Soil Characteristics such as texture, structure, and salinity determine upward movement.
  - Shallow placement (8-10") coarse soils work better
  - Deep placement of hose (14-24") fine texture soils works better
  - Beds need to be firm
- sprinkler or furrow irrigation may be needed to germinate field and vegetable crops.

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## Freeze Protection

- Microsprinklers can protect young trees and partially protect mature trees - generally don't protect fruit.
  - Raise the dew point or frost point
  - Heat released as water vapor is converted to ice crystals – rate of air cooling slows
  - Moist air rises and condenses higher in canopy
  - Sometimes create fog, reducing radiation loss
  - If enough water is continuously applied to a plant, the heat generated when water freezes can keep the plant at or near 0°C.
  - At very low temps, low humidity, or high winds, more water must be applied to get adequate protection.

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- Ice on leaves and wood protect tree
  - Lower leaves in the direct water spray zone stayed above freezing and were as much as 7.8°C warmer than dry leaves in non-irrigated plots (Parsons et al., 1981).
- Improper irrigation can increase evaporative cooling or ice loading and cause greater damage

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## Freeze Protection

- Young trees - microsprinkler must be close enough so that water sprays directly on the trunk and lower part of the tree.
  - 90° or 180° pattern concentrate the water provide better protection than 360° patterns.
  - Too far - wind can blow the water away.
  - If the water freezes before it hits the tree, milky white ice can form - protection is usually not as good as for clear ice.
  - Microsprinkler - upwind side 15-25 ft from trunk
  - Dense canopy retains heat from the soil
- Mature trees - greatest benefit in calm frosts
  - Several examples of improved recovery following windy freezes.
  - In a relatively calm frost, microsprinklers benefited trees over 13 ft tall.
- In general, higher water volume provides more effective the cold protection.
  - Generally about 34 gpm/acre.
  - High application rates can exceed a soil's infiltration rate -- ponding and runoff.
- Systems designed for 7-8 gpm/ac in Wash. to meet max crop use req.
- Frost protection increases initial costs by 30- 40% & increased annualized costs 10% (Snyder et al., 1996).



### Salinity

- Salts tend to concentrate at the soil surface and below the surface at the perimeter of the soil volume wetted by each emitter.

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### Hose and seed placement

- Seed, planted below
- Seed, planted below
- Seed, planted below

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### Rain

- Light rains can move salts into the root zone
  - For rain of less than 2 in., operate irrigation system
  - If this soil dries between irrigations, reverse movement of soil water may carry salt from the perimeter back toward the emitter.

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## Leaching and Reclamation

- Leaching - process of applying irrigation water in excess of soil moisture depletion to flush salt from the root zone.
- Types of leaching
  - Maintenance - maintain soil salinity at a more or less constant level over time
  - Reclamation - periodic leaching to reduce accumulated salts in the soil to an acceptable level
- Drip tape can be used for both leaching and reclamation

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## Leaching and drip irrigation

- Leaching conditions
  - Localized leaching occurs around the drip line
  - Soil salinity is the smallest near the drip line; reflects the amount and salinity of the irrigation water
  - Soil salinity is the highest near the periphery of the wetted pattern
  - The leaching fraction is the largest beneath the drip line or emitter
  - The leaching fraction decreases with distance from the drip line
  - Low salt zone increases as amount of applied water increases

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## Leaching and drip irrigation (continued)

- No leaching condition – soil salinity is the highest near the drip line
- Buried drip lines – no leaching above the drip line; rainfall/sprinkle irrigation needed for leaching
- Difficult to estimate actual leaching fractions
- Factors affecting salt distribution
  - Salinity of irrigation water
  - Amount of applied irrigation water
  - Salinity of ground water
  - Depth to water table
  - Soil texture

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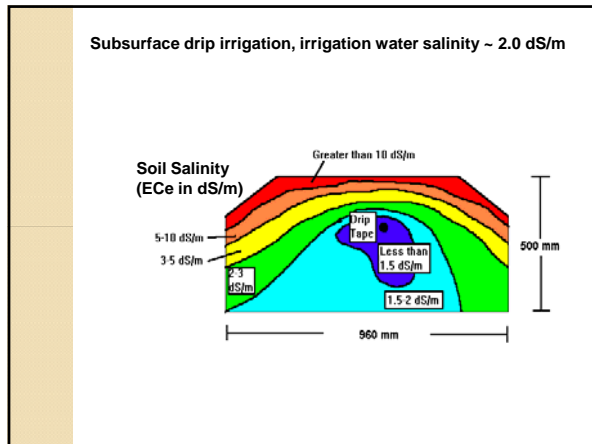
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### Soil Backsiphoning

- Occurs usually at the beginning of buried hoses and tapes
  - Air relief installed downstream of all shut-off valves and high points of manifolds
  - Vents should be installed so they don't become a source of contaminants

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- On steep ground at shut-off tapes rapidly collapse at the inlet even if there are air vents on the manifold.
- A steep slope may be as low as 0.5% if the tape is very long.
- On steep ground hose lengths may need to be relatively short even if the hydraulics program indicates that it is OK

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### Air value - manifold placement

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## Unequal Drainage

- EU greatly effected
- Long and large diameter tapes hold large volumes of water, if the field is sloping the downstream emitters will continue to have pressure long after shut-off. Upwards of 20 hours
- Options
  - Anti-drain emitters
  - Special drain valves at the end of lateral

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## Pulsing

- Not practical in most cases
- Need combination of the following
  - Non-drain
  - Very small blocks
  - Very short hoses
  - Flat ground
  - Spring loaded check valves at the head of hoses

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## Pulsing/High frequency Irrigation



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Drip Irrigation System Maintenance Tips for the Growing Season				
What to Check	Frequency	Compared to What	What to Look For	Possible Causes
Pump flow rate and pressure for each zone	weekly	Original or low flow rate	High flow and/or low pressure Low flow and/or high pressure	Leak in pipeline Closed flow valve Closed flow valve Blocked or restricted Air in pipeline Pump malfunction Well problems
Pressure difference across filter	Every irrigation	Manufacturer's specifications	Exceeds or is close to maximum allowable	Filter becoming clogged Obstruction in filter
Operating pressure at ends of laterals	Monthly, unless other checks indicate possible clogging	Backflow pressure	Pressure greater than expected Pressure lower than expected	Pressure clogging Obstruction in pipe Broken lateral leads to lateral line valve pressure
Water at lateral ends & flush valves	As needed	Water source	Particulate in water Other debris	Broken pipeline Leak in filter screen Near to filter mouth Clogging under flow Clogging filter problems Clogging of filter Low flow rate High flow rate, the filter clogging
Overall pump station	weekly	Manufacturer's specifications	Leak, trouble, engine power is low, tank level	Power maintenance Old equipment
Injection pump settings	weekly	Calibrated settings at start up	Proper setting for length of pipe/zone	
Overall system	weekly	System at start up	Blockage or clogging at ends of laterals Leak in pipe Adding air	Leakage possible both up of material, broken pipe, and/or the filter line Leak or mechanical damage Leak at the pump Leak between high pressure Leak may also be affected by particles Leak clogging Leakage, or broken

Torro Irrigation  
Owners Manual

## Hand out Drip Maintenance