# Irrigation system maintenance: chlorination and acidification

**By Tom Obreza, Ed Hanlon and Mongi Zekri**

Water quality is a major concern in the management of microirrigation systems. Emitters have small openings which make them vulnerable to clogging by particulate matter, organic growth or chemical precipitate from the irrigation water. Algal and bacterial growth is a potential problem associated with the use of surface water, and high levels of minerals that can precipitate and form scale are present in groundwater. Therefore, effective and reliable water filtration and chemical injection into irrigation systems must be considered for proper maintenance and successful irrigation operation. The following sections provide information on potential emitter-clogging problems and maintenance procedures that should be taken.

## CHLORINE INJECTION

The least expensive treatment to control algae or bacterial slime that can plug a microirrigation system is chlorine injection to obtain 1 part per million (ppm) of free chlorine at the end of the system. To be effective, the amount of chlorine needed to achieve 1 ppm concentration at the far end should be injected *each* time the irrigation system is used. This technique is called continuous chlorine injection. The intent is to continuously introduce free chlorine at a relatively low concentration to prevent organic growth in the irrigation system.

Super-chlorination — the so-called "shock" treatment — does not require continuous free chlorine injection because it is usually done every one to two weeks. With this method, a concentration of about 50 ppm free chlorine should be achieved at the end of the system. Take care if superchlorinating because this method may damage sensitive plants and irrigation system components. For more details regarding chlorination, see "Treating Irrigation Systems with Chlorine" (http://edis.ifas.ufl.edu/AE080) and "Dealing with Iron and Other Micro-Irrigation Plugging Problems" (http://edis.ifas.ufl.edu/ss487).

## SCALING

Chemical scaling is caused by precipitation of calcium or iron. These elements, usually associated with limestone or iron oxides, are often dissolved in the irrigation water source. Using this water for irrigation without treatment for calcium or iron can lead to scaling and ultimately plug the emitters or even irrigation system pipes.

### Calcium Scaling and Treatment

Preventing calcium from forming scale within the irrigation system is preferable to treating scale that has already formed. Calcium scale may be easily prevented with the injection of an appropriate concentration of acid, which allows the calcium to remain in solution so it can exit the irrigation system harmlessly. Typically, sulfuric acid and hydrochloric acid are the least expensive choices for this purpose. While any source of acid may be used to treat the calcium condition before it forms scale, all acids pose safety concerns regarding storage as well as personal safety. For more information regarding calcium scaling prevention, see "Neutralizing Excess Bicarbonates From Irrigation Water" (http://edis.ifas.ufl.edu/SS165) and "Maintenance Guide for Florida Microirrigation Systems" (http://edis.ifas.ufl.edu/SS436).

| Plugging hazard based on concentration | | | | |
|---|---|---|---|---|
| **Measurement** | **Units** | **Slight** | **Moderate** | **Severe** |
| Suspended solids[1] | ppm | < 50 | 50 – 100 | >100 |
| *pH* | | < 7.0 | 7.0 – 7.5 | > 7.5 |
| Total dissolved solids[1] | ppm | < 500 | 500 – 2000 | > 2000 |
| *Iron*[1] | ppm | < 0.1 | 0.1 – 1.5 | > 1.5 |
| Manganese[1] | ppm | < 0.1 | 0.1 – 1.5 | > 1.5 |
| Calcium[1] | ppm | < 40 | 40 – 80 | > 80 |
| *Alkalinity as $CaCO_3$*[1] | ppm | < 150 | 150 – 300 | > 300 |
| *Hydrogen sulfide*[1] | ppm | < 0.2 | 0.2 – 2.0 | > 2.0 |
| Bacteria | #/mL | < 10,000 | 10,000 – 50,000 | > 50,000 |

[1]Concentration as mg/L or parts per million (ppm)
Factors in *italics*: Measure in the field if at all possible.

## Iron Scaling and Treatment

Scaling caused by iron is much more difficult to deal with than scale formed by calcium. Iron is abundant throughout the earth, composing up to 5 percent of the earth's crust. Hence, iron compounds are common. Irrigating with iron-rich water may result in staining, not only of equipment, but also of foliage. Within the irrigation system itself, iron scaling can reduce flow in pipes and clog emitters. When iron concentrations exceed 0.3 ppm, staining and scaling conditions exist.

Iron chemistry is complex because ionic Fe can exist in two forms. The reduced cationic form, exhibiting two plus charges, is the ferrous form ($Fe^{2+}$). The ferrous form may be introduced into the irrigation system with the source water because this form of iron is soluble. Chemical conditions may change within the irrigation system, resulting in formation of a highly insoluble oxidized form with three positive charges (ferric, $Fe^{3+}$). It is the ferric form that causes scale within the irrigation system. The maximum amount of ferric iron that can be retained in solution as ferric oxide is 0.6 parts per billion (ppb).

The conversion from ferrous (soluble) to ferric (insoluble) form is affected by several chemical parameters, the most important of which are oxygen content and water pH. The ferrous form results when oxygen content of the water is low, such as in groundwater of many aquifers. When water is pumped from these locations into the irrigation system, the water moves from an anaerobic condition to an aerobic condition with much higher oxygen concentration. When the ferrous form is exposed to oxygen, the result is a rapid conversion to the ferric form, with subsequent iron oxide precipitation (scale). The pH of the water has an effect on the rate of this conversion as well. The higher the pH, the faster will be the conversion.

### CONTROLLING IRON SCALING

The first step in controlling scaling of any type is to complete field and laboratory tests on the irrigation water source. The accompanying table above provides interpretations for laboratory water test results, indicating the potential hazard to plug a microirrigation system.

### USE OF A SEDIMENTATION POND

A sedimentation pond allows the aeration of the source water, and hence the precipitation of ferric iron, before the water is introduced into the irrigation system. Well water is pumped into a pond allowing equilibration of the water with the atmosphere. As oxygen enters the water, ferric iron is formed and precipitates as iron oxide. Factors affecting the time needed for precipitation include water temperature, wind speed, depth and mixing of the water, aeration and wave action. A good first estimate for the minimum time required is several hours, especially if air is pumped into the water below the surface. After the iron precipitates, water is removed from the pond and conveyed into the irrigation system for subsequent filtering and distribution.

#### Advantages of a Sedimentation Pond

A sedimentation pond permits the removal of iron from the system without any chemical treatment, leaving behind iron scale in the pond itself. Since most Florida aquifers are composed of limestone, initial water pH from these aquifers is quite high. The sedimentation pond, in addition to oxygenating the water to remove ferric iron, also allows time for the equilibration of the water with the atmosphere and the dissipation of carbonates and bicarbonates. As the carbonates and bicarbonates dissipate from the water source, the initial high water pH is lowered 1 to 2 pH units, improving water quality for irrigation.

Unfortunately, while the sedimentation pond improves water quality with respect to both iron and high pH, it is an open water source. The pond is likely to introduce organic particulates and living organisms into the irrigation system and higher levels of filtration will likely be required.

## IRRIGATION LINE MAINTENANCE CHEMICALS

In situations where iron has already formed, or as a preventive measure in situations where iron scale has been problematic for other users of the same water source, scale can be controlled by injecting appropriate chemicals, which are grouped according to their reactions.

Inorganic acids react quickly with water and solids to help prevent scale formation. The reaction is partially controlled by regulating the strength of the acid through dilution with water. In some cases, these acids may also supply nutrients after they have reacted in the irrigation system.

Chelating agents are organic compounds that sequester or occlude iron from further reactions by binding to the iron, removing it either as a free agent in solution or as scale. The iron is held by the chelating agent, and the combined molecule flows out of the irrigation system. In some cases, the iron and other elements chelated by this group of chemicals may later serve as a nutrient source for the crop.

The last chemical group is the reducing agents. These chemicals cause ferric iron to revert to ferrous iron, greatly increasing the solubility of the iron, which may then exit the irrigation system in solution. This group of chemicals can be quite reactive and should be handled and stored safely. Some of these chemicals are the byproducts of industrial processes, contributing to a so-called green reuse in the treatment of scale.

### Scale Removal from Irrigation Lines

In addition to preventing iron scaling, many of these chemicals may help remove iron scale from irrigation tubing. The irrigation manager should understand that preventing scaling from forming in the first place is usually much more effective than trying to restore an iron scale-impaired system.

Research using selected chemicals indicates that some chemicals are much more effective at removing the iron scale from tubing than others. Sodium hydrosulfite proved to be quite effective at removing scale. This reducing agent is also used to bleach paper and can present handling and safety issues for agricultural use that should be built into the farm safety program. However, this chemical is readily available from many sources, and proved to be the best chemical for removing scale.

The next best chemical was a chelating agent, citric acid, which is readily available from many sources and does not pose the same level of handling problems as sodium hydrosulfite.

### Potential Problems for Treating Existing Iron Scale Irrigation Systems

When any of these chemicals are introduced into a system that has been affected by iron, scale on the tubing walls may be removed. However, it is likely that some scale may flake off as a result of the treatment process, rather than being completely dissolved. The resulting iron scale flakes may in turn cause plugging at the emitter as the small particles build up. To avoid this potential problem, the irrigation system should be flushed before injecting chemicals to treat the iron scale. For information concerning proper flushing of irrigation systems, see "Maintenance Guide for Florida Microirrigation Systems" (http://edis.ifas.ufl.edu/SS436) and "Flushing Procedures for Microirrigation Systems" (http://edis.ifas.ufl.edu/WI013).

After flushing, the irrigation system should be treated with the desired chemical concentration, letting the system sit idle for at least one day. This technique gives the chemical time to react with the iron scale, and yet does not move the iron scale particles to the emitters, preventing their possible clogging. Before using the system to irrigate, flush it a second time to move iron scale particles out of the system so they do not adversely affect the emitters.

## SUMMARY AND CONCLUDING REMARKS

Iron scaling is a common problem in some areas. Pre-treating the source water before it enters the irrigation system is the most reliable way to avoid iron-related problems. However, if the system has already been impaired by iron scaling, chemicals and management strategies are available to at least partially remediate the irrigation system. Treatment of existing scaling problems may increase the problems with plugged emitters due to scale particles migrating to the emitters as the scale is removed from the tubing. Flushing, subsequent chemical treatment and additional flushing may also ameliorate some of the existing scale problems. Avoiding iron scale through the pretreatment of irrigation water is by far the best solution.

**List of irrigation line treatment chemicals, grouped by chemical reaction**

| Inorganic acids | Chelating agents | Reducing agents |
|---|---|---|
| Hydrochloric acid | Citric acid | Sodium sulfite |
| Phosphoric acid | Glycolic acid | Sodium hydrosulfite |
| Sulfuric acid | Malic acid | Sodium metabisulfite |
| Nitric acid | Gluconic acid | |
| Sulfamic acid | Oxalic acid | |
| | Sodium EDTA | |
| | Sodium citrate | |

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