

FILTRATION: A BASIC COMPONENT FOR SDI TO AVOID CLOGGING HAZARDS

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The major cause of failures in Subsurface Drip Irrigation (SDI) and other microirrigation systems worldwide is clogging. The emitters in SDI systems are small, leaving a small margin for error, so it is important to understand the filtration and maintenance requirements of SDI systems and take a proactive approach to the prevention of clogging. Fortunately, most SDI users in the Great Plains are pumping high-quality groundwater, such as from the Ogallala Aquifer. This reduces the potential for clogging. Even so, proper steps must be taken to prevent clogging and maintain effective SDI system operation. With proper selection of a filtration system and maintenance, SDI can be used with surface water and other low-quality waters. Prevention of clogging and proper maintenance of the SDI system start before it is installed. Chemical and biological analysis of the irrigation water will help in filter selection, and indicate measures required to prevent clogging. The drip tube requirements, emitter-opening size in particular, may play a role in the selection of the filtration system to use. Proper placement and use of flow meters and pressure gauges are required to provide feedback to the system operator. Monitoring the flow meters and pressure gauges over time can reveal system performance anomalies that may require attention. Air vents, check valves, and vacuum relief valves may be required at various places in the system to prevent entry of chemically treated water into the water source and soil particles into the drip tapes. Also, flush lines are required to occasionally remove the material accumulated in the drip tapes. These basic components are shown in Figure 1, and a cut away diagram of a typical emitter is shown in Figure 2. Clogging hazards for SDI systems, regardless of the water source, fall into three general categories: physical, chemical, and biological. This article will discuss prevention of clogging

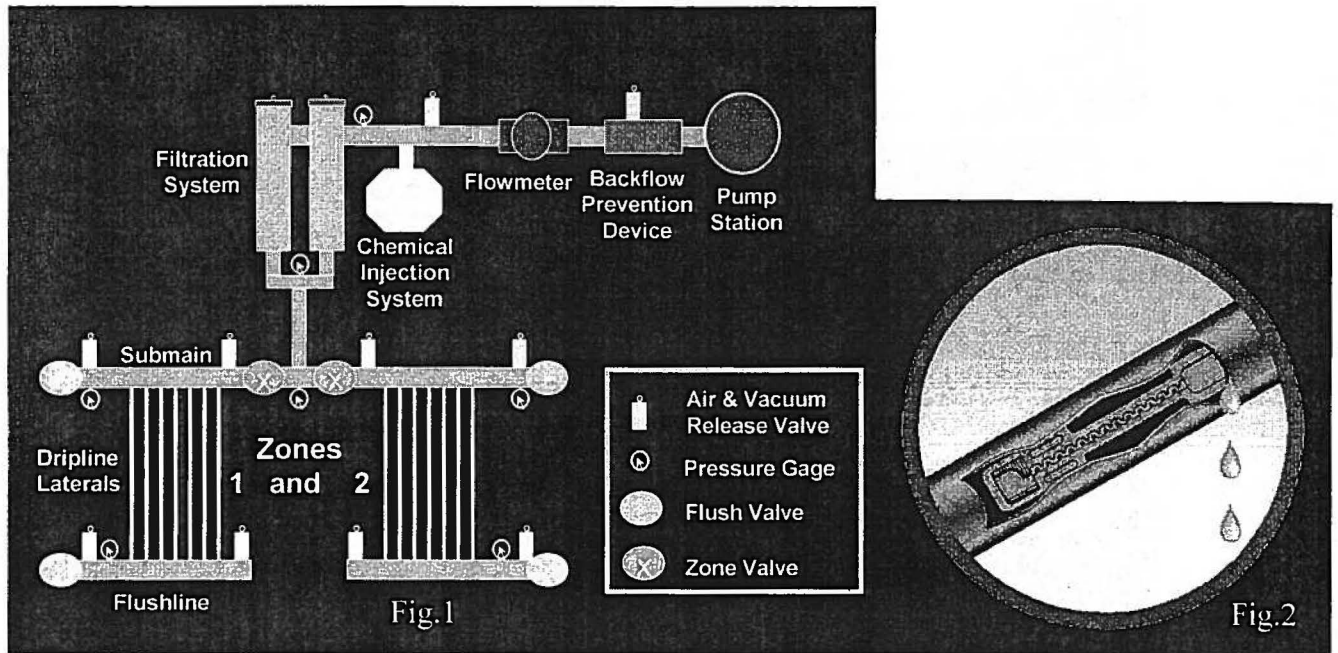


Figure 1 and 2: Schematic layout of a system and cut away diagram of an emitter

problems in these three categories with special emphasis on how they apply to SDI systems in the Great Plains.

Physical clogging hazards

Wells may produce sands that pose a threat of physical clogging of the emitters. Physical clogging hazards are usually removed with screen filters (Figure 3). Sizing of screen filters is based on the maximum particle size allowable according to emitter opening, quality of the irrigation water, the flow amount between required cleanings, and the allowable pressure drop across the filter. The maximum allowable particle size should be available from the drip tape manufacturer. If not, a rule of thumb is to use 0.1 times the smallest diameter in the emitters used. A 200-mesh screen filter will remove the fine sand and larger particles (larger than 75 microns or 0.003 inches), and is usually adequate for SDI systems using groundwater in the Great Plains. (Table 1 and 2).

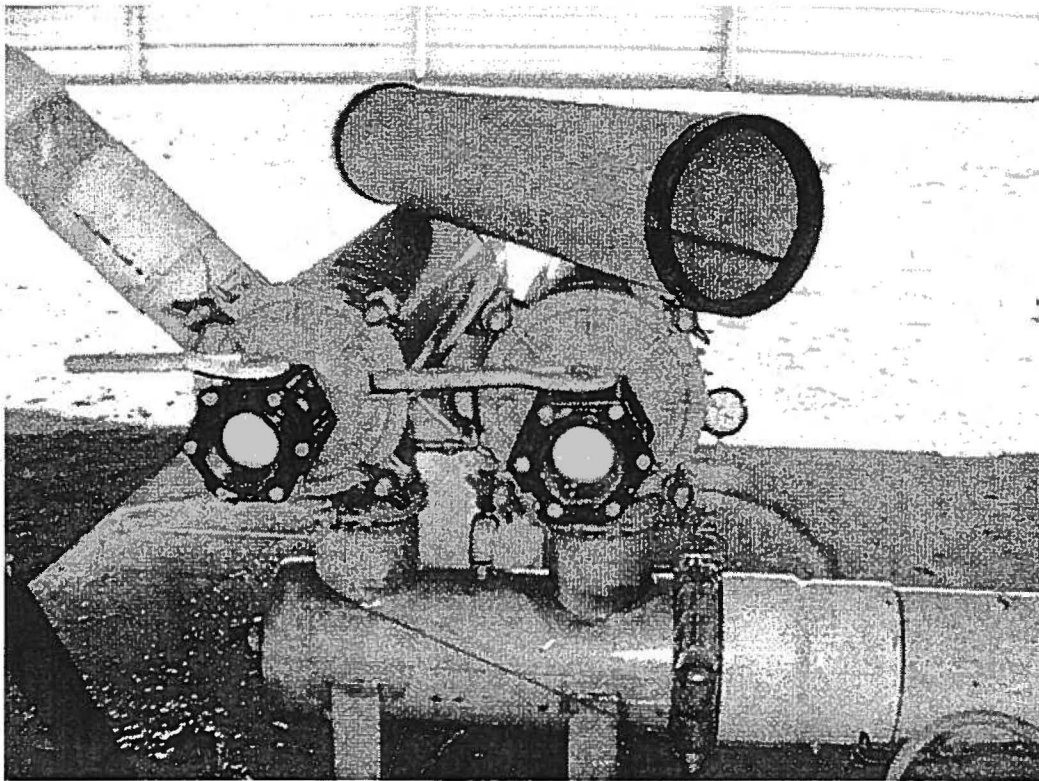


Figure 3: Screen filter showing installed system and a screen on top for display

Table 1. Screen Filter Opening Sizes

Mesh	Inches	Mm	Microns
40	0.017	0.425	425
100	0.006	0.150	150
150	0.004	0.105	105
200	0.003	0.075	75
270	0.002	0.053	53
400	0.0015	0.038	38

Table 2. Selected Equivalent Diameters

Particle	Diameter, mm
Coarse sand	0.50 to 1.00
Fine sand	0.10 to 0.25
Silt	0.002 to 0.05
Clay	<0.002
Bacteria	0.0004 to 0.002
Virus	<0.0004

Flow rates through screen filters should not exceed 200 gallons per minute per square foot of effective filter area. The effective filter area is defined as the area

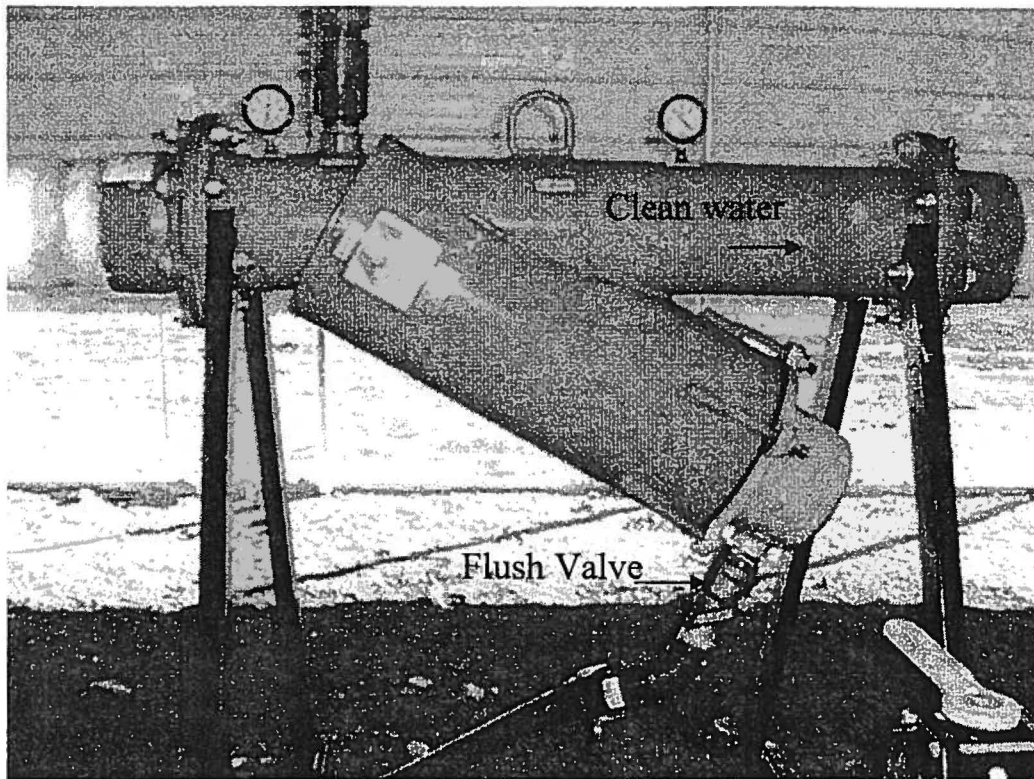


Figure 4: Spin filter in use in Western Kansas

of the openings in the filter screen. A 200-mesh screen has 200 openings in a linear inch. Generally, a 200-mesh screen area of 2.8 square feet will provide 1 square foot of effective filter area. Screen filters should be cleaned (back flushed) when the pressure drop across the filter increases by 3 to 5 psi, or as recommended by the manufacturer. Automatic flushing is available on some filtration systems. Also available are self-cleaning screen filters called "spin filters." These are continuous-flushing units. They swirl the water inward. Filtered particles move to the bottom of the filter and eventually leave the bottom of the filter through an opening to the outside (Figure 4). A small amount of water is continuously pushing the filtered particles out of the system and is removed from the irrigation system. Many producers use spin and screen filters as a combined set up. If large amounts of sand are in the water, a sand separator (also called a vortex sand separator or cyclone sand separator) may be required. Sand separators swirl the water and the centrifugal force separates the sand and other heavy particles from the water. If the amount of sand in the irrigation water is small, screen filtering will usually be adequate and a sand separator will not be required. For surface water, other steps may be required. For water with a large silt concentration, a settling basin may be required to remove the silt. For surface water, pre-screening of the water to remove debris such as stalks, leaves, and other plant residue may be required. When surface water is used for SDI, more extensive filtration systems such as media or disk filters may be desirable.

Biological clogging hazards

Sand media filters (Figure 5) are commonly used to filter organic materials. The effective sand size of the media is selected according to the desired degree of filtration. (Table 3).

Table 3. Sand Media Size and Screen Mesh Equivalent

Sand No.	Effective Sand Size (in)	Screen Mesh Size
8	0.059	70
11	0.031	140
16	0.026	170
20	0.018	230
30	0.011	400

Flow rates for media filters should not exceed approximately 25 to 28 gpm per square foot of filter surface area. Lower flow rates should be used with water sources containing greater than 100 ppm of suspended material, to reduce the need for frequent back flushing. Media filters should be back flushed when the pressure drop reaches about 10 psi, or as recommended by the filtration system manufacturer. Use of two filters in parallel allows back flushing of one filter while the other is actively filtering the water. Back flushing flow rates depend on the media size; lower flow rates should be used for finer filter media. Automatic flushing is generally required on media filtration systems. Some manufacturers

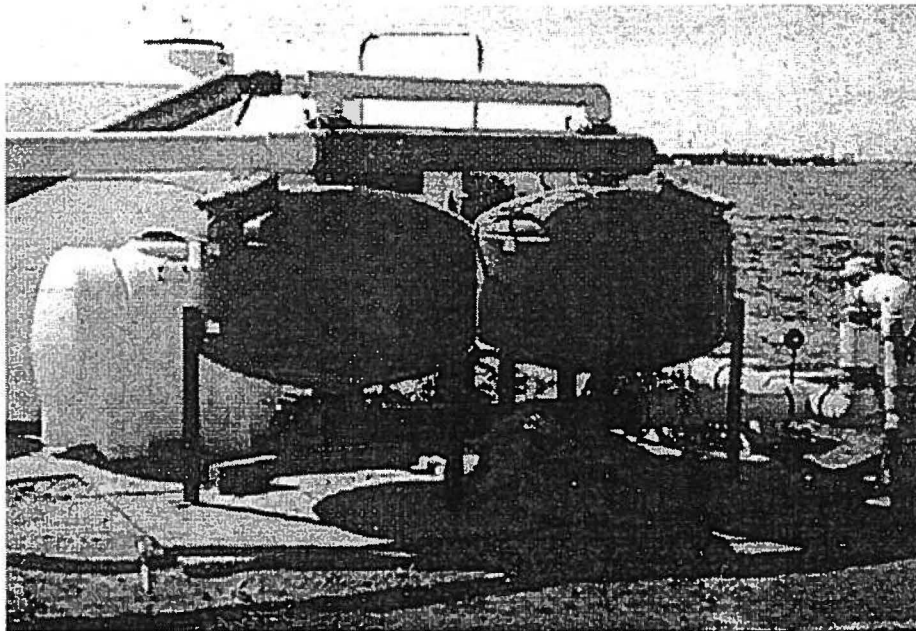


Figure 5: Sand media filter

recommend the use of a screen filter after the media filter to reduce the hazard of runaway media clogging the SDI system should a catastrophic failure of the media filtration system occur. Disk filters (Figure 6) are sometimes used.

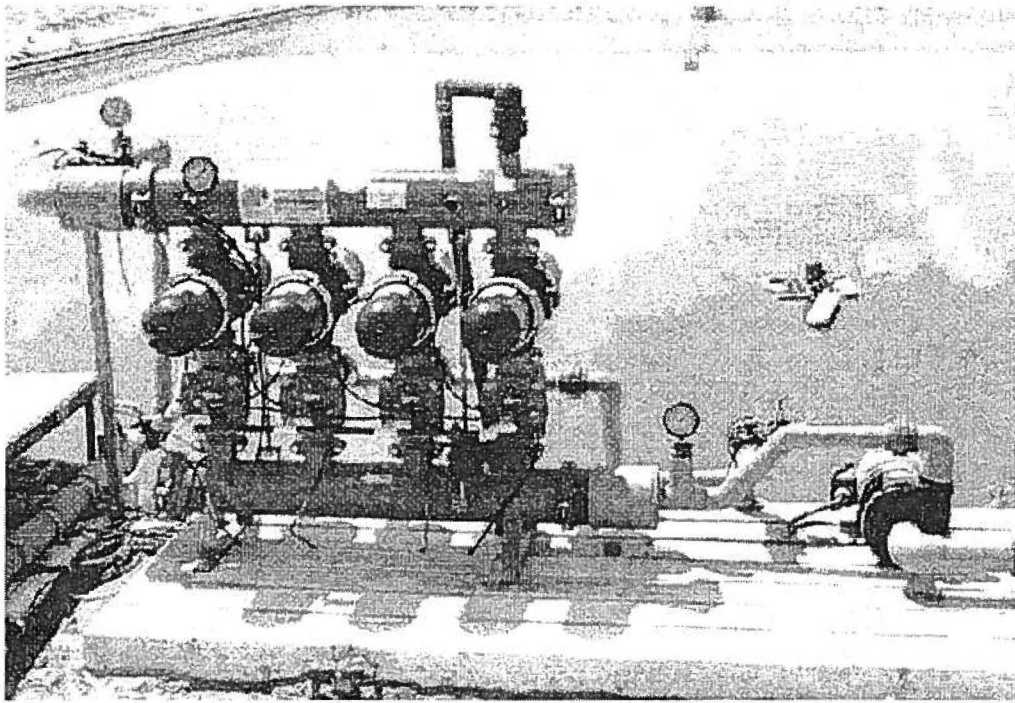


Figure 6: Disk filters

They are a hybrid of screen filters and sand media filters. Water flows in microscopic grooves between disks that filter the particles. Disk filters generally separate during back flushing and require less water than media filters. However, back flushing pressure as high as 50 psi may be required, which may require the use of a pressure-sustaining valve or booster pump or both. Separation of the disks may not be desirable if sand is present. Sand may be removed by using a sand separator before the disk filter. A typical recommended flow rate for filtering groundwater with 200-mesh-equivalent disk filters is 50 gpm per square foot of filter area. Chlorine injection is commonly used to insure that any unfiltered biological material does not accumulate elsewhere in the SDI system. If the microbiological load of the irrigation water is high, a low concentration (1 to 2 ppm) of chlorine should be injected continuously. Chlorine shock treatment may be desirable even when biological load is not particularly high, but a single biological clogging is suspected. A shock treatment uses a concentration of 10 to 30 ppm. Frequency and duration of shock treatments are determined by the severity of the problem. Considering 20 ppm injection for a 600 gpm well, one would require, 0.012 gallons of chlorine per minute. Household bleach generally contains about 2.5 percent of chlorine. So one will need to inject about half a gallon of bleach per minute. Chlorine injection rate calculation formula is provided

in K-State bulletin no. MF-2361, titled *Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems*.

Chlorine gas is the most effective and least expensive chlorine source for injection. This may be hazardous and must be used with caution. Specialized controllers are available and service providers may supply gas cylinders. Sodium hypo chlorite (liquid bleach) is safer and easy to obtain and use. It degrades over time so it should not be stored for long periods of time. Calcium hypo chlorite granules or tablets are more stable than bleach, but more expensive. Chlorine has no effect on scale deposits. There are other commercial materials to dislodge scales.

Chemical clogging hazards

Two major chemical clogging hazards to SDI systems in the Great Plains are precipitation of calcium carbonate (CaCO_3 also called lime), and formation of iron ochre (slime). Precipitation of CaCO_3 can occur in one of two ways: evaporation of water, leaving the salts behind, or change of solubility due to change of solution characteristics (mainly temperature or pH). Evaporation is usually not a problem in SDI systems, but chemistry changes and increased water temperature can cause CaCO_3 precipitation. In SDI systems, the buried drip tapes do not get as hot as surface installed drip irrigation lines, so temperature-induced CaCO_3 precipitation is not as great a problem. Increased pH also decreases CaCO_3 solubility, raising the potential for precipitation. A water analysis can be used to determine the predisposition of the water source to CaCO_3 precipitation. In many cases, bicarbonate may be present. Bicarbonate can react with naturally occurring calcium in the water to form calcium carbonate or lime. In many cases, if precipitation is likely to occur, acid injection is used to lower pH and decrease the propensity of CaCO_3 precipitation. Lowering water pH to 6.5 cuts bicarbonate levels significantly. An acid formulation of nitrogen fertilizer (N-phuric) can be used for pH control and nitrogen fertilization concurrently. Commercial acidifiers are available in the market. Acid will also remove any existing calcium carbonate in the system. Acid is noncorrosive to pipes made of polyvinyl compound (PVC) and polyethylene (PE) tubing, but may be corrosive to steel and aluminum. At very low concentrations, it may be possible to keep iron in the solution by adding acid to lower the pH. One hazard of iron is bacterial interaction. Various bacteria can react with ferrous (+2 charge) iron through an oxidation process. The resulting ferric (+3 charge) iron is insoluble. The ferric iron eventually will be surrounded by filamentous bacteria, forming the slime or gel that clogs emitters. Chlorination is used to oxidize the ferrous iron. The resultant ferric iron is filtered before it can reach and clog the emitters. It is necessary to know the fill volume of the SDI system and determine the minimum time requirement to fill the system for a shock treatment. Time of injection and the total volume can be calculated by knowing the flow rate, concentration of chlorine injection required, and the acreage to treat. If the water pH is high, concurrent acidification and chlorination may be required. Injection

points of the two materials into the water stream should be at least 2 to 3 feet apart. *Acid and chlorine source bleach should never be combined in the same container, because dangerous toxic chlorine gas is released.* Pump lubrication oil may cause plugging of the screen. Selecting lubrication material may help. There are some materials that may break the greasy substance produced from lubricants by soap action.

Concluding Statements

When using SDI systems, it is important to prevent clogging problems to ensure that the system will last for many years. To be economical the SDI system require to perform well for at least 15 years, which is very much possible. The best prevention plan includes an effective filtration and water treatment strategy. Depending on the water source and its quality, various combinations of sand separation, screen filtration, sand media or disk filtration, chlorination, and acid injection may be required. Filtration equipment may be the single item of greatest cost when installing the SDI system. One must resist the temptation to “cut corners.” Good filtration and system maintenance will pay for itself by avoiding labor, or extra effort that may be required to fix a damaged system that was not adequately maintained. Despite all efforts on filtration, some materials will not be removed and will find their way into the drip tape. To prevent the accumulation of those materials in the drip tape and the resultant emitter clogging, the drip tapes should be flushed occasionally. A useful way to provide flushing is to connect all the distal ends of the drip tape laterals within a zone to a common sub main or flush header. This allows the flushing to be accomplished from one point, and helps in keeping the system free from accumulated sediments while providing water below the clogging point of any plugged drip tape. If a break occurs, positive water pressure on both sides will limit sediment intrusion. Flow meters and pressure gauges should be checked periodically to assure that the system is operating correctly. If measured flow rates and pressure distributions indicate problems in the system, some reconditioning may be possible with chemical injection (including chlorine shock treatments), flushing, and other steps. Profit margins for crops typically grown in the Great Plains are not as high as the profit margins for fruits and vegetables traditionally grown with SDI systems. To make SDI systems in the Great Plains economically viable— they must have a long life. Prevention of clogging is therefore critical to the successful and economical use of SDI in the Great Plains.

Reference

Alam, M. et al. 2002. Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems. MF-2361 (Revised), Kansas State University.

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