DRAGON-LINE®

MOBILE DRIP IRRIGATION

RECOMMENDATIONS FOR THE CONTROL OF IRON IN DRIP IRRIGATION SYSTEMS

CAUTION: Always consult with an authorized distributor for proper guidance before utilizing any of the steps listed here.

Iron deposit problems (ochre) in drip irrigation systems have been reported mainly in the United States, but also from other parts of the world including Australia, Zambia, Taiwan, and Israel. These deposits create severe clogging problems in drip systems. Iron deposit is described as a filamentous amorphous gelatinous type of brown-reddish slime that precipitates from water that contains iron. Iron combined with slim gets stuck in drippers and causes complete plugging of the system.

The problem exists in well water areas where the groundwater aquifers are formed mainly of sandy soils or organic muck soils (very common in Florida) usually with a pH of below 7.0 and in the absence of dissolved oxygen. These waters contain ferrous iron (Fe^{+2}) which is chemically reduced, 100% water soluble and serves as the primary raw material for slime formation.

Iron bacteria, mainly from the filamentous genuses like *Gallionella Sp. Leptothris* and *Sphaerotilus* and less from the rod type like *Pseudomonas* and *Enterobacter*, when present in the water, react with the ferrous iron (FE^{+2}) through an oxidation process. This changes the iron form to ferric iron (Fe^{+3}) which is insoluble. The insoluble Ferric iron is surrounded by the filamentous bacteria colonies and creates the sticky iron slime gel that is responsible for clogging the dripper.

Concentrations of ferrous iron as low as 0.15-0.22 ppm (parts per million) are considered as a potential hazard to drip systems (H.W. Ford 1982). Between 0.2-1.5 ppm emitter clogging hazard is moderate. Concentrations above 1.5 ppm are described as severe (Bucks and Nakayama 1980). Practically any water that contains concentrations higher than 0.5 ppm of iron cannot be used in drip systems unless they are treated chemically or otherwise. Experiments in Florida indicate that chlorination successfully controls iron slime when iron concentrations were less than 3.5 ppm and the pH was below 6.5 (Nakayama and Bucks 1986). It is also stated that long term use of water with a high level of iron may not be suitable for drip irrigation. The literature mentions that water containing more than 4.0 ppm cannot be efficiently chemically treated and it should undergo a pond sedimentation process before pumping it back to a drip system.

Using the following system, 40 acre of greenhouses, shade houses and field grown containers were drip irrigation with water containing up to 6.0 ppm of iron. Daily irrigation for three years occurred without any significant clogging problems.

The system designed and installed to control the iron problems consisted of the following components:

1. Gas Chlorinator – to allow consistent injection of chlorine in its most available and efficient form
2. Disc Filter with 80 Mesh Rings – to ensure complete and uniform mixture of the gas in the water within a limited space
3. Sand Media Filters – to settle the oxidized iron and filter it from the water
4. Back-up Disc Filters – to provide final filtration and safety to downstream system.

IRON CONTROL METHODS

There are several ways to control iron slime problems. The common denominator of all treatments is prevention of the formation of slime.

Basically there are two preventive treatments:

1. **STABILIZATION (Precipitation Inhibitors)**
   Stabilization treatments keep the ferrous iron in solution by chelating it with sequestering agents. Such agents include various poly phosphates and phosphonate.
2. **OXIDATION – SEDIMENTATION – FILTRATION**
   This type of treatment oxidizes the soluble “invisible” ferrous iron into the insoluble “visible” ferric iron. It then will precipitate, so it can be physically separated from the water by means of filtration.

The second procedure was the preferred treatment for the severe iron problems in our supply water.

OXIDATION

The various means to oxidize iron include aeration, chlorination, and potassium permanganate. There are also other oxidizers.
Chlorination using gas chlorine was selected for the following reasons:

1. Since the operation is located in the middle of a residential area, there was no room for a settling basin, proper safety precautions should be used when using gas chlorine.
2. The price per unit of chlorine derived from gas chlorine is the least expensive among all the options of oxidizers and also a very efficient one.

SEDIMENTATION – FILTRATION

A sand media filter is the most appropriate filter for settling down the oxidized iron and filtering it from the water.

INSTALLED SYSTEM DESCRIPTION

Based on these facts, three treatment stations were built within the 40 acre farm. The system description that deals with the heaviest load of iron (the components appear in their sequence order from the pump on) is as follows:

System Flow:	90 – 95 GPM @ 45 – 50 psi
Water Analysis:	Iron – 3.0 – 6.0 ppm
	pH – 6.8
	EC – 0.5 – 0.68 m/mhos.
	Ca. – 89 ppm
	HCO_2 – 319 ppm
	SO_2 – 60 ppm
Drip System:	Netafim pot drippers 0.5 GPH and 1.0 GPH operating at 20-25 psi
Gas Chlorinator:	REGAL, 100 lbs. cylinder with maximum injection rate of 4.5 lbs./day using booster pump and venturi injector

Plastic Disc Filter:

Recommended Flow Rate:	30 – 110 GPM
Filtering Surface Area:	148 sq. in.
Filtering Volume:	75 cu. in.
Surface Area of Filtration Element:	4418 sq. in.
Mesh Equivalent:	80

Sand Media Filter Battery:

Recommended Flow Rate:	80 – 120 GPM
Filtering Area:	310 sq. in.
Media:	Silica Sand 6/20 about 250 each
Effective Sand Size:	0.85 mm
Mesh Equivalent:	180
Velocity Through Media:	0.05 ft./sec.

2" In-Line Plastic Disc Filter (Backup)

Recommended Flow Rate:	90 GPM
Filtering Surface Area:	106 sq. in.
Filtering Volume:	55 cu. in.

RESULTS AND DISCUSSION

Since water quality, iron content, zone size and free chlorine change slightly with time, the following table represents several measurements at different times.

TABLE 1: The levels of free chlorine and iron in different spots during irrigation-chlorination cycle.

	LOCATION IN SYSTEM			
MINERALS	Head of System	After Filtration	At the Dripper	Backflush Water
Iron (ppm)	3.5 - 6.0	3 - 5	3 - 5	30 - 45*
Chlorine (ppm)	10 - 15	2 - 2.5	0.4 - 0.5	0.4 - 0.5

ppm = Parts per Million
* Estimated and calculated through dilution

As shown in Table 1, there is a very slight change in the iron content because the field kit is measuring both ferrous and ferric. The very dramatic chlorine consumption indicates that most of the ferrous was converted to ferric. The free residual chlorine at the dripper indicates that the oxidation process was brought to completion – the bacteria was inhibited by the presence of chlorine and iron slime was avoided so that the system could function without clogging.

The reasons for chlorination were:

1. To oxidize the soluble ferrous iron to insoluble ferric iron which can be removed by filtration.
2. To control bacterial growth in the system which helps control iron slime.

The following criteria determine the type of chlorine application:

1. Water Quality
2. Size and type of the irrigation system
3. The time between the chlorine injection and the moment the water is being filtered and from filtration, the time it takes to reach the drippers
4. Crop type
5. Soil type
6. Fertilizer type

Since the iron levels were so high, we decided to use continuous injection of chlorine. This was the best way to ensure no build-up or iron slime. It is important to remember that the drip system which is being used irrigates individual containers, which means that one plugged dripper results in losing the plant because there is no compensation between the drippers. High levels of iron also dictate high concentration of chlorine. Since we are dealing with herbaceous plants which are relatively insensitive to chlorine, and the soil-less mixture which is being used is rich in organic material, allowed the use of water with initial levels of up to 15 ppm chlorine. Therefore, we decided to use gas chlorine which is the least expensive chlorine unit on the market plus the fact that it does not lose its availability (which is 100%) over time. Another advantage of gas is its ability to acifify the water, which helps to maintain high efficiency of chlorination. Other chlorine sources tend to raise the pH of the water and reduce chlorination efficiency. The gas reacts with the water according to the following equation: $H_2O + CL_2 \rightarrow HOCl + H^+ + Cl^-$. The next step is: $HOCl \leftrightarrow H^+ + OCl^-$. HOCl and OCl^- are both considered as free chlorine but HOCl is 40 to 80 times more efficient. For pH less than 6, most of the free chlorine will be in the HOCl form. On pH greater than 7.5, the predominate form will be OCl^-. Another advantage of the gas chlorinator is simplicity, reliability, and dependability of the system.

The efficiency of the chlorination also depends on contact time. Since the existing conditions dictated a relatively small and compact system. Contact time and distribution uniformity of the chlorine in water was improved by installing a 80 mesh disc filter downstream from the chlorine injection point in order to assure a proper mixture of gas and water. This also helps spread the water in very thin layers via the discs which also improves the contact and uniformity of the mixture. The disc backup filters are used as an additional safety factor to separate any iron deposits that were able to pass the media filters.

CONCLUSION

Working under the conditions of very high iron levels, limited space, high cash crop (tropical foliage) and individual drippers system, a system was designed, installed and maintained that drip irrigated and fertigated a 40 acre farm since 1991 without any significant clogging problems by using either plastic or ten stage epoxy coated filters (media) to avoid corrosion, backflushing the system automatically every 1.0 hour for 3 minutes. Changing the media every two months and rinsing the discs with weak hydrochloric acid at the same time. The system was kept in excellent condition. Replacement was needed on some small rubber parts on the hydraulic relay valves, solenoids and some plain steel bolts.

REFERENCES:

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