DRAGON-LINE®
MOBILE DRIP IRRIGATION

RECOMMENDATIONS FOR THE TREATMENT OF DRIP IRRIGATION SYSTEMS WITH CHLORINE

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

WARNING!!

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

Prior to filling any tank with chlorine solution, be sure it is absolutely clean of fertilizer residue. Remember that direct contact between chlorine and fertilizer will create a thermo-reaction, which can be explosive. This is extremely dangerous!!

> **NOTE:** The direct contact of chlorine and fertilizer in the irrigation water after it has been injected into the system is not hazardous.

OBJECTIVES

Active chlorine is a strong oxidizer and as such, is useful in achieving the following:

A. Prevent clogging and sedimentation of organic substances.
B. Destroy and decompose sulfur and iron bacteria, as well as accumulated bacterial slime in the system.
C. Improve performance of filtration systems while reducing back flush water.
D. Clean systems of organic sediments. (Chlorine has no effect on scale deposits.)

MATERIAL

In the market, a few sources for active chlorine exist, such as liquid chlorine (sodium hypochlorite), solid chlorine, gaseous chlorine, etc. The most commonly used sources are chlorine solutions and gas.

METHOD OF APPLICATION

Chlorination is the injection of specific concentrations of active chlorine into the irrigation system during regular system operation. When liquid chlorine is used, common devices used for fertilizer applications can possibly be used to chlorinate.

In principal, three methods are recommended:
1. Continuously: at very low concentration - the most recommended.
2. Intermittently: at a higher concentration.
3. Shock treatment: very high concentration (> 50 ppm).

NOTE: Under certain conditions, i.e., hard water with a very high pH, there might be a need to raise the acid concentrate in the system to 1%. Please consult your local fertilizer supplier, extension service or consultant prior to such a treatment.

APPLICATION OF ACID BY FERTILIZER PUMP

The goal of acid treatment is to lower the pH level of the water in the irrigation system to values between two to three for a short time (twelve – fifteen minutes). This is achieved by injection of a suitable quantity of acid into the system.

INSTRUCTIONS:

1. Determine the discharge of the water from the system through which the acid will be injected, and the discharge of the fertilizer pump.

2. Calculate the required amount of acid that should be injected into the system in order to get 0.6% of acid concentration in the irrigation water.

3. Inject the acid into the system within fifteen minutes only after the system has reached maximum operation pressure.

   NOTE: Acids suitable to be injected in 0.6% concentrations are:

Nitric Acid	60%	Phosphoric Acid	75% - 85%
Sulfuric Acid	90% - 96%	Hydrochloric Acid	30% - 35%

   It seems that the most economical acids are sulfuric acid (battery acid) and hydrochloric acid (swimming pool acid).

4. Immediately after applying the acid, clean the filters.

5. Flush the system with clean water as follows: flush the mainlines first, then the manifold lines and finally the drip lines by opening several lines at a time (for example: ten lines) so that enough pressure is maintained to get a vigorous flush. Flush the lines for about 1 minute or until the water is clear. Close the open ten lines and open the next ten lines.

DRAGON-LINE®

MOBILE DRIP IRRIGATION

RECOMMENDATIONS FOR THE CONTROL OF IRON IN DRIP IRRIGATION SYSTEMS

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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:

1. Clark, G.A. and A.G. Smajstria (1992) Treating Irrigation Systems With Chlorine. Circular 1039 Florida Cooperative Ext. Svc., I.F.A.S., University of Florida, Gainesville.
2. Ford, H.W. (1982) Iron Ochre and Related Sludge Deposits in Subsurface Drain Lines. Circular 671 Florida Cooperative Ext. Svc., I.F.A.S., University of Florida, Gainesville.
3. Malchi, I. 1968a. Iron in Irrigation Water "Hassadeh", Vol. 66 (12) September 1986 (Israel). Malchi, I. 1986b. Personal and Internal Information (Netafim Irrigation, Inc. U.S.A.).
4. Nakayama, F.S. and D.A. Bucks (1986) Trickle Irrigation for Crop Production, Elsevier Science Publishers B.V. 1986. (pg. 383).

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CONCENTRATION AND INJECTION POINT

It is important to remember that chlorine concentration decreases as time and distance from the injection point increases. The lowest concentration will always be found furthest from the injection point. The injection point should be as close as possible to the treated system.

The required concentration of active chlorine is a result of the chlorination objective.

CHLORINATION OBJECTIVE	APPLICATION METHOD	REQUIRED CONCENTRATION (Parts per Million)	
		System Head	System End
Prevent Sedimentation	Continuous Chlorination	3 - 5	.05 - 1
	Intermittent Chlorination	10	1 - 2
System Cleaning	Continuous Chlorination	5 - 10	1 - 2
	Intermittent Chlorination	15 - 50	4 - 5

When the purpose of chlorination is improving filtration performance, the injection point should be close to the filtration plant to assure even distribution throughout the filters. Chlorine concentration downstream of the filter battery should be no less than 1-2 ppm for constant chlorination and three times more for intermittent chlorination.

For continuous chlorination, the injection should start after pressurizing the system. For intermittent chlorination, the procedure should be as follows:

Start: By flushing the system with clean water. Flush the mainlines first, then the manifold lines and finally the drip lines by opening several lines at a time so that enough pressure is maintained to get a vigorous flush. Flush the lines for about 1 minute or until the water is clear. Close the open lines and open several more drip lines.
Injection: Inject required amount over time, preferably at the beginning of the cycle.
Contact Time: Preferably one hour, but not less than thirty minutes.
Flush: At the end of the process, open the end of the line, flush out and run fresh water for an hour.

CALCULATION METHOD

Use the following information to determine the proper injection rate of chlorine in terms of GPH for liquid and Lbs./hr. for gas.

LIQUID:

1. Choose the proper chlorine solution factor:
   - 5% Chlorine Solution: The factor is = 2.00
   - 10% Chlorine Solution: The factor is = 1.00
   - 15% Chlorine Solution: The factor is = 0.67
2. Multiply the solution factor by the treated flow in terms of GPM.
3. Multiply by the desired chlorine concentration in terms of ppm.
4. Multiply by the factor of 0.0006.
5. The result will be the required injection rate of chlorine in terms of GPH

For example:
The chlorine solution is 10%.
The flow is 100 GPM.
The desired chlorine concentration is 10 ppm.

Chlorine Solution Factor	x	Flow GPM	x	Desired Chlorine concentration (ppm)	x	0.0006	=	Chlorine Injection Rate GPH
1.0	x	100	x	10	x	0.0006	=	0.6

The injection rate of chlorine solution will be 0.6 GPH

GAS:

1. Determine the flow of the treated zone in terms of GPM.
2. Multiply the flow by the desired chlorine concentration in terms of p.p.m.
3. Multiply it by the factor of 0.0005.
4. The result will be the injection rate of the gas in terms of lbs. per HOUR.

For example:
The flow is 100 GPM
The desired chlorine concentration is 10 ppm.

Flow GPM	x	Desired Chlorine Concentration (ppm.)	x	0.0005	=	Chlorine Injection Rate (lb./hr.)
100	x	10	x	0.0005	=	0.5

The injection rate of the gas will be 0.5 Lb./hr.

TRANSPORTATION STORAGE AND DILUTION

Sodium hypochlorite is transported by tanks. It should be stored in a clean tank without any remnants of fertilizers. The tanks should be painted white and placed in a shaded area. In field storage should not exceed 20 days. In case of gas chlorine, transportation, storage and general handling should be carried out in accordance with the manufacturers' specific instructions under supervision of the relevant authorities.

INJECTION OF FERTILIZER AND CHLORINE

The contact of free chlorine in water and nitrogenous (ammonium and urea) fertilizer creates the combination of chlor-amine which is called "combined chlorine". Hence, if possible, avoid any application of ammonium or urea fertilizers together with chlorination.

In the case that chlorination is required, it is recommended to ask your local Extension Service for assistance in the computation and application methods.

There are alternatives to using chlorine to kill algae or eliminate organic matter. Materials based on hydrogen peroxide, which are less sensitive to plants, are available. Please consult with the suppliers of those products on how to use them.