Water Quality

Focus Area
Drinking Water

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Understanding Home Water Treatment Systems

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The home water treatment industry has responded to recent public concern over water quality by introducing a wide variety of home water treatment products into the marketplace. When faced with so many choices, consumers wonder what, if any, water treatment system they need. The various methods for treating water and some of the advantages and disadvantages of those methods are described in this bulletin. This is not an endorsement of any particular method or product for treating water in the home.

If you are on a public drinking water supply, it most likely meets national safety standards. Home treatment should not be needed for health protection. Homeowners using a private water supply are responsible for monitoring the quality of their own drinking water supply (see MU Publications WQ 100, *Water Testing, What to Test For*, and WQ 101, *Understanding Your Water Test Report*). Water treatment devices can improve the quality of water by reducing health hazards such as bacteria, chemical pollutants and other toxic substances, or help remove nuisance problems, such as odors or hardness.

Before considering any treatment devices, you should know the quality of your water supply. Odor and hardness problems can sometimes be detected by simple observation. Detection of bacteria, potentially toxic substances and other contaminants usually requires laboratory-conducted tests. If any undesirable qualities are identified in the water, the problem can often be solved by repairing or replacing the existing water system or treating the home water supply.

Locating a safe water supply is usually the best solution to combat a health risk. When persistently contaminated water poses a health threat or makes the water unusable, consider the following options: correct well construction faults, eliminate sources of contamination, install a new private well, connect to a public water supply or develop a community water system. After considering all of the options, a home water treatment system may be the most economical choice. Be sure the system you select bears the mark of the National Sanitation Foundation (NSF).

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Mark of the National Sanitation Foundation (NSF).

Before purchasing a system, you should know how the various systems work, what problems they address and the maintenance required. If more than one problem exists, treating water can become complicated. Purchasing water for drinking and cooking may be more cost effective than owning and maintaining equipment.

Water treatment systems generally use one or a combination of these five basic categories:

1. Disinfection methods (chlorination, ultra violet light, etc.)
2. Filtration, including activated carbon filters
3. Reverse osmosis
4. Distillation
5. Ion exchange (water softeners)

Disinfection

Disinfection methods kill most of the harmful bacteria, viruses, cysts and worms found in water which can cause acute illness. Disinfection methods include chlorination, pasteurization, ultraviolet light and boiling (see MU publication WQ 102, *Bacteria in Drinking Water*, for a detailed discussion of disinfection methods).

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Chlorination

The most common, oldest and relatively inexpensive method used to disinfect water is chlorination. A chemical feed pump continuously dispenses chlorine chemicals into the water supply. Chlorine, an oxidizing agent, kills most bacteria and some viruses. In the proper concentrations and under adequate exposure time, chlorine is an excellent disinfectant.

However, care must be taken to assure that only clean, clear water is used. Chlorine reacts with certain metals and organic matter in the water. The major problem with chlorination is the potential formation of hazardous, chlorinated, organic chemicals (trihalomethanes) when the chlorine reacts with organic molecules in the water supply. Using an activated carbon filter after chlorination will remove excess chlorine and limited amounts of chlorinated chemicals formed. Chlorination may also oxidize and remove some color and odor-causing substances including some iron and hydrogen sulfide.

The chemical feed pump requires frequent maintenance. The chemical reservoir must be kept filled and the pump checked at regular intervals for worn parts.

Pasteurization

With pasteurization, water is heated to kill bacteria, viruses, cysts and worms. The limited efficiency of the heat exchange makes pasteurization expensive. Pasteurization does not leave behind a residual product which continues to disinfect beyond the immediate treatment period.

Ultraviolet radiation (UV)

Low-pressure mercury arc lamps produce ultraviolet light which has germicidal properties. The radiation kills or deactivates pathogens. Bacteria are killed with relatively low amounts of radiation, viruses are more resistant, and cysts and worms are unaffected.

The lamp's efficiency decreases with age and must be replaced annually. Color, turbidity and organic impurities in the water also interfere with transmission of ultraviolet energy and may reduce efficiency to unsafe levels. Also, radiation leaves no residual product that continues to disinfect beyond the treatment period.

Boiling

Boiling water for three minutes kills bacteria, including disease-causing organisms and giardia cysts. However, boiling concentrates inorganic impurities such as nitrate and sulfates. Boiled water also tastes flat because the carbon dioxide is removed.

Filtration

Filter systems are a relatively simple and effective way to control a variety of contaminants. These include mechanical filters, activated carbon filters, oxidizing filters and neutralizing filters. Filtration systems are designed for use **only** on potable water. This means that your water supply should be clean, uncontaminated and suitable for drinking.

Mechanical filters (microfiltration)

Mechanical filters remove suspended material from water, including sand, silt, clay and organic matter. They do not remove dissolved or very fine particles and are often used in combination with other treatment equipment. Filters are commonly of fabric, fiber, ceramic or other screening material. Mechanical filters can be cartridge units, mounted in a single waterline or on a tap, or tank units, which treat an entire household water supply. The filters must be serviced periodically.

Activated carbon filters

Activated carbon filters absorb impurities as they pass through a carbon cartridge. Generally, they are used to eliminate undesirable odors and tastes, organic compounds and to remove residual chlorine. Most inorganic chemicals, metals, microorganisms and nitrates are not removed by the filters.

Carbon filters also remove some potentially hazardous contaminants such as radon gas, many dissolved organic chemicals and trihalomethanes. If low levels of these contaminants exist, a whole-house unit can be used. However, these filters are not designed to remove persistently high levels of these contaminants. When contamination cannot be eliminated, an alternative water supply may be the safest solution.

The carbon filter loses its effectiveness as it becomes saturated with contaminants, and must be replaced on a regular basis. Using the filter longer than its rated lifetime may cause contaminants to be flushed into the drinking water. Before purchasing the unit, ask the dealer if the filter can be replaced, the frequency of replacement, where replacement filters may be purchased and their price.

The material in an activated carbon filter provides a growth surface for certain bacteria. If the filter has not been used for five or more days, simply run chlorinated water through the filter for at least 30 seconds before use.

Some manufacturers claim the addition of silver in their carbon filters will reduce or prevent bacteria growth. These carbon filters are registered as bacteriostatic by the Environmental Protection Agency (USEPA) due to a requirement by the Federal Insecticide, Fungicide and Rodenticide Act. The required registration indicates the filter does not release excessive amounts of silver. The EPA has not endorsed these methods for reducing bacteria in the filter or in the water. Furthermore, a bacteriostatic carbon filter is not adequate to treat water that is microbially unsafe.

Oxidizing filters

Oxidizing filters remove iron, manganese and hydrogen sulfide (rotten egg odor). A manganese zeolite-coated filter causes dissolved iron and manganese to form particles the filter then traps. These filters are useful in removing iron if a water softener is not wanted. The filter usually treats the entire household water supply. Periodically, the filter must be rinsed with a chemical solution to remove the accumulated iron and manganese.

Neutralizing filters

Neutralizing filters treat acidic water. The filter treats all of the home water supply by passing it through limestone chips or other neutralizing agent. Where acidic water does occur, it can leach lead, copper or other toxic metals from household pipes into the water supply.

Two potential problems occur with the filter. First, it may increase water hardness. Secondly, acidic water may intensify any iron problems already present in the water supply. The filter requires little maintenance except the need to occasionally replace the limestone chips.

Reverse osmosis

Reverse osmosis pressurizes and passes impure water through a semi-permeable membrane and removes many of the impurities (approximately 90% free of mineral and biological contaminants). The quality of the membrane and the pressure of the water help determine how effective the water separates the contaminants.

Reverse osmosis (RO) units remove substantial amounts of most inorganic chemicals (such as salts, metals, minerals), most microorganisms and many organic chemicals. They do not effectively remove some organic compounds such as nitrate; they will reduce levels somewhat.

Mechanical filters and activated carbon filters are most always used with a RO unit. First, the mechanical filter removes dirt, sediment and other impurities which clog the reverse osmosis membrane. The RO unit is installed next. An activated carbon filter then removes some organic compounds which pass through the RO unit. Nitrates, however, will pass through carbon filters.

Reverse osmosis units use large amounts of water. Typically, about 75% or more of the water put into RO units is discarded with the contaminants. These systems may not be appropriate for households with a limited water supply. These units are expensive to purchase and require regular maintenance. Usually they are connected to a cooking and drinking line only and installed under the kitchen sink. Regular testing of the water supply is necessary to make sure the membrane is intact.

Distillation

Distillation heats water until it vaporizes as steam. Minerals, bacteria and other substances are left behind when the steam recondenses into relatively pure water. Distillers remove bacteria, minerals, trace amounts of metals, many organic chemicals and nitrate. Some stills allow contaminants with boiling points lower than water (some pesticides and volatile solvents) to vaporize with the water and recondense with the distilled water. A vented distiller avoids this problem. Distillers also remove beneficial minerals and make water taste flat or bland.

The distillation process is very slow (daily capacity is usually between two and five gallons). Approximately five gallons of tap water is required to produce one gallon of distilled water. Stills are relatively expensive. They require frequent cleaning and may be difficult to keep clean. The maintenance requirements and electricity consumption should be major considerations when purchasing a distiller.

Ion exchange (water softeners)

A common problem of water supplies is hardness, mainly caused by excess calcium and magnesium. Ion exchange systems soften hard water by removing the minerals causing hardness. These hardness minerals may interfere with the cleaning action of soaps and detergents and cause scale buildup in hot water pipes, water heaters and fixtures. The system also effectively removes some iron, manganese and many heavy metals.

The hard water is pumped through a tank containing an exchange resin. Sodium on the exchange resin replaces the hardness minerals. The sodium remains in soluble form in the softened water. Persons with heart problems should discuss this issue with a physician who will need to know the sodium level in the existing household supply of softened water.

To function properly, the resin tank must be periodically flushed (or recharged) with a solution of sodium chloride (salt). Some softeners automatically recharge the tank either on a regular schedule, or when an electronic sensor detects that the resin needs to be recharged. With automatic recharge you only need to keep the sodium storage container filled. Other softeners must be recharged manually and are usually serviced by water treatment companies.

Purchasing considerations

Before buying a water treatment system, know the quality of your water supply and if treatment is needed. Consider the simplest and most economical solution to the problem. Removing the source of contamination, obtaining a new source of drinking water or treating the water with a water treatment system may be appropriate solutions.

When purchasing a treatment system, ask the following questions:

1. **What testing is needed to evaluate my water supply?** There is no single test to determine if water is safe. On-site demonstrations are not an accurate indicator of contaminant levels. Test water for suspected contaminants through a certified water testing laboratory.
2. **Is the system designed to treat the specific water quality problem?** Check the NSF rating for performance standards of water-treatment devices.
3. **How many gallons of treated water does the unit produce per day?** Is the amount sufficient for your household needs? If water need is low, purchasing bottled water may be more cost effective than purchasing water treatment equipment.
4. **Is there a sufficient water supply for the treatment unit to work properly?** Distillation and RO units use large amounts of water.
5. **How will you know if the unit is not working properly?** An alarm or indicator light should alert you to a malfunction.
6. **What maintenance is required?** All equipment requires maintenance and service. The more treatment you have, the greater your responsibility.
7. **What routine servicing is offered?** Is a service contract available? Unless you are unusually dedicated, automated and self-monitoring features or dealer's service agreements are recommended to insure correct operation and high quality water.
8. **Is there a warranty?** What does it cover? Make sure any claims about the performance of the treatment unit are clearly identified in writing.
9. **What is the total cost?** Consider the expected life, purchase price, installation cost, maintenance cost and operation cost. Every treatment system has its own advantages and disadvantages.
10. **If you rent the equipment, does your agreement include an option-to-buy provision?** Compare the rental cost to the purchase price and expected life of the equipment.

Some of the more common treatment methods used to handle certain contaminants are mentioned in Table 1 (on page 5). This is a general guide and does not contain all of the potential treatment techniques or contaminants. The concentration of the contaminant and combination of various contaminants can have a major impact on the effectiveness of the treatment method.

For further information

For further information on water testing or suspected contamination in your area, contact your local health department or county University Extension Center. The following MU publications in the Water Quality series may also be helpful:

WQ 100, *Water Testing: What to Test For*
WQ 101, *Understanding Your Water Test Report*
WQ 102, *Bacteria in Drinking Water*
WQ 103, *Nitrate in Drinking Water*

Other sources of information

Private Water Systems Handbook, MWPS-14, Midwest Plan Service.

References:

Shaw, Byron H. and James O. Peterson, *Improving Your Drinking Water Quality*, Cooperative Extension Service, University of Wisconsin-Madison, Madison, Wisconsin.

Water Treatment Fundamentals, 1983, Water Quality Association Education Services.

Solutions to water quality problems

1 = First choice or best treatment option; 2 = Second choice; 3 = Third choice

Contaminant or problem	Locate & remove source of contaminants	Alternate water supply	Chemical feeder	Neutralizing filter	Activated carbon[a] filter	Zeolite-ion exchange softening	Resin-ion exchange softening	Reverse osmosis	Distillation	Chemical contaminant filter	Sediment filter
Bacteria	1	2	3[b]						3		
Acidity/alkalinity/pH			1	1							
Sediment/asbestos								2	2		1
Common inorganic chemicals								1	1		
Heavy metals such as cadmium, chromium, lead, mercury, silver, etc.					2[f]			1	1	2[f]	
Nitrate/nitrite	1	2						3[d]	3		
Sodium		1						2	2		
Total dissolved solids (salts)								1	1		
Iron and manganese						1[c]	2[c]				
Hardness						2	1				
Odor/taste					1[c]					1[c]	
Pesticides/VOCs		1			4			3	3[g]	2	
Turbidity		3			2						1

[a]Caution: A carbon filter (also called taste and odor filter) is an ideal medium for bacteria growth and should be used only on water supplies that are continuously disinfected or known to be free of bacteria. The chemical contaminant filter is usually a two-stage carbon filter.

[b]Continuous disinfection (chlorination).

[c]Iron removal capacity of softening depends on amounts of iron, filter capacity, and type of exchange media. Higher concentrations require use of special iron treatment equipment, i.e., iron filter.

[d]Requires a semi-permeable membrane, pressure over 60 psi and regular monitoring of salts to insure effective removal by reverse osmosis. Reverse osmosis reduces but does not remove all nitrates.

[e]Activated carbon generally does a good job of removing odor and taste from chlorine, organic sources and certain gases.(when tastes are from minerals, it will probably not improve taste).

[f]Removes small amounts of some contaminants.

[g]A vented distiller is necessary for this process.

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