

# FILTRATION AND MAINTENANCE CONSIDERATIONS FOR SUBSURFACE DRIP IRRIGATION (SDI) SYSTEMS<sup>1</sup>

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## QUICK FACTS

- The filtration unit is the most important component of a subsurface drip irrigation (SDI) system. It is justified to minimize investment cost whenever practical. However, one should not cut corners when considering a filtration system.
- The major cause of failure of SDI systems around the world is clogging of the emitters. Poor maintenance and improper design also are major causes of SDI failure.
- Economic study on subsurface drip irrigation for corn (K-State Irrigation Management Series Bulletin, MF-2242) has shown that the return is sensitive to system life. A 15-year life expectancy of SDI will make it quite competitive to a center pivot system on a quarter section (160 acres) field. The life expectancy depends primarily on filtration, maintenance, and proper design. Flushing of the driplines should be a part of routine maintenance.
- Recovery or corrections are costly, if not impossible. Economic losses will occur during the process.

All irrigation systems require proper maintenance. Subsurface drip irrigation (SDI) systems are no exception. The major cause of failures in 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

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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 driplines. Also, flushlines are required to occasionally remove the material accumulated in the driplines. These basic components are shown in Figure 2, and a cut away diagram of a typical emitter is shown in Figure 3.

Clogging hazards for SDI systems, regardless of the water source, fall into three general categories: physical, chemical, and biological. This bulletin will discuss prevention of clogging 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 1). Sizing of screen filters is based on the maximum particle size allowable according to emitting 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 dripline 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, and is usually adequate for SDI systems using groundwater in the Great Plains. 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 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 (backflushed) 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 (Figure 5). 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 6) are commonly used to filter organic materials. Particle size of the media is selected according to the desired degree of filtration. 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 backflushing. Media filters should be backflushed when the pressure drop reaches about 10 psi, or as recommended by the filtration system manufacturer. Use of two filters in parallel allows backflushing of one filter while the other is actively filtering the water.

Backflushing 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 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 7) are sometimes used. 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 backflushing and require

less water than media filters. However, backflushing 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.

If the biological load is not particularly high, a single clogging problem is severe, or biological clogging problems are due to sources other than irrigation water, chlorine shock treatment may be desirable.

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 at the end of this paper.

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 hypochlorite (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 hypochlorite 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 ( $\text{CaCO}_3$  also called lime), and formation of iron ochre (slime).

Precipitation of  $\text{CaCO}_3$  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  $\text{CaCO}_3$  precipitation.

In SDI systems, the buried driplines do not get as hot as surface-installed drip irrigation lines, so temperature-induced  $\text{CaCO}_3$  precipitation is not as great a problem.

Increased pH also decreases  $\text{CaCO}_3$  solubility, raising the potential for precipitation. A water analysis can be used to determine the predisposition of the water source to  $\text{CaCO}_3$  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  $\text{CaCO}_3$  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) tubings, 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 with iron. 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 saponification.

### **Concluding Statements**

When using SDI systems, it is important to prevent clogging problems to ensure that the system will last for many years. 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 dripline. To prevent the accumulation of those materials in the dripline and the resultant emitter clogging, the driplines should be flushed occasionally. A useful way to provide flushing is to connect all the distal ends of the driplines within a zone to a common submain 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 dripline. 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.

Table 1. Screen filter opening sizes

<b>Mesh</b>	<b>Inches</b>	<b>mm</b>	<b>Microns</b>
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

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

Calculation for chlorine injection:

Fill volume may be calculated using the total length of the drip tube and the diameter of the tube. For example, the tube length in a one acre field at 60 inch a (5 feet) spacing is (43,560 square feet per acre divided by 5 feet) = 8,712 feet per acre. If the drip tube is 7/8 inch diameter then the volume inside the tube in one acre is, 36.38 cubic feet: ( $\pi r^2 \times L$ ; where,  $r$  = radius of the tube in feet,  $L$  = length of the tube in feet, and  $\pi = 3.14$ )

Converting to gallons, 36.38 cubic feet x 7.48 gallons per cubic foot = 272 gallons. A 20 acre zone in a field will have 272 x 20 = 5,440 gallons of fill volume of drip tubes. Add the volume of the mainline, header, and footer (used for the flush line) to the drip line. Assume that the total adds to 6,000 gallons. A 600 gallons per minute flow of the pump will fill the system in 10 minutes.

Chlorine injection rate:

To inject 20 ppm in a shock treatment use the following equation, to calculate the injection rate.

**IR** =  $Q \times C \times 0.006 \div S$  where,

**IR** = Chlorine injection rate (gal./hr.)

**Q** = System flow rate (gal./min.)

**C** = Desired chlorine concentration (ppm)

**S** = Strength of chlorine source (in percent, not fraction)

Household bleach generally contains 5 percent sodium hypochlorite which can produce 2.5 percent of free chlorine. So, **S** for this equation will be 2.5.

Substituting in the equation,

**IR** =  $600 \times 20 \times 0.006 \div 2.5 = 28.8$  gallon per hour or, 0.48 gallons per minute

About 5 gallons of bleach needs to be injected in the 10 minutes for the 20 acre zone.



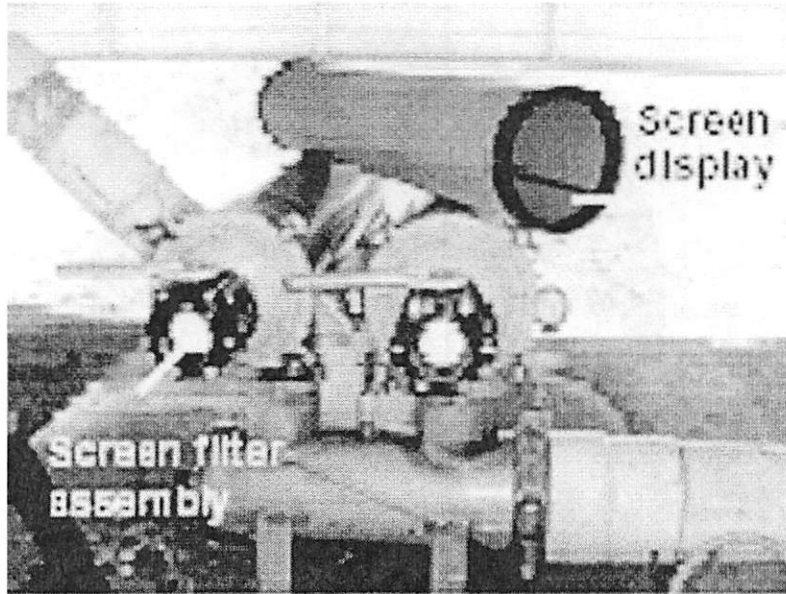


Figure 1. Screen filters in use in Kansas.

### Schematic of Subsurface Drip Irrigation (SDI) System

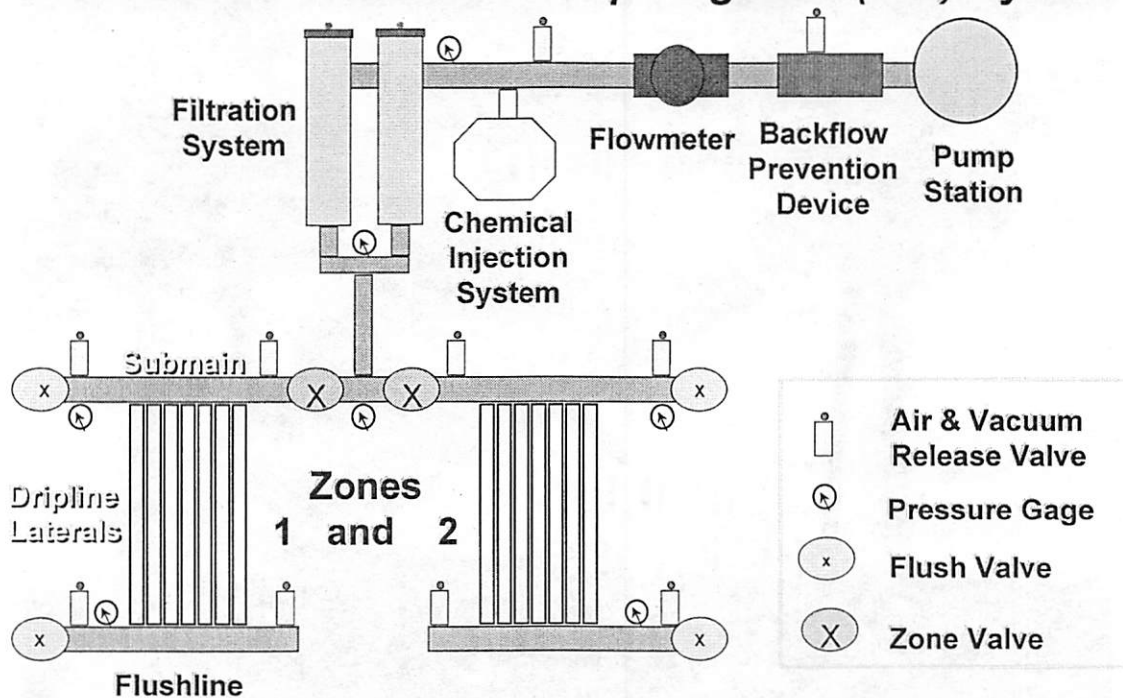


Figure 2. Schematic of a subsurface drip irrigation system.

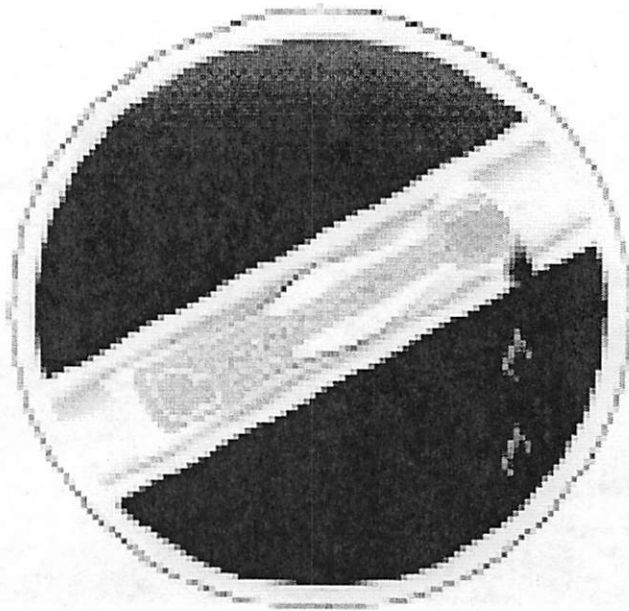


Figure 3. Cutaway example dripline emitter

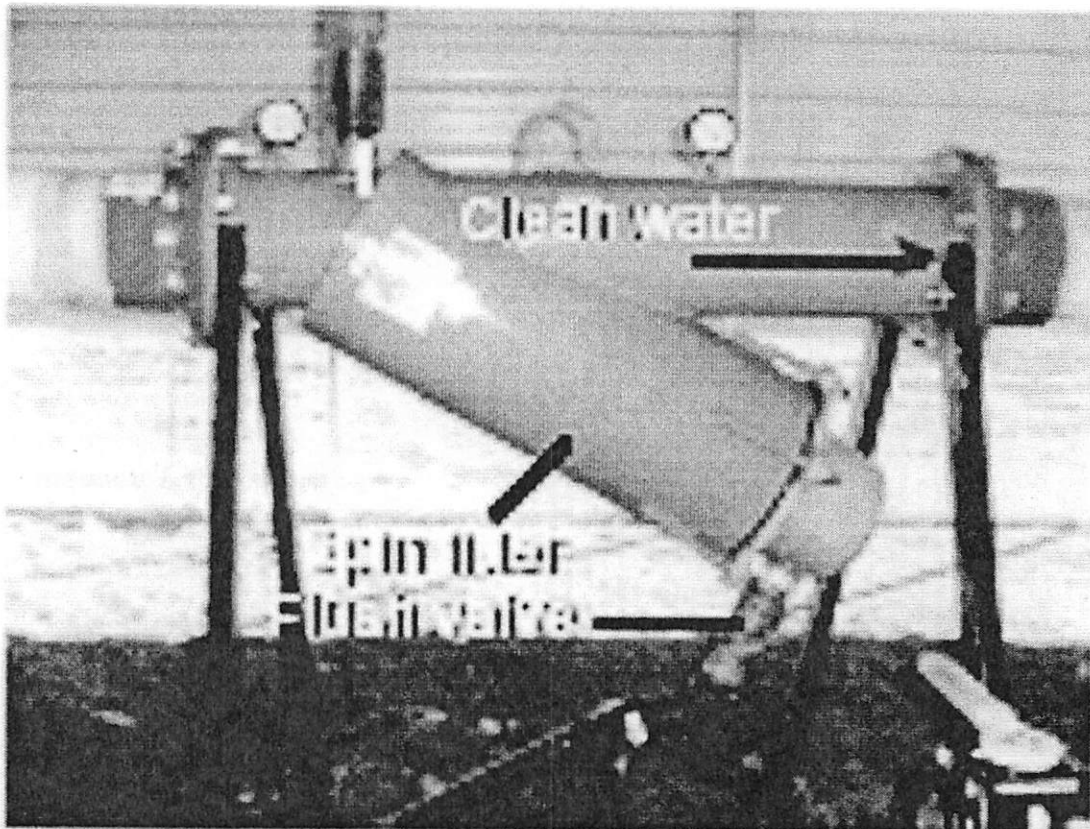


Figure 4. Spin filter

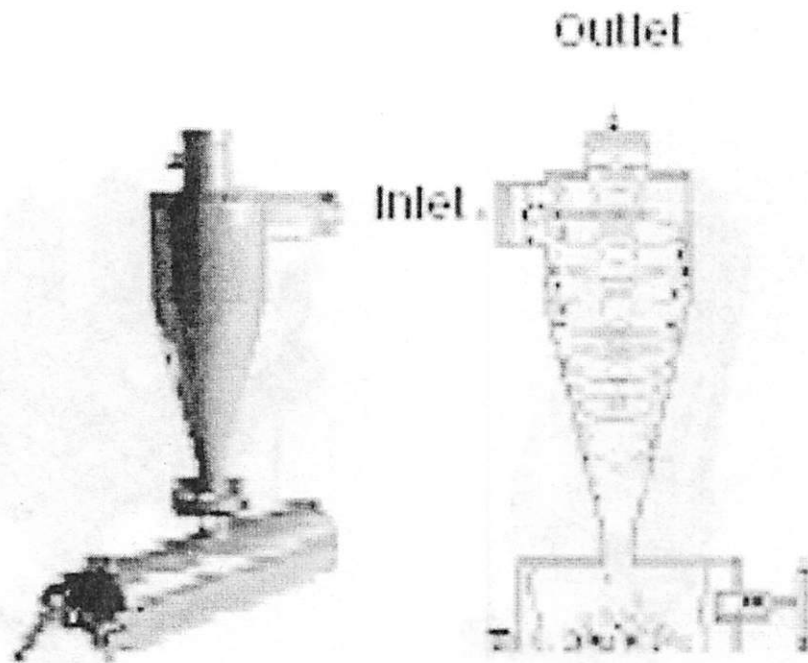


Figure 5. Schematic diagram and example sand separator.

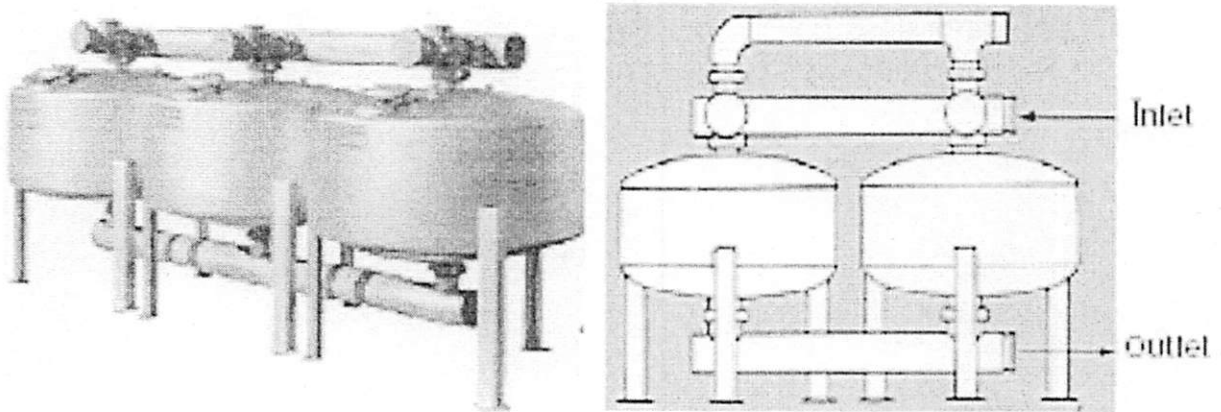


Figure 6. Schematic diagram and example media filter.

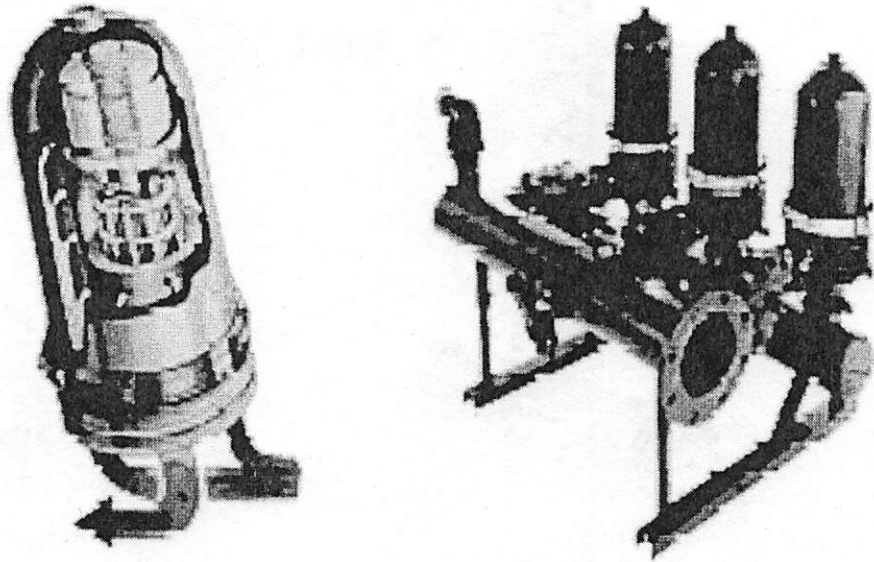


Figure 7. Schematic diagram and example disk filter.