Blockage in Micro Irrigation Systems – Causes and Cures

Main Entry: **blockage**
Pronunciation: 'blä-kij
Function: noun
an act or instance of obstructing : the state of being blocked, :to block, choke, clog, close congest, obstruct, occlude, plug, stop, cork, pack, impedance, impediment, disrupt, hinder, interrupt, cut off, shut off, turn off, to make unsuitable for passage or progress by obstruction, to prevent normal functioning of ,

<a blockage in a coronary artery (or micro irrigation system)>

Blockage of emitters is the most serious problem when dealing with micro-irrigation systems. Properly designed and maintained filtration systems generally protect the system from most blockages. Blockages cause poor water distribution, which in turn may damage the crop if emitters are plugged for a long period of time. When the plants show excessive stress, it is generally too late to correct the problem. Therefore, multiple emitters per plant are highly recommended. The main causes of clogging include algae, bacterial slime, precipitates, construction debris, and sediment. In general, adequate filtration, line flushing, and chemical treatment can prevent most blockage.

It's like the old game of Twenty Questions? Is it a Mineral, Vegetable, or Animal? When it comes to blockages, it can be one of the above or all three. Most blockages are a combination of two or more.

Minerals

Pure mineral blockage is the rarest form of plugging. The most common forms of "alleged" blocking results from iron and calcium buildup. It is common to hear a grower say that he or she has 'an iron or calcium problem'. However, iron is not the cause of this plugging. Iron is what is visible, but it doesn't cause blockage by itself. Almost all iron is soluble and remains in solution. Iron precipitates out of solution only after oxidation has occurred. This oxidation process takes 8 to 12 hours on average. Let me give you an example. If you had a 100 gallon aquarium and you filled it with your irrigation water, at that time there would be no visible iron in the water. The iron would remain in solution, and there would be no sign of any iron in the water. However, if you observe the water the next morning, you would see a light orangish brown dust near the bottom of the aquarium. The iron oxidized overnight and became a heavier molecule, falling out of solution.

The iron bacteria converts soluble iron, from a liquid state (Fe^{2+}), to the insoluble form, (tiny rusty flecks), many times referred to as "red water" (ferric iron (Fe^{3+})). Most naturally occurring iron is in the soluble ferrous state. This tells us that the iron will flow through even the smallest emitter, because it is soluble. Something must catch and hold the iron for it to be visible. However, as stated earlier, the problem isn't actually the iron. Iron may be visible, but it is only a symptom of an underlying problem rather than the cause. Visible iron is usually associated with bacteria, bacterial slimes, or sulfate reducing bacteria. Iron bacteria will be discussed later. Therefore, organisms are the underlying problem associated with iron buildup. The iron buildup is only a symptom of this underlying problem. The organisms are filimentatious, which are long stringy organisms. In the case of bacterial slimes, the organisms appear in the form of a jelly. These organisms begin to lay down a matrix, and as the organisms continue to grow, this matrix becomes deeper and begins to form a cross-linked matrix. This matrix resembles a fine polymer filter. This "filter" then begins trapping even the smallest particles, such as iron or calcium. This gives iron the opportunity to oxidize, and it becomes visible in the form of rust. Therefore, when you open up a blocked emitter, you will see visible signs of rust. What you don't see is the green, brown, black or red algae, or the bacterial slime that is growing underneath the iron. Filters are normally not fine enough to catch these organisms, they are built primarily for filtering out particulate matter. When the filter begins to plug, colonies of organisms begin to build within the filter. An indication of this is when the pressure rises and flow rate is reduced through the system.

The other mineral of most concern is calcium, which appears as a white crusty deposit. If hardness, a term used to measure calcium and magnesium content in water, creates a blockage, it would take the form of "scale". Scale is generally formed by the calcium becoming insoluble and falling out of solution. Calcium deposits in micro-irrigation are usually too small to determine constituents via qualitative analysis. However, a simple field test can be performed. If a small amount of acid (such as hydrochloric acid (also called muriatic), phosphoric acid, nitric acid, or vinegar) is dropped onto the deposit, the deposit will dissolve.

Calcium hardness in water is generally determined by the amount of calcium available in the ground. In Florida, shells provide a source of calcium and iron. The discoloration in seashells is caused when the animal takes in the sea water and extracts calcium and iron to form its shell. In places such as Atlanta that have granite as the major substrate, we find that the hardness of water is almost zero due to the fact that granite does not dissolve in water. The quality of this water is excellent, but it is also corrosive. When you reduce water's hardness (calcium and magnesium), it tends to become corrosive. This explains why installing a water softener in your home often causes problems with copper fittings and elbows. The water leaches the copper out of the pipes. Out West, you are more likely to find more calcium sulfate with moderate amounts of calcium carbonate. Calcium sulfate is less soluble and much more likely to form scale. As a general rule, if you have higher calcium you will have lower corrosion, and lower calcium will mean higher corrosion.

How much calcium is in the water? To put the amount of calcium in the water in perspective, consider how much or little is in the water and what it means. At 200 ppm, that translates to 200 lbs. of calcium for every million lbs. of water. That is 200 lbs. in every 120,000 gallons of water. On a percentage basis this is 0.02%. This is a very small amount and is being spread over a large area. 200 lbs. of calcium can be spread over 40 acres and would form a very thin film. At this concentration, the calcium would not form scale for many years. In order for scale to cause clogging at these levels, the drip tape would have to be several decades old.

A mineral scale will generally not form without heat and pressure, such as you would find in a cooling tower or boiler. It takes heat, an imbalance of alkalinity vs. calcium, or recirculation and evaporation for scale to form.

A very simple formula can be used to determine if the calcium is soluble or insoluble. Take your total alkalinity or M-alkalinity, and multiply by your total hardness (which is the total calcium and magnesium carbonate or calcium and magnesium sulfate).

$$\text{M (or total) Alkalinity} \times \text{Total Hardness} \leq 110{,}000$$

The total M must be less than 110,000. An example, 400 ppm hardness and 225 ppm alkalinity (which is extremely high) only yields 90,000 which is far less than 110,000. The calcium in this example is soluble. If the number is above 110,000 the calcium is going to come out of solution. You would generally add acid to reduce the alkalinity. In this case, you can use sulfuric or n-furic. This will reduce the alkalinity, but it does not affect the calcium. You can use any acid, however sulfuric is generally used for pH control because it is highly concentrated and inexpensive. I have never seen insoluble calcium in agricultural irrigation water. However, I have seen it deposited on organic growths. If you remember the aquarium example, the same rule applies to calcium. However, in this case the calcium is not going to come out of solution even if you let the water sit overnight. The calcium will remain soluble and you will not see calcium on the bottom of the container. It isn't impossible for calcium to fall out of solution, but it's extremely unlikely. Therefore, plugging from hardness in the water is not a major cause of blockage.

Other minerals in the water are found in such small concentrations, (silica, sulfates, chlorides, etc) that the chance of forming scale and blockage is remote. The mineral most likely to cause plugging is silt. Silt is a combination of sand, clays, and other insoluble soils. This is a filtration issue that can be solved by using an effective filter. Coarseness of filters, the costs, etc are all variables involved in choosing the right filter for your system. Generally, the best type of filter is a media filter. The sand can be supplemented with DE (diatomaceous earth) for very fine filtration if necessary.

Plants and Algae

In the most general sense, a plant is a member of the lower or vegetable order of living organized things. Thallophyta are the most lowly organized plants and include a great variety of forms, the vegetative portion of which consists of a single cell or a number of cells forming a more or less branched thallus. They are characterized by the absence of differentiation of the body into root, stem and leaf which is a common feature in higher plants. Both sexual and asexual reproduction occurs in these types of organisms. They can be unicellular or complex organisms, lack mobility, have simple processes for digestion and reproduction, have little defense mechanisms, tend to have thinner cells walls, and can either be aerobic or anaerobic. They can survive and thrive in sunlight, darkness, or a combination of the two. Even if they become substantially dehydrated, these organisms will revive when exposed to water again. Types of these include algae (including Seaweeds) which contain chlorophyll, the Fungi which have no chlorophyll and therefore lead a saprophytic or parasitic mode of life, and the Lichens which are composite organisms consisting of an alga and a fungus living together in a mutual parasitism (symbiosis). A study of phylogeny has suggested twelve classes arranged in the following sequence: (1) Bacteria; (2) Cyanophyceae (Blue-green algae); (3) Flagellatae; (4) Myxomycetes (Slime-fungi); (5) Pendineae; (6) Conjugatae; (7) Diatomaceae (Diatoms); (8) Fleteroconteae; (9) Chlorophyceae (Green Algae); (10) Characeae (Stoneworts); (II) Rhodophyceae (Red Algae); (12) Eumycetes (Fungi);

In Green Algae (the most common algae) the differentiation of cells is comparatively slight. Many forms, even when multicellular, contain identical cells in structure and function, and are therefore physiologically unicellular. The cells are commonly joined end to end in simple or branched tissue filaments. These contain chlorophyll and constitute a self supporting organism. The rhizoid, a certain type that lives on or in the soil, penetrates the ground to absorb food substances (dissolved salts) from the substratum.

The simpler Fungi, like the Green Algae, consist of single cells or simple or branched cell-threads. However, among the higher forms, a massive body is often formed, particularly in connection with the formation of spores, and may exhibit considerable tissue-differentiation. A characteristic feature of the fungal vegetative body (mycelium) is its formation from independent tubes or cell-threads. These organisms branch, and may be packed or interwoven to form a very solid structure, but each grows in length independently of the others and retains its own individuality. Its growth is defined by external conditions and is correlated with that of its neighbors.

Plugging can be caused by the plant that you are growing. Some plants such as watermelons, or peppers have extremely fine hairs which can penetrate into the emitters and cause plugs. A root control agent can be used to remove roots from micro-irrigation systems if handled properly.

If you are using your irrigation system for fertigation, you need to remember that just as the fertilizer makes your plants grow, it will also make algae and slimes grow. So while fertigation is great, you need to remember that you may be making your plugging problem worse. During times of the year when there is a shortage of water, plants and algae will draw it up as much as possible in order to survive.

Plants are much easier to control. Think of the difference between killing a plant and trying to kill a wild boar. The dead cells from plants bio-degrade much easier than that of animals. Plants will scavenge the dead cells for food. Simple plants will consume dead cells with the same DNA readily and but are apprehensive about taking in cells with foreign DNA.

Animals and Bacteria

Any of a kingdom (Animalia) of living things including many-celled organisms and often many of the single-celled ones (as protozoans) that typically differ from plants in having cells without cellulose walls, in lacking chlorophyll and the capacity for photosynthesis, in requiring more complex food materials (as proteins), in being organized to a greater degree of complexity, and in having the capacity for spontaneous movement and rapid motor responses to stimulation. The lack of a rigid cell wall allowed animals to develop a greater diversity of cell types, tissues, and organs. Most animal bodies are made up of organized cells that are specialized to perform a specific task. Other cells are organized into even more specialized organs. Most animals are capable of moving relatively fast, unlike plants. Most animals reproduce sexually. Single-cell animals, and bacteria, typically have some mechanical means of movement. Some bacteria use long external whip-like filaments called flagella. Flagella are rotated by a molecular motor to cause propulsion through water. The larger single-cell animals may use flagella similar to bacteria, or they may have rows of short filaments called cilia, which work like oars. Most ingest food and digest it in an internal cavity. Some one-celled organisms display both plant and animal characteristics.

Some of the lower organisms that affect irrigation are iron bacteria, sulfate reducing bacteria, denitrifying and nitrifying bacteria. Some are beneficial and others can cause severe problems throughout the system.

Iron bacteria [...(1) Leptothrix Ocharacea ...(2) Gallionella Ferruginea ...(3) Spirophyllum Ferrugineum ...(4) Crenothrix Polyspora ...(5) Cladothrix Dichotoma ...(6) Clonothrix Fusca] are bacteria that “feed” on iron. They are a natural part of the environment in most parts of the world. There are several non-disease causing bacteria which grow and multiply in stringy clumps in water and use iron dissolved in water as part of their metabolism. In the presence of the bacteria, the dissolved iron reacts with the oxygen from the air forming rust colored iron oxides. These oxides do not dissolve in water and either settle to the bottom or are stored in the slimy jelly like material that surrounds the iron bacteria’s cells.

Simply because iron is abundant in ground water, iron bacteria is generally more common than sulfur bacteria. Iron bacteria are "oxidizing agents." That is, they combine iron or manganese dissolved in ground water with oxygen. A side effect of this process is a foul smelling brown slime which can coat well screens, pipes, and plumbing fixtures. This slime isn't a health hazard, but it can cause unpleasant odors, corrode plumbing equipment, and clog well screens and pipes. If conditions are right, the bacteria can grow at amazing rates and an entire well system may be rendered virtually useless in just a few months. There are several signs that may indicate an iron bacteria problem. Water may have a yellow, red or orange color. Rusty slime deposits may form in the distribution system. A strange smell resembling fuel oil, cucumbers, or sewage may be noticeable. Sometimes the odor will only be apparent in the morning or after other extended periods of non-use.

Sulfur Bacteria

There are two categories of sulfur bacteria: sulfur oxidizers and sulfur reducers.

Sulfur-oxidizing bacteria

Sulfur-oxidizing bacteria produce effects similar to those of iron bacteria. They convert sulfide into sulfate, producing a dark slime that can clog plumbing.

Sulfur-reducing bacteria

Sulfur-reducing bacteria (SRBs) live in oxygen-deficient environments. They break down sulfur compounds, producing hydrogen sulfide gas in the process. Hydrogen sulfide gas is foul-smelling and highly corrosive.

Of the two types, sulfur-reducing bacteria are the more common. The most obvious sign of a sulfur bacteria problem is the distinctive "rotten egg" odor of hydrogen sulfide gas. As with odors caused by iron bacteria, the sulfur smell may only be noticeable when the water hasn't been run for several hours. In some cases, the odor will only be present when hot water is run; this could indicate that SRBs are building up in the water heater. Blackening of water or dark slime coating the inside of water system may also indicate a sulfur bacteria problem.

Iron bacteria and sulfur bacteria contaminations are often difficult to tell apart because the symptoms are so similar. To complicate matters, SRBs often live in complex symbiotic relationships with iron bacteria, so both types may be present. Fortunately, both types of bacteria can be treated using the same methods.

Virus- Viruses are not alive in the strict sense of the word, but reproduce and have an intimate, if parasitic, relationship with all living organisms. Viruses invade plants and animal cells, but are not part of either kingdom.

Treatments

Chlorine

Chlorine has been tried with limited success and effectiveness. It does kill at high concentrations, but it does not remove cells at lower dosages. The dead cells will remain and become food for future generations. These dead cells allow organisms to grow much more quickly. The growth cycle for these organisms is 7 to 10 days. They grow exponentially: 10^2 to 10^5 power, 100 to 100,000 times growth rate. One of the things to think about with chlorine is that chlorine is adequate for prevention, but it is not good for the removal of organic matter. An example would be a mildewed towel or shirt. It would show signs of mildew as black spots. An initial plan may be to place it in the laundry with some chlorine bleach. You will notice when you remove it from the laundry that the chlorine has in fact faded the spots slightly, however the spots do remain and are now a slightly lighter black color. Therefore, you decide to increase the chlorine dosage and try again. When you do that, you end up with a degraded piece of cloth with holes in it. The stain was removed, but you destroyed the cloth in the process. This same thing would happen in the field. Small doses are usually recommended, up to 5 ppm on plants. At higher dosages you would cause serious damage to the tissue of the plant, just like it caused damage to the cloth in the above example.

Liquid bleach is about 10 percent chlorine. A 20 ppm chlorine shock treatment for an irrigation system with a capacity of 500 gpm would require approximately 6 gallons of chlorine per hour or about one-tenth of a gallon of bleach per minute. One should continuously monitor system performance and adjust the water treatment and maintenance schedule as needed. Chlorine will inhibit growth at the time of treatment, but it readily dissipates and does not remove organic matter at this 20 ppm shock level unless treatment is continuous for 6 to 12 hours.

Acids

A wide variety of acids have been used for treating water. Acids fall into two categories: mineral acids which include sulfuric, hydrochloric (muriatic), nitric, phosphoric, and n-furic, and organic acids such as sulfamic and citric. Various combinations have been tried with mixed results. Acids are usually corrosive to tissue and to metals, and can contribute high levels of chlorides, sulfates, and phosphates which can form compounds that will cause blockages. Acid has no killing power. It will not destroy the cell walls. Another of the effects of using acid in these systems is that acids dehydrate and draw water out of tissue. Acids will even draw the water out of plastic. If you spill acid on your hands, you will see your skin begin to shrivel up. Contrary to popular belief, your skin is not being burned, but rather the acid is drawing the water out of your skin. After contact with acid, Plastic becomes extremely brittle and at times you can touch it and it will shatter. It will dehydrate tissue in a high enough concentration, but if it dehydrates the cell walls of tiny organisms, it will also dehydrate plants.

Industrial water treatment facilities frequently use acid to increase calcium solubility. The acid is added to reduce the alkalinity. The calcium becomes more soluble as the alkalinity decreases. This allows the water to be able to hold more calcium in solution to keep the calcium from forming scale (blockage). In this case, acids are not added to water to remove calcium, but to lower the alkalinity. Almost any acid can be used to reduce alkalinity, but again, as I stated above, generally sulfuric acid is used due to low cost and higher concentration.

Most of the mineral acids will attack and dissolve calcium. Acids are used to remove scale that has formed. In order to remove calcium using an acid, the pH of the water must be below 2.5 and must remain below 2.5 while the calcium is slowly dissolved. Of course, a pH below 2.5 would be extremely toxic to plants. Many acids are used for descaling, including organic acids such as sulfamic, which is frequently used in cooling towers.

Sulfuric and n-furic acid are not used to remove calcium. Neither acid will dissolve acid. Sulphuric and n-furic have no effect on calcium. Many years ago I had a customer who was purchasing drain opener (sulfuric acid) in large quantities. I finally asked them what they were trying to do with all of this drain opener. They explained that an opossum crawled into a sewer pipe and died, and they were trying to dissolve the bones which would be easier than digging up the sewer pipe. They had been using countless gallons of sulfuric acid. We suggested they try hydrochloric acid and in one dose, it dissolved the bones and opened the sewer pipe.

Pour sulfuric acid and hydrochloric acid side by side on concrete. The sulfuric acid won’t bubble and fizz as hydrochloric acid does. Looking at the photograph, you can see that the sulfuric acid has no visible effects on the concrete while the hydrochloric acid shows great activity.

Acid treatments have also been tried. Acids first reduce the bicarbonate alkalinity. In order to dissolve calcium, all of the alkalinity must be 100% removed before the acid can attack the calcium. In the water sample we discussed previously, 200 ppm of total alkalinity requires 200 ppm of acid (active). If you are using sulfuric or n-furic acid, the alkalinity can be reduced to 0 ppm, but that’s as far as the acid can go. These acids do not attack or dissolve calcium. The pH at which the acid will dehydrate cell walls is below 3.5.

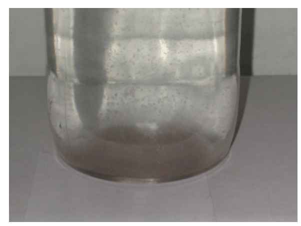
Acids and Chlorine

The idea behind this treatment is that chlorine works best at a lower pH, and the acid will lower the pH. Yes, it is true that the acid will lower the pH and that chlorine does work better at a lower pH. But what happens is that the acid shears the chlorine from the hypochlorite molecule and releases it into the water to form a salt. The caustic nature of the hypochlorite solution neutralizes the acid. They work against each other. And the bad part is that the chlorides are still available to the plant and usually it forms salt (sodium chloride). A simple experiment shows the results. Add 1.3 ozs. (38 grams) of a 10% liquid chlorine solutions to a 5 gallon bucket of water. This will yield a chlorine residual of 2 ppm. Now add the same amount of sulfuric acid to the bucket and stir. Run the chlorine test again, and then check the pH. The chlorine level will be zero and the pH will be around 5.0.

New Technology

The advent of new organic compounds have given us a new compound for treating blockages. A derivative of peracetic acid (or peroxyacetic acid) has proven effective at removing blockages of all types. It removes the organisms from emitters which releases the calcium and the iron deposits. The dosages used are as low as 100 ppm. This compound does not affect the pH, it does not affect plants, it has no taste, it leaves no residue, it is 100% organic, and it is economical to use. It can also be used in weekly dosages to prevent the blockage from ever occurring. It has been used in greenhouses and has been sprayed on orchids at 1500 ppm with no resulting damage. The only effect during this experiment was the removal of lichen moss that was growing near the root of the orchid. This new compound is non-specific in that it removes all organisms including algae, bacteria, viruses, slimes, molds, etc. Using an injector for precise control has yielded superior results in unplugging drip tape, drip lines, micro jets, and other micro irrigation equipment. It is best to inject this compound before the filter as the compound also cleans the filter and thereby removes the greatest source of contaminants within the irrigation system.

Final Results



The only disadvantage of this new material is that it is a corrosive oxidizer. Therefore, it has the potential of causing severe burns and eye damage while in concentrated form and should be handled with caution.