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Say Rain

PERACETIC ACID Controls IRON Plugging in Drip/Micro Irrigation Systems

Micro irrigation systems are wonderful for precisely delivering water and fertilizer directly to plants. But the “micro” part presents a big challenge when combined with poor water quality. The small water passageways/outlets (emitters) common to micro irrigation systems are relatively easy to plug. For example, the cross sectional area of the pathway of a typical drip tape emitter is only 0.0004 in^2 (0.02 in. x 0.02 in.), or 0.26 cm^2 (0.51 cm x 0.51 cm).

Plugging results from physical (grit, sand), microbial (bacteria, algae), and/or chemical (iron, manganese, calcium) water quality problems/factors. Frequently plugging is caused by a combination of more than one of these factors. Controlling emitter plugging requires (1) identification of the cause(s) and (2) application of some common, practical treatment(s).

Iron in Water

Iron in water is in one of two states of oxidation: ferrous (+2) and ferric (+3). Ferric (+3) is formed when ferrous (+2) is combined with oxygen (oxidized):

Ferrous Iron + Oxygen => Ferric Iron = Rust

(Iron[II] hydroxide) + (oxygen) → (water) + (Iron[III] oxide)

$$2Fe(OH)_2 + O_2 \rightarrow H_2O + Fe_2O_3$$

Ferrous (+2) iron is soluble, and will not plug micro irrigation systems. Ferric iron is not soluble; it precipitates and stains (attaches to) surfaces as reddish-orange rust deposits. When microbes are also present in the water, ferric (+3) iron forms iron-laden microbial-masses that readily plug micro irrigation emitters.

The water that is associated with iron plugging of micro irrigation systems/emitters is taken directly from wells. In ground water, iron is the soluble ferrous (+2) type. To get a visible confirmation of iron in ground water, collect/mix some with air/oxygen in a clear container. When first collected, the water will appear clear and free of residue, and the bottom of the container will be free of iron particles. The conversion/reaction of ferrous to ferric in water occurs almost instantly when oxygen is abundant; but it takes time for the oxidized, non-soluble ferric to coagulate and precipitate. After a period of time (say 4 to 12 hours), some of the iron will have dropped to the bottom of the container. Normally the iron will have turned to a dull brick-orange color and appear to be very light in texture. When the water is lightly swirled the iron particles will be wispy-like.

Iron Plus Microbes in Water

While it takes time for the ferric (+3) to coagulate and precipitate, it will immediately attach to surfaces, like the walls of the hose and emitters of micro irrigation systems. In time, the built-up of ferric (rust) on the surfaces of micro irrigation systems may flake-off and accumulate in, and plug the small passageways of emitters.

But, usually iron alone does not plug emitters; that's caused when microorganisms (such as iron bacteria) are present and grow/produce bio-masses that become impregnated with the insoluble ferric iron. These iron-laden, microbial-masses usually appear as brown gelatinous slime. They build up on the surfaces of micro irrigation systems, and can readily plug the emitters. Thus, to control plugging of micro irrigation systems by iron laden ground water requires treatment to (1) limit/prevent oxidation of ferrous to ferric, or (2) limit/prevent and destroy microbial slimes so that the iron will move through the system with the water; i.e., control microorganisms.

Treatments to Control Microbes

For several reasons, routine chemical disinfectants (e.g., chlorine) that effectively wipe out other microbes are only modestly successful against some found in micro irrigation systems. This is particularly true of microbes that build up in thick layers of slime that keeps disinfectants from penetrating beyond the surface cells, and from breaking-up the slime-masses. In addition, iron dissolved in water can combine with much of some disinfectants before they can reach and react with the microbial cells. Also, because chemical reactions are slowed at the cool temperatures common to well water, some routine chemical disinfectants require a long exposure time for effective treatment.

Peracetic Acid

Peracetic acid ($C_2H_4O_3$ or CH3CO3H) is a cost effective product known to control and correct plugging by iron-laden, microbial-masses. It prevents the growth of microorganisms by oxidizing their outer cell membranes; additionally, it penetrates and breaks-up the iron-laden microbial-masses that tend to plug micro irrigation systems. Peracetic acid is an organic peroxide, produced by a reaction between acetic acid (CH_3COOH) and hydrogen peroxide (H_2O_2). It is a colorless, weak acid (weaker than acetic). It is highly corrosive and a very powerful oxidant; the oxidation potential is greater than that of chlorine. Its degradation products (water, oxygen, and carbon dioxide) are non-toxic, and they easily dissolve in water. Its activity is hardly/barely influenced by organic compounds that are present in the water. However, pH and temperature do influence its activity. Peracetic acid is more effective when the pH value of the irrigation water is below 7 than when it is above 7. At a pH value of 7, five times more peracetic acid is required to affectively deactivate microbes at 60 °F than at 95 °F.

A stable peracetic acid complex for use in micro irrigation systems is sold as a watery solution. It can be injected continuously or intermittently. Its low dosage results in no significant change in the pH of the irrigation water (nor of the growing media). And, it offers a low cost solution to plugging of micro irrigation systems by iron.

Chlorine

Chlorine can be used to prevent/control the growth of microorganisms in micro irrigation systems, including some using waters that contain iron. One treatment scheme is to continuously inject chlorine – maybe beginning with a rate of (1) 10 ppm of free (uncombined as HOCL) chlorine or (2) 5 ppm of free chlorine for each ppm iron, and then adjusting the chlorine level to maintain a residual (say 0.3 ppm or more) of free chlorine at the end of the laterals/lines. Even though the chlorine will oxidize the iron and make it insoluble, the goal is to prevent microbial growth and to move the insoluble iron through the micro irrigation system without causing plugging.

Other Treatments

Another treatment is to remove the iron from the water before it enters the irrigation system. The ground water is pumped directly into a pond (tank), making sure air/oxygen is introduced. This allows the iron to oxidize and fall out of solution or collect on surfaces such as sand, gravel, and vegetation. After the iron has been removed from the water, a second pump is used to feed the irrigation system with the iron free pond water.

Polyphosphates (or other sequestering agents) can be injected into irrigation water to bond with the ferrous iron before it combines with oxygen and converts to the ferric state. The iron bonds with the polyphosphate rather than with oxygen. The iron-phosphate is soluble and is discharged from the irrigation system without plugging issues. Because of cost and other issues, this is usually reserved for horticulture and residential irrigation systems to prevent rust stains on sidewalks, houses, cars, and plants.

Acid can be added to ground water to keep ferrous iron from oxidizing and coming out of solution. But the pH of the water after adding enough acid to keep the iron in solution (say, 3.5) is just too low to apply to crops. Further this treatment is expensive and on a long term basis, lowers the soil pH too much.