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Flushing Procedures for Microirrigation Systems[1]

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Overview

Microirrigation systems can be plugged by a variety of causes, including particulate matter, chemical precipitates, organic growths, or insects in the pipelines. Plugging often results from a combination of the above.

In a detailed discussion of the causes and prevention of emitter plugging, Pitts *et al.* (1990) described four critical components for successful microirrigation system operation as:

- 1) proper filtration,
- 2) appropriate chemical water treatment,
- 3) careful attention to the types of chemicals such as fertilizers injected into the system, and
- 4) routine flushing of pipelines.

Flushing of irrigation system pipelines is an essential part of the maintenance program required for long-term success with microirrigation. Flushing will prevent accumulation of small particles and their buildup to a size that can plug emitters. This publication explains the requirements for proper flushing of microirrigation pipelines.

Need for Flushing

Pipeline flushing is needed to remove any particles that accumulate in microirrigation pipelines before they build-up to sizes and amounts that cause plugging problems. Particles accumulate in pipelines from several sources. Filtration systems do not remove all suspended materials from the water. Due to the high cost of removing very small particles, agricultural filters are usually designed to only remove particle sizes larger than about 20% of the emitter orifice diameter. Therefore, filters do not remove clay, silt, and some very fine sand size particles. Although these particles are small enough to be discharged through the emitters, they can cause plugging problems if enough are present. They may travel through the filters as individual particles, but then flocculate or become attached to organic residues, and become large enough to plug emitters.

Organic growths in pipelines, especially bacteria, are difficult to completely eliminate, and they provide the "glue" that sticks small particles together. Many types of algae are too small to be

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filtered, and so they readily enter pipelines. Even if they are killed by chlorination or other chemical treatment, these algae can cause small particles to stick together. As the algae die, their cells rupture and the organic residue becomes an adhesive for small particles or groups of cells.

Other material can also enter irrigation pipelines and require flushing. Sand and other soil particles can travel backwards through emitters, especially if pipelines and emitters are buried. However, even on the surface, dust and debris can be blown or washed into the emitters. Small insects also enter, sometimes carrying debris with them. Insects and other debris can also enter through flush valves at the ends of laterals and other pipelines, especially through normally open automatic valves.

Chemical precipitates can also occur in irrigation pipelines. Minerals and salts may be dissolved in water and then precipitated because of changes in water temperature, pressure, exposure to oxygen, or injection of materials such as fertilizer. This problem must be addressed by avoiding chemical precipitation altogether because it is difficult (and often impossible) to flush chemical precipitates from irrigation systems, especially when they adhere to system components such as pipe walls and emitter passageways. Chemical precipitation can be avoided by injecting only water soluble or acid-forming fertilizers, or by injection of acid or other chemical water treatments.

Most debris in pipelines begins as small particles which then join together to cause plugging problems. These small particles are light enough to be suspended and readily transported by the flowing water when the velocity is high. However, water flow velocity in a microirrigation system decreases as water is discharged along the length of the pipelines, especially along the lateral lines. At the very end of laterals, the water flow is reduced to the flow rate of the last emitters. Most debris accumulates at this point because the velocity is no longer sufficient to carry particulate matter. As a result, even small particles settle to the bottom of the laterals, which is why emitter plugging from this cause normally begins at the ends of the laterals.

The accumulation of loose debris in pipelines can readily be removed by flushing. To be effective, flushing must be done often enough to remove debris *before* it accumulates in amounts capable of plugging emitters. *Note: flushing velocities must be sufficient to dislodge and transport the accumulated debris.*

Lateral and manifold pipelines should always be equipped with flush valves. Flush valves are required because the velocities in these multiple-outlet pipes are low at the downstream end during normal irrigation operation. Conversely, the velocity in mains and submains remain high throughout the length of the pipeline, so low-velocity zones where debris would normally accumulate are absent. Some designers specify flush valves at the ends of main and submain pipelines, however flushing is less often needed at these locations.

Flushing Procedure

Irrigation pipelines are flushed by opening the ends of the lines during operation and allowing water to freely discharge, carrying particulate matter along. The goal of flushing is to discharge water at sufficient velocity so that any particulate matter will be suspended and removed from the system with the flush water. Pipelines must be equipped with valves or other means of allowing the pipeline to be opened quickly. Either manual or automatic valves can be used, or flexible polyethylene (PE) tube can simply be folded over and clamped or tied. Manual valves are often used if infrequent flushing is adequate, while automatic valves are preferred when frequent flushing is needed.

When flushing pipelines, it is important to observe what type and how much debris is being discharged. Use a clean, white bucket or other suitable container to collect the flushed material as soon as the valve is opened. Cheesecloth or a similar filter placed over the end of the pipe can also be used to trap flushed sediment. It is important to collect and observe the flushed material regularly because water quality may change, requiring changes in the flushing frequency throughout the year. If large amounts of material are discharged, then more frequent flushing may be required, while if only a small amount is flushed, it may be possible to increase the amount of time between flushings.

Observing the type and amount of material flushed may suggest other changes in management practices. For example, the presence of organic growths could indicate the need for chlorination or other chemical applications. The presence of large particles might indicate the failure of a filter. The presence of chemical precipitates that have been deposited and then flaked off of the pipe walls might suggest a need to inject acid or change fertilizer injection procedures.

Because the flush water is dirty, it is normally discarded rather than re-used. For this reason, flushing should not occur when chemicals other than pipeline cleaning chemicals such as chlorine are being injected. This will prevent loss of fertilizers or pesticides and avoid possible pollution problems.

Flushing Frequency

The frequency of flushing depends on the amount of debris removed. In some systems, the water quality is very good, and only very small amounts of debris are found. In those cases, only infrequent flushing (weekly, bi-weekly, or monthly) flushing is required. Pipelines should be flushed at least once a month during irrigation season.

In other systems, a large amount of debris accumulates in the pipelines each time the irrigation system operates. An example is systems that use pond water containing large amounts of suspended algae, clay and silt particles. In those cases, it may be necessary to flush laterals during each irrigation, using automatic flush valves.

For permanent irrigation system installations, systems may be idle for weeks or months at a time during off-seasons or in rainy months when irrigation is not required. It is a good idea to start these systems and flush them every four to six weeks even when irrigation is not required. The potential for system plugging is typically highest when hot, humid climate conditions favor bacterial and algae growth in pipelines. Operating and flushing the system during these times (even though irrigation is not necessary for plant growth) can help remove plugging sources before they accumulate to the point that large chemical shock treatments are required to reclaim the system.

Flushing Duration

The duration of flushing depends on many factors, especially the water quality and system design. Before a system is installed, it is difficult to accurately estimate the time required to adequately flush a pipeline. Fortunately, in the field, it is simple to determine when a system is adequately flushed. Flushing should occur until the water discharged runs clean. This normally only requires a short time--a minute or two--because the debris mainly accumulates at the end of the pipeline near the flush valve. Depending on the system design, amount and type of debris, and the flushing velocity, longer times may be required for some systems.

Flushing Velocities Required

For proper flushing to occur, the discharge velocity must be high enough to both dislodge and transport particulate matter from the pipelines. Researchers who have studied this problem do not all agree on the exact minimum velocity needed, however, a minimum velocity of 1 foot per second (fps) is recommended in the ASAE national microirrigation standards (ASAE, 1998) and in some standard irrigation textbooks (Jensen, 1980). Other researchers recommend a minimum velocity of 2fps, especially where larger particle sizes need to be discharged. The 2-fps-minimum velocity is often recommended for microsprinkler systems where coarser filters than those required for drip emitters are used. These coarser filters (due to the large microsprinkler orifice sizes) allow larger particles to enter the system with the irrigation water, and therefore, require higher flushing velocities.

In general, flushing velocity should be as high as possible in order to dislodge and transport as many particles as possible, but never less than 1fps. Higher flushing velocities will aid particle removal and shorten the flushing time needed.

Microirrigation systems must be properly designed so that adequate flushing velocities can be obtained. It is rarely possible to flush all laterals at once because sufficient velocity will not be available for all laterals. Rather, open only a few flush valves at once, allow them to operate, and then close them before moving to the next valves. Flushing order is manifolds first, and then the laterals served by the manifolds that have just been cleaned.

Use Table 1 to determine if adequate flushing velocity is being obtained for the polyvinyl chloride (PVC) and polyethylene (PE) pipes commonly used for microirrigation manifolds and laterals. Because velocities are difficult to measure in the field, this table shows flow rates that will produce 1fps in commonly used pipe sizes. These flow rates should be doubled to 2fps for microsprinkler irrigation systems or other systems where larger particle sizes must be flushed.

Measuring Flushing Velocities

In the field, flushing velocity can be determined by measured the flow rate during flushing and comparing it with the required minimum values given in Table 1. Flow rate can be measured by recording the time required to collect a given volume of flush water in a graduated cylinder or other graduated container.

Table 2 shows flow rates in gallons per minute (gpm) based on the time required to catch a specified number of gallons. Example: when flushing a 2-inch PVC manifold pipeline in a drip-irrigation system, a grower uses a graduated tank and collects five gallons of water in 20 seconds. This is a flow rate of 15gpm. From Table 1, the minimum required flow rate for effective flushing of a 2-inch pipeline is 12gpm, therefore the measured flow rate of 15gpm is adequate.

If the flow rate was inadequate, the grower would need to increase it by shutting off flow to other sections of the irrigation system and directing it to this manifold for the flushing operation. This could be done with manual valves used only during flushing. Irrigation system designers should take this need into account when systems are planned and installed.

As another example, in a microsprinkler-irrigated citrus grove, a grower flushes thirty 1-inch PE lateral pipelines at one time. A flow rate of 2.0gpm is measured at the end of each lateral. From Table 1, a minimum flow rate of 2.7gpm is required to obtain a flush velocity of 1fps, and double this rate (5.4gpm) is recommended for microsprinkler systems. Therefore, the measured flushing velocity is inadequate, and something must be done to increase the discharge rate per lateral. This can be done by simply closing some of the flush valves and flushing fewer laterals at once. The grower should close flush valves until the required flow rate is obtained from the remaining open valves.

In most cases, growers will need to follow this trial-and-error field procedure to calibrate their systems. The number of laterals in a system that can be flushed at the same time depends on many factors, and the easiest way to determine it is to measure it for each irrigation zone by opening and closing flush valves until the required minimum flow rate is obtained. *Note: higher velocities than those shown in Table 1 can be used and will be more effective, but values smaller than these should not be used.*

In some systems, frequent flushing is required due to poor water quality. This can be done by installing an automatic flush valve on each lateral. These valves are typically normally open valves that close at low pressures (1-3psi) or after a certain time of operation or amount of water has been discharged. Thus, the first surge of water in each lateral is discharged through the valve, carrying debris with it. This approach is effective in many cases, but may not always be adequate since the valves may not always provide the required flush velocity or duration, especially as water quality changes during the year. Thus, it may still be necessary to periodically manually flush these systems.

Summary

Microirrigation systems can be plugged by a variety of causes. Recognizing this, the thoughtful grower will have a comprehensive management program including filtration, chemical water treatment, careful attention to the types of chemicals injected into the system, and routine pipeline flushing.

As a minimum, lateral and manifold pipelines should be equipped with flush valves. The frequency of flushing depends on the amount of material that is removed. When water quality is poor, flushing may be required with each irrigation. Automatic flush valves may be effective, but growers may still need to periodically flush their systems manually.

Pipelines should be flushed at least once a month during the irrigation season and every four to six weeks during the off-season until the discharged water runs clean.

For proper flushing to occur, the discharge velocity must be high enough to dislodge and transport particulate matter from the pipelines. A minimum velocity of 1fps (ft per second) is required, but velocities of 2fps are desirable for microsprinkler or other systems where filters allow larger particles to enter the systems.

Tables are furnished which allow growers to easily determine flush velocities from flow rates measured in the field, and to manage systems for optimum flushing.

References

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Table 1. Minimum flow rates in gallons per minute (gpm) required to flush microirrigation lateral and manifold pipelines at a velocity of 1 foot per second (fps).

Pipe or Tubing Size (inches)	Required Flow Rate (gpm) for 1fps velocity
0.5	1
0.75	1.7
1	2.7
1.25	4.7
1.5	6.3
2	12
2.5	17
3	26
4	42
6	92
8	155
10	241
12	339

Note: Polyethylene tubing assumed for sizes below 2 inches. Class 160 PVC pipe assumed for sizes of 2-inch and larger.

Table 2. Flow rate in gallons per minute (gpm) based on the time required to catch a specified number of gallons.

Time (seconds)	Gallons caught					
	1	2	3	4	5	10
10	6.0	12	18	24	30	60
20	3.0	6.0	9.0	12	15	30
30	2.0	4.0	6.0	8.0	10	20
40	1.5	3.0	4.5	6.0	7.5	15
50	1.2	2.4	3.6	4.8	6.0	12
60	1.0	2.0	3.0	4.0	5.0	10
70	.86	1.7	2.6	3.4	4.3	8.6
80	.75	1.5	2.3	3.0	3.8	7.6
90	.67	1.3	2.0	2.7	3.3	6.6
120	.50	1.0	1.5	2.0	2.5	5.0