

# HOME WATER TREATMENT USING USING ACTIVATED CARBON

A carbon (AC) filters have been used in home water purification systems primarily to remove taste and odor. Taste and odor, although undesirable, are generally not considered unhealthy. In recent years, however, AC filters have been used to remove some of the contaminants that have been discovered in water supplies.

AC is most effective at removing organic compounds such as volatile organic compounds, pesticides and benzene. It can also remove some metals, chlorine and radon. As with any treatment system, it cannot remove all possible drinking water contaminants.

Because AC systems are limited in the types of compounds they can effectively remove, it is essential that the homeowner determine which water contaminants are present before purchasing such a system. Anyone who suspects they have a water quality problem should first have their water analyzed by their local health department or a reputable laboratory. These analyses are costly, but worth the expense since they are necessary to determine the appropriate home treatment system and how best to operate such a system. A state or local health official can interpret water analysis result. Some laboratories may also provide this service.

Note that home water treatment is considered only a temporary solution. The best solutions to a contaminated drinking water problem are to either end the practices causing the contamination or change water sources.

## ACTIVATED CARBON

**AC IS A BLACK**, solid substance resembling granular or powdered charcoal. It is extremely porous with a very large surface area. One ounce of AC has an estimated 30,000 square yards of surface area. Certain contaminants accumulate on the surface of the AC in a process called adsorption.

The two main reasons that chemicals adsorb onto AC are a "dislike" of the water, and attraction to the AC. Adsorption of most contaminants results from a combination of these reasons. Many organic compounds, such as chlorinated and non-chlorinated solvents, gasoline, pesticides and trihalomethanes can be adsorbed by AC. AC is effective in removing chlorine and moderately effective in removing some heavy metals. AC will also remove metals that are bound to organic molecules. Fluoride, chloride, nitrate, hardness (calcium and magnesium) and most metal ions are not removed by AC to any significant degree.

It is important to note that carbon is not necessarily the same as AC. AC removes vastly more contaminants from water than does ordinary carbon. Fig. 1 shows how contaminants adsorb on an activated carbon filter.

## AC FILTERS

Home AC treatment systems are quite simple. The AC is normally packaged in filter cartridges that are inserted into the purification device. Water needing treatment



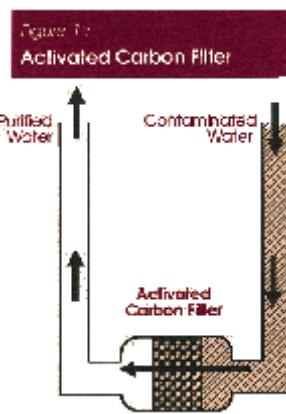
passes through the cartridge, contacting the AC on its way to the faucet. AC filters eventually become fouled with contaminants and lose their ability to adsorb pollutants. At this time, they need to be replaced.

AC treatment systems are typically point-of-use (POU) - installed where they typically treat water used for drinking and cooking only. AC filters can be placed on the end of the faucet, on the countertop, or under the sink. POU systems often have a bypass so that water for purposes other than drinking and cooking can also be dispensed at the tap without being treated. This increases the life of the AC, reducing the time between filter replacements.

**A POINT-OF-ENTRY (POE)** system is more appropriate if a contaminant is present that poses a health threat from general use as well as from consumption. Volatile organic compounds and radon are examples of this type of contaminant. These contaminants may get into the indoor air when water is used for showering and washing. In this case, it is more economical to have a large POE system that treats water as it enters the home than to have POU systems at each tap.

AC filters used for home water treatment contain either granular activated carbon (GAC) or powdered block carbon. Although both are effective, one study comparing GAC with block AC filters showed that the block AC filters were more effective in removing chlorine, taste and halogenated organic compounds.

The amount of AC in a filter is one of the most important characteristics affecting the amount and rate of pollutant removal. More carbon in a cartridge means more capacity for chemical removal, resulting in longer cartridge lifetime. This means fewer cartridge changes and less chance of drinking contaminated water. Particle size will also affect the rate of removal; smaller AC particles generally show higher



adsorption rates.

Rust, scale, sand or other sediments can clog any AC filter. A solution to this problem is to place foam or cotton filters (often called sediment or fiber filters) between the cartridge and incoming water. When sediment filters become clogged, they need to be replaced or they will cause water pressure to drop.

An AC filter must be deep enough so that the pollutants will adsorb to the AC in the time it takes the water to move through the filter. The appropriate filter depth depends on the flow rate of water through the filter. The slower the flow rate, the better the removal. The poor performance of some end-of-faucet devices is probably due to improper filter depth.

Physical and chemical characteristics of the water will also affect performance. The acidity and temperature can be important. Greater acidity and lower water temperatures tend to improve the performance of AC filters.

## OPERATION, MAINTENANCE AND COST

### AC FILTERS

have a limited lifetime. Eventually, the surface of the AC will be saturated with adsorbed pollutants, and no further purification will occur. This is called breakthrough - the pollutants have broken through the filter to emerge in the treated water. When this occurs, it is possible that the contaminant concentrations in the treated water will be even higher than those in the untreated water. At this time, the cartridge needs to be replaced. Knowing when breakthrough will occur and thus when to replace the cartridge is a major problem with AC treatment.

Unfortunately, no alarms accompany breakthrough. Unless the pollutants are smelled or tasted they can be unknowingly consumed. In most cases, breakthrough can be positively verified only by costly chemical testing. Frequent chemical testing is impractical.

*Public health officials consider AC home treatment a temporary solution to be used only until the source of contamination can be eliminated.*

and expensive. However, occasional sampling may be useful in helping to predict when breakthrough will occur and alert the user to replace the filter before this happens.

SOME CARTRIDGES are sold with predictions about their longevity. These are generally only crude, estimates since they do not take into consideration factors that are characteristic to a specific water source, such as pollutant concentration. The retailer you purchase the treatment device from can make better estimates of the filter's useful lifetime based on water usage (flow rate) and pollutant concentrations shown in the chemical analysis. Hence, to get the most accurate estimates, you should learn what these amounts are before purchasing the system. Note that if pollutant concentrations increase over time and testing is not performed to reveal this change, such estimates may turn out to be not very practical or useful.

The water flow rate through the filter can either be estimated or measured with a flow meter installed near the AC filter. The retailer can calculate the maximum allowable number of gallons that can pass through the filter before breakthrough occurs and the homeowner can replace the filter when this number is reached. Remember, any prediction for filter replacement must be based on the actual pollutant concentrations present in the water. This makes the necessity of an initial water analysis and periodic routine analyses all the more important.

Some systems are sold with claims that the device will alert the user when replacement of the cartridge is needed. This is based on a pressure drop across the filter, which may or may not result from saturation of the filter. Saturation and breakthrough may occur long before a filter becomes sufficiently clogged to cause excess pressure drop. Thus, these types

of devices may not protect you.

SINCE PREDICTING when breakthrough will occur is not always easy or accurate, it may be beneficial to replace the cartridge more often than the manufacturer recommends. In some cases cartridge replacement should be performed twice as often as recommended by the manufacturer. Reduction in water pressure, change in taste, or sediment in the water are indicators of filter malfunction. When these occur, the cartridge should be replaced.

Unfortunately, AC filters can be excellent places for bacteria to grow. Conditions for bacterial growth are best when the filter is saturated with organic contaminants, which supply the food source for the bacteria, and when the filter has not been used for a long period of time. It is still unclear whether the bacteria growing on the carbon poses a health threat. Some manufacturers have placed silver in the AC in order to prevent the growth of bacteria. The effectiveness of this procedure has, not been independently verified. In addition, silver may contaminate the drinking water.

The above considerations have led public health officials to consider AC home treatment a temporary solution to be used only until the source of contamination can be eliminated and the water supply is safe. Even with proper installation, maintenance and operation, malfunction of home water treatment systems can occur.

AC filters vary in cost as in effectiveness. Good under-the-sink models cost between \$200 and \$700, while POE devices can cost as much as \$3,000. End-of-faucet devices can be purchased for as low as \$10. Tests show that under-the-sink models generally have more carbon, and provide superior performance and greater convenience than faucet or countertop models.

(NOTE. Dollar values are provided as a rough guide to compare costs of different systems. Current prices are likely to be higher than those quoted.)

## **AC FILTER GUIDELINES**

1. Make sure the filter contains AC.
2. Know the quantity of AC in the filter since this will determine the amount and rate of pollutant removal.
3. Use pre-filters to add life to AC filters.
4. Replace pre-filters and AC filters regularly.
5. Determine appropriate intervals for replacement of AC filters based on contaminant concentration, water characteristics, water flow rate, depth of filter, type and amount of AC and pre-filter. Retailers can help in this analysis.

## **SUMMARY**

HOME WATER purification using AC is one option that is often used by people with a drinking water quality problem. AC is considered the best home method, for treating certain organic compounds. However, it is not recommended for metals and other ions that can also be common drinking water contaminants.

## **CERTIFICATION AND VALIDATION**

CERTIFICATION of treatment products is available from independent testing laboratories, such as the National Sanitation Foundation (NSF). Results from NSF tests provide good measures of the effectiveness of devices designed to treat water for both esthetic and health reasons. The Water Quality Association (WQA) a self-governing body of manufacturers and distributors, offers voluntary validation programs to its members. Validation is less stringent than certification. Note that certification or validation will not ensure effective treatment; all systems must be designed for each particular situation and maintained properly.

The selection of an AC filter should be based upon., water analysis and a thorough assessment of the individual homeowner's situation. Being well informed before making a decision is a homeowner's best insurance for protecting health.

This material is based upon work supported by the U.S. Department of Agriculture, Extension Service, under project number 89-EWQI-1-9144. The publication was developed by the Community Assistance Program in Environmental Toxicology, a program in Michigan State University's Center for Environmental Toxicology and Department of Resource Development that is supported in part with a grant from the Charles Stewart Mott Foundation

For general water quality information and referrals, contact:

**Your county Cooperative ExtensionService office** (listed under "County Government" in the white pages of your phone book).

**Center for Environmental Toxicology**

Michigan State University  
East Lansing, Michigan 48824  
(517)353-6469

**Institute of Water Research**  
Michigan State University  
East Lansing, Michigan 48824.  
(517)353-3742

For questions about water testing, test interpretation and treatment systems, contact:

**Your local health department**  
(listed under city or county in the phone book).

**Michigan Department of Public Health**

Division of Water Supply 3423 North Logan Street P.O. Box 30195 Lansing, Michigan 48909 (517) 335-9216

For further information on water and home water treatment, consult the following publications, available from your county Extension office:

E-2016, "Testing for Contaminants: A Guide for the Home and Farm"

WQ 02, "Guidelines for Testing of Private Wells"

WQ 19, "Nitrate- A Drinking Water Concern"

WQ 21, "A Guide to Home Water Treatment"

WQ 22, "Distillation for Home Water Treatment"

WQ 24, "Reverse Osmosis for Home Treatment of Drinking Water"

MSU is an Affirmative Action/Equal Opportunity Institution. Cooperative Extension Service Programs are open to all without regard to race, color, national origin, sex or handicap. Issued in furtherance of Cooperative Extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. J.Ray Gillespie, interim director, Cooperative Extension Service, Michigan State University, East Lansing, MI 48824. This Information is for educational purposes only. Reference to commercial products or trade names does not imply endorsement by the Cooperative Extension Service or bias against those not mentioned, This bulletin becomes public property upon publication with credit to MSU. Reprinting cannot be used to endorse or advertise a commercial product or company.