Household Water Treatment: Mechanical Filtration Methods and Devices

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Mechanical filtration removes suspended solids (or dirt) and greatly improves the clarity of water. Various kinds of mechanical filtration methods and devices are available for home water treatments. Primarily, the size of suspended solids will determine the appropriate type of mechanical filtration device suitable for your unique situation. Consumers interested in filtration devices should discuss the advantages and disadvantages of various available options with a water treatment professional. This publication will discuss the various aspects of mechanical filtration.

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What is mechanical filtration?

In mechanical filtration, untreated water passes through a mesh filter or cartridge that traps suspended particles on the surface or within the filter.

- Mechanical water filters mostly remove larger suspended material from water, including sand, silt, clay, loose scale, and organic matter.
- These filtration systems do not remove dissolved chemicals or very small particles.
- When used in combination with other water treatment equipment (as is often the case), they can be helpful in removing dissolved or very fine particles. For example, they can remove iron, manganese, or hydrogen sulfide after they are converted from dissolved to particulate states by a separate oxidation treatment water system installed before the mechanical filtration unit.

Microfiltration devices (microfiltration membranes) can filter out bacteria and other microorganisms from water as long as the pore size of the microfiltration membranes is smaller than the size of the target microorganisms. ***For example:***

- Bacteria: 1-2 µm
- Protozoa (Giardia, Cryptosporidium): 100-500 µm
- Algae (Cyanobacteria): 1 µm
- Yeast: 10 µm
- Viruses: 0.03-0.3 µm

1 µm (micrometer) = 0.000001 m (meter)
1 m = 39.37 inches
A period (.) character in 12-point Helvetica font is 500 µm in size.

Types of mechanical filtration

Mechanical filtration devices differ in design, cost, and effectiveness. The three most common types of mechanical filters are:

- Cartridge sediment filters
- Single media filters
- Multimedia filters

The type of mechanical filtration that will be suitable to your unique situation depends on the amount and size of suspended solids in the water and the rate at which water needs to be filtered. For example, a sand media filter has a faster contaminant removal capacity than other types of filtration devices, but it is not suitable for the removal of smaller particles. In contrast, cartridge sediment filters with fiber or ceramic filter materials are made with a smaller and more uniform pore size and can be more reliable in removing smaller particles, but they are much slower and need more frequent replacement.

Cartridge sediment filters

Sediment cartridge filters consist of a solid housing that encases a filter medium. The filter medium can be made of cellulose (paper), fabric (rayon), fiber, ceramic, or other materials that are useful for screening particles. The cartridges are often corrugated around a tubular opening to form a cylinder that creates a larger filter surface area for contact with untreated water.

Cartridge sediment filters are generally point-of-use (POU) devices that are typically suited for a single water tap, which can be installed under a kitchen sink, for example. Sediment filters can also be used in combination with other drinking water treatment methods. For instance, aeration, ozonation, or chlorination systems are used to precipitate dissolved iron, manganese, or hydrogen sulfide. Cartridge sediment filters are useful in removing leftover solid particles. Sediment cartridge filters can also be used as pretreatment for other processes such as activated carbon (AC) filtration and reverse osmosis (RO) in order to increase their effectiveness and longevity.

Types of cartridge sediment filters

There are two basic types of sediment cartridges, *depth-type* and *pleated-type*.

Depth-type filters have graded densities with large openings (or porosities) at the outermost surface of the filter, which decrease in size toward the center core. These filters trap particles within the filter material and are usually inexpensive.

Pleated-type cartridge filters contain a rigid polypropylene core for support and are made of one of the following materials:

- ***Pleated paper*** – These filters are the most economical but are not reusable. They are sensitive to water with low or high pH (less than 6.5 or greater than 8.5). Use them only when the water contains no active bacteria, which may grow on the cellulose portion of the filter. Water testing for pH and total coliform and *E. coli* should be conducted to assess whether your water is suited for these types of filters.
- ***Pleated cotton and polyester*** – These filters are generally considered the most versatile. They combine the filtration ability of cotton with the strength of polyester. As long as the water pH is between 4 and 9, they can be cleaned and reused several times.
- ***Pleated polyester and polypropylene*** – These filters are the most expensive but can be repeatedly rinsed and reused. However, since the fibers are smoother than the other filter materials, they are not quite as effective at retaining particles.

Pleated cartridges have a large surface area for filtration, which allows for a faster filtration rate. The filter accumulates particles on the outermost surface, allowing a filter cake to build up which increases the filtering action, but slows the water flow (or speed of filtration). They can handle large quantities of particulates and high turbidity before a noticeable drop in water pressure. Although they initially cost more than depth-type cartridges, in the long run they are less expensive and have longer durability.

Turbidity is the measure of relative clarity of water. Technically, it is an expression of the amount of light that is scattered by the materials contained in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher the turbidity. Materials that cause water to be turbid include clay, silt, finely divided inorganic and organic matter, algae, soluble colored organic compounds, and microscopic plants (not visible by naked eye) and other microscopic organisms.

How cartridge sediment filters work

In the sediment filtration process, the water pressure pushes water through the media or fiber wraps into the inner cylinder where it is then free to move through the water line. Contaminants and suspended solids from the water are retained on the medium.

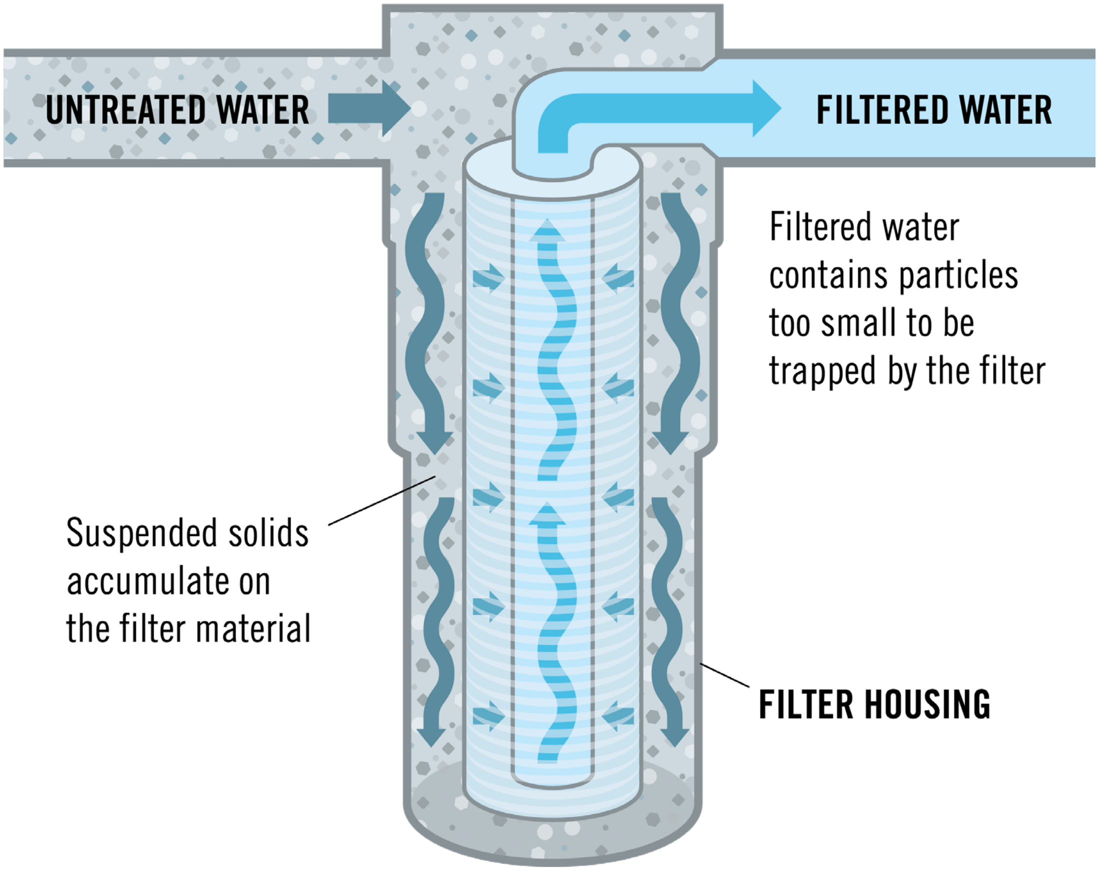

Figure 1. The sediment filtration process.

The amount of particles retained will depend on the pore space between media fibers or granules. These filters are available in a variety of sizes and meshes, from fine to coarse. Most filters list an average pore size and are rated by the manufacturer according to the smallest particle they can trap. For example, a 10 micron (one-thousandth of a millimeter) filter would trap contaminants 10 microns in diameter or larger. Check the filter rating when purchasing since many filters are only rated for particles 20 microns in diameter or larger. Filters with this rating may not effectively remove clay (less than 2 microns) and some silt particles (silt particles are 2.0-50 microns) smaller than 20 microns. However, they would trap sand particles, which range in size from 50 microns to 2 millimeters.

The finer the filter, the more particles are trapped and the more often the filter must be changed. If the pore size of the filter material is too small, or if the concentration of suspended solids in the untreated water is too high, the filter will be clogged easily and would require frequent replacement. On the other hand, if the pore size is too large, suspended solids may pass through the device.

Water flow through a filter is greatest when a new or replacement cartridge is installed. As trapped material accumulates in the filter, a filter cake develops, which can increase its effectiveness by assisting in the filtration process. However, water flow will gradually decrease as trapped material continues to accumulate. When the water flow becomes too slow for use, the filter cartridge should be cleaned or replaced.

Capacity

Some cartridge filters are rated according to the number of gallons of water they can treat. Although this may be a helpful guideline, differences in the type and amount of contaminants in the water make it difficult to accurately predict how much water a filter will effectively treat. During use, take note of when there is a noticeable drop in water flow and clean or replace the cartridge as needed.

Special considerations

When selecting a sediment filtration device, you should be aware of the following:

- The typical household has water pressure measuring about 30 pounds per square inch (30 psi). Check the manufacturer's installation guide to verify if it is suitable or if adjustments need to made on the operating pressure or initial flow rate entering the filtration device.
- The estimated amount of water that can be treated before maintenance is an important component.
- The desired quality of treated water is integral to selection a product. Clay particles, which are 0.2-2.0 microns, are typically too small to be removed by typical cartridge sediment filtration. A microfiltration process which uses a membrane with smaller pore sizes to remove particles of 0.02-2.0 microns may be more effective in such a situation, but keep in mind that microfiltration filters cannot handle large quantities of suspended material.
- The external housing for cartridge sediment filters often look alike. Make sure it contains the appropriate media to suit your needs.
- The filter media may be a source for bacteria to grow in devices, specifically filters using biodegradable paper. Bacteria can accumulate on these filters because cellulose in the paper serves as a food source (a growing medium). Though these bacteria may not cause illness, they can contribute to other water quality problems such as the water having an unpleasant taste or odor. ***Consider using a filter that uses nonbiodegradable media material to avoid such problems.***
- The device should be validated and certified by the National Sanitation Foundation (www.nsf.org) or the Water Quality Association (www.wqa.org).
- The system must be installed and operated according to the manufacturer's instructions.

Maintenance

Regardless of the quality of the equipment purchased, it will not perform properly unless managed in accordance with the manufacturer's recommendations for maintenance, cleaning, and part replacement. Keep a logbook to record water test results, equipment maintenance, and repairs.

- After installation, test both the raw water (before filtration) and the treated water to ensure that it is working properly and removing the contaminants.
- Continue to test the quality of both the untreated and treated water annually. This annual test will also help you determine how well your treatment system is working and whether maintenance or replacement of components may be necessary.
- Replace or clean the cartridge when there is a noticeable drop in water flow through the device—this will depend on the amount of contaminants being removed but can be after several weeks or months of use.
- Some cartridges are rated according to the number of gallons they can treat. Treat these ratings as a general guideline for maintenance, as variations in the nature and quantity of suspended solids make it difficult to accurately predict the time between cartridge replacements.
- If the cartridge requires replacement too often, a media filter (as discussed below) may be more economical.

Single filters and multimedia filters

Media filters consist of a tank, a single filter medium, multiple filter layers, a support system, and an underdrain. The bed depth of the filter medium is usually 24 to 36 inches and is comprised of silica sand, aluminum silicate, and/or crushed anthracite (a hard, compact variety of mineral coal). Usually a gravel support system prevents the medium from being washed out of the device. Media filters can be cleaned by backflushing and reused. Filters are rated by the smallest particle sizes they remove. With a same sized tank, multimedia filters have a greater filtering capacity than a single-media filters. Generally, multimedia filters also operate at a higher flow rate and require less frequent maintenance than single-media filters.

Uses of media filters

Media filters are point-of-entry (POE) devices that treat water at its entry point into the home. The following are some common uses of media filters:

- Media filters remove particles that cause turbidity (cloudiness of water). These filters can also be part of iron, manganese, and hydrogen sulfide removal after they have been oxidized into solid particles via aeration, chlorination, ozonation, or greensand filtration. See UGA Extension Bulletin 939, Circular 858-11, and Circular 858-15 for explanations of these treatment systems.
- A media filter can be used as a prefilter when suspended solids in the source water could reduce the effectiveness or service life of another primary treatment device like ultraviolet light or chlorination units used to disinfect water. If suspended solids are not removed prior to the UV device or chlorination unit, the solids may shield microorganisms from the killing action of light or chlorine and result in unsatisfactory treatment performance. See UGA Extension Bulletin 1487, "Household Water Treatment: Disinfection Methods and Devices."
- Prevention of sediment build-up in washing machines, dishwashers and hot water heaters.

How single media filters work

Untreated water enters the filter tank through the top under pressure and percolates through the medium, which traps any suspended solids. Treated water exits the device through the bottom of the medium at a slightly reduced pressure. As suspended solids accumulate on the media surface, developing a filter cake, they help to filter fine particles but gradually reduce water flow.

How multimedia filters work

In a multimedia filter, multiple layers of filter media are placed in sequence with the coarsest material at the top and the finest at the bottom. Here are two examples of a sequential layering of media from the top: bituminous coal/plastic beads and anthracite coal/sand/garnet.

A media support system (usually gravel) and underdrain are located at the bottom of the media bed. The gravel support prevents the media from washing into the underdrain. Water enters the top of the tank under pressure and flows through the media layers. Suspended solids pass through the top layer and are trapped by lower layers. In contrast to single-media filters where suspended particles are trapped on the top of the media column, multimedia filters trap the particles within the entire depth of the media. Therefore, multimedia filters require less frequent maintenance than the single-media filters. The particle size in the various media layers determines the interparticle pore space, which ultimately determines the size of suspended solid particles in untreated water that would be filtered out.

Capacity of media filters

The filter tank's diameter determines a media filter's flow rate capacity—the greater the diameter, the greater the flow. The flow rate is also affected by the media particle size and the amount of suspended solids in the water. Generally, a tank with a larger diameter would have higher service flow rate. The water flow rate available for backwashing would limit your choice of tank size unless a water treatment dealer provides a backwashing service. Manufacturers or water treatment equipment dealers can provide information concerning flow rates for various-diameter multimedia filters. Select the maximum tank diameter appropriate for the available backwash rate.

Maintenance

- Your water treatment equipment will not perform properly unless managed in accordance with the manufacturer's recommendations for maintenance, cleaning, and part replacement. Keep a logbook to record water test results, equipment maintenance and repairs.
- As recommended by the manufacturer, media filters should be backwashed on a regular basis to prevent accumulated particles from clogging the device. Backwashing reverses the direction of water flow through the filter by forcing water from the bottom of the filter tank and out through the top. This reverse flow expands the media bed and washes the collected solids out of the filter. The physical characteristics of the filter media allow the layers to resettle in their proper order after backwashing.
- For continued satisfactory performance, backwash the filter media if the flow rate is diminished or as recommended by the manufacturer.

Special considerations

- Backwashing the filters will put additional wastewater into your septic system. Make sure your system can handle this. Manufacturer recommendations for backwashing rates, times, and frequencies can help estimate the increased load that would be put on the septic system.
- Some arid regions of the U.S. are considering banning backwashing because it increases water consumption. Before purchasing equipment that requires backwashing, check your local ordinances for information on restrictions.
- Install and operate the system according to the manufacturer's instructions.
- After installation, test both the untreated and the treated water to determine whether the equipment is working properly.
- Continue to test the quality of both the untreated and treated water annually. This will also help to determine whether your treatment system is working effectively and whether maintenance or replacement of components is necessary.
- Multimedia filters can fail because of:
    - An inadequate backwash flow rate
    - An irregular backwashing schedule or insufficient time allowed for backwashing

If backwashing is done improperly, untreated water may eventually channel through the media, resulting in a clogged underdrain or incomplete treatment. For households with an inadequate backwash flow rate, some water treatment equipment dealers offer a backwashing service.

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