

Drinking Water Treatment: **Distillation**

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Homeowners are increasingly concerned about contaminants in their water supply that may affect health or cause taste, odor, or nuisance problems. Distillation, one of the oldest methods of water treatment, is an effective method for reducing many impurities found in water. This NebGuide discusses the process and related equipment used for household drinking water treatment by distillation.

Contaminants Removed from Water by Distillation

Distillation can remove nearly all impurities from water. Compounds removed include sodium, hardness compounds such as calcium and magnesium, other dissolved solids (including iron and manganese), fluoride, and nitrate. Operated properly, it effectively inactivates microorganisms such as bacteria, viruses, and protozoan cysts (though protozoan cysts are not likely to be found in Nebraska groundwater).

Distillation also can remove many organic compounds, heavy metals (such as lead), chlorine, chloramines, and radionuclides. Because distillation also removes some oxygen, along with trace metals, which give water a pleasing taste, people often claim that distilled water tastes “flat” or “bland.”

Contaminants Not Removed from Water by Distillation

No one piece of treatment equipment manages all contaminants. All treatment methods have limitations, and, often, situations require a combination of treatment processes to effectively treat the water. Distilled water may still contain trace amounts of the original water impurities after distillation.

Removal of organic compounds by distillation can vary depending on chemical properties of the contaminant. Certain pesticides, volatile solvents, and volatile organic compounds (VOCs), such as benzene and toluene, with boiling points close to or below that of water will vaporize along with the

water as it is boiled in the distiller. Such compounds will not be completely removed unless another process is used prior to condensation. See the section in this NebGuide on treatment principles for further discussion of ways distillers may remove VOCs.

The boiling process during distillation generally inactivates microorganisms. However, if the distiller is idle for an extended period, bacteria can be reintroduced from the outlet spigot and may recontaminate the water.

Water Testing

Regardless of which water treatment system is considered, the water first should be tested to determine what substances are present. Public water systems routinely test for contaminants. Water utilities are required to publish Consumer Confidence Reports (CCRs), which inform consumers on the source of the water, contaminants present, potential health effects of those contaminants, and methods of treatment used by the utility.

Depending on the population the utility serves, CCRs may be mailed, published in newspapers, or posted on the Internet, but copies can be obtained from the local water utility. Public supplies must conform to federal standards established by the Safe Drinking Water Act. If contaminants exceed the Maximum Contaminant Level (MCL), the water must be treated to correct the problem and/or another source of water suitable for drinking must be provided.

In contrast, monitoring private water systems is the homeowner’s responsibility. Therefore, contamination is more likely to go undetected in a private water supply. Knowing what contaminants may be present should guide the testing, since it’s not economically feasible to test for all possible contaminants. It is essential to know what contaminants are present, their quantities, and reasons for removal (e.g., health risks, foul tastes or odors, etc.) prior to selecting treatment methods or equipment. Refer to the NebGuide *Drinking Water Testing for Quality* (G907) for testing information and to the Extension Circular *Drinking*

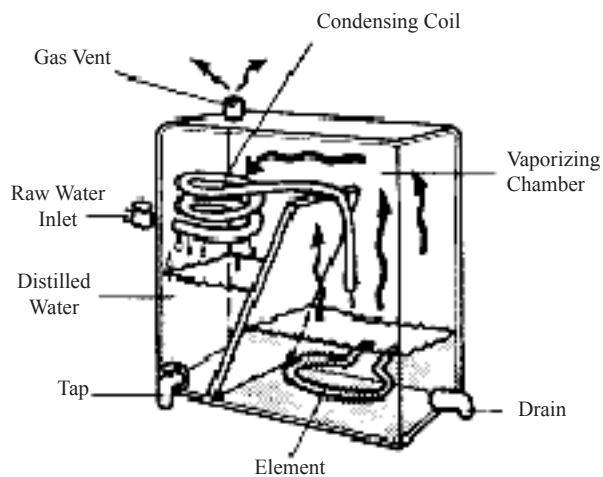


Figure 1. The distillation process. From "Treatment Systems for Household Water Supplies: Distillation." North Dakota State University Extension Service.

Water Treatment: An Overview (EC703) for further information on matching water problems to potential contaminants.

Treatment Principles

Distillers use heat to boil contaminated water and produce steam. Impurities such as inorganic compounds and large non-volatile organic compounds are not vaporized and are left behind in the boiling chamber of the unit. The heat inactivates bacteria, viruses, and protozoan cysts. The steam rises and enters a cooling section containing condensing coils. The steam cools, condenses back to a liquid, and the water flows into a storage container. This collected water can have up to 99.5 percent of impurities removed. The water remaining in the boiling chamber has a much higher concentration of impurities. This water is removed by a drain and discarded. *Figure 1* shows a typical household distiller.

Since volatile organic compounds also can vaporize as the water is boiled and turned to steam, methods for removing them can be incorporated into the system. Distillers that use a combination of removal methods for VOCs are more efficient than those with a single method. Gas vents (small holes in the passage of the distiller leading to the condensing coils) can allow VOCs to escape the distiller before entering the cooling section.

Another option is using a fractional column distiller. In this type of distiller, the VOCs are cooled and condensed in a separate section of the distiller than where the water is condensed.

A third option is to use an activated carbon (AC) filter to remove VOCs from the condensed water before it enters the storage tank. Alternatively, the AC filter can be placed in the water feed line to the distiller so VOCs entering the unit are reduced. See the NebGuide *Drinking Water Treatment: Activated Carbon Filtration* (G1489) for information on AC filtration as a drinking water treatment.

Since VOCs generally have boiling points close to or below that of water, they will vaporize early in the distillation process. If not removed, the VOCs then condense back to a liquid along with the water. For distillers without gas vents,

fractional columns, or AC filters, VOCs may be removed to some degree by discarding the first pint (1/2 liter) of distilled water collected.

Operation costs for distillation should be considered prior to purchase. The most significant operational cost for distillation is the electricity required to heat the water to generate steam (other costs include cleaning solution and if equipped, AC filter replacement). Operational costs are directly dependent on the amount of distilled water used daily (which determines how often the unit operates). The operational cost for distillation can be among the highest of available home drinking water treatment systems.

The cost to distill 1 gallon of water is determined by the wattage rating of the unit and the local electrical rate. The approximate cost of distilling 1 gallon of water can be determined as follows:

$$\text{electric cost, (\$/gal)} = \frac{\text{wattage rating, (watts)}}{1000 \text{ watts/kWatt}} \times$$

hours needed to distill 1 gallon x local electric rate, \\$/kWh

For example, an 1100-watt unit that takes three hours to distill 1 gallon where the electric rate is \$0.10/kWh would have an electricity cost of:

$$\text{electric cost} = \frac{1100 \text{ watts}}{1000 \text{ watts/kWatt}} \times 3 \text{ hrs} \times \$0.10/\text{kWh} = \$0.33/\text{gallon}$$

Equipment

Distillers are generally constructed of stainless steel, aluminum, and plastic material. These materials can be kept sanitary and do not tend to absorb contaminants from water. Also, distilled water should be stored under sanitary conditions to prevent recontamination. Storage containers should be glass or stainless steel.

There are two basic types of distillers. A batch distiller has water poured directly into the boiling chamber. When the unit is started, the water is heated to boiling by a heating element in the chamber. The unit shuts off when all water in the boiling chamber is evaporated. The distilled water is stored in a container for household use. The capacity of batch distillers generally ranges from 1 to 10 gallons. The smaller capacity distillers are similar in size to a coffee maker and sit on the countertop. Larger capacity distillers are floor units. Batch distillers typically produce 3 to 10 gallons of distilled water per day, which is generally sufficient for drinking and cooking.

A continuous flow distiller connects to the water supply line. A float valve in the boiling chamber regulates and maintains the water level in the chamber. As distilled water is used from the storage container, the unit automatically starts producing more distilled water. The water and impurities remaining in the boiling chamber are periodically removed through a discharge line.

Additional equipment, such as supplemental storage containers, transfer pumps, and special kitchen taps for instal-

lation at the point of use, may be included with a distillation system. For example, if a continuous flow distiller is located away from the point of use in the kitchen, a special tap and an additional storage container may be located beneath the kitchen sink. A level switch within the storage container can be connected to a transfer pump. As the tank under the sink empties, the level switch activates the transfer pump and distilled water from the distiller storage tank is transferred through additional plumbing to beneath the sink. The distiller then automatically starts as the level in the storage tank is lowered.

As water is boiled in the distiller, minerals and other solids accumulate within the boiling chamber. If scale and sediment are not periodically removed, the distiller may become less efficient and require more electricity to distill a given amount of water. Appropriate commercial cleaning agents to remove build-up materials are available from the vendor. Cleaners are generally an organic acid. Strong mineral acids, such as hydrochloric acid, sulfuric acid, or nitric acid, should not be used as they may damage stainless steel or aluminum parts. A 50 percent solution of vinegar, which contains a weak organic acid, also can be used as the cleaning agent.

Removal of scale buildup is done by filling the distiller with the proper cleaning solution to 1/2 inch above the mineral line, letting the solution sit for the recommended time, discarding the solution, and rinsing the distiller. For relatively hard water, pretreatment by a water softener can reduce the frequency of cleaning and help maintain efficient operation.

Other regular maintenance includes keeping the gas vents clear of scale deposits and replacing the AC filter, if present. This maintenance helps assure that units equipped for VOC removal will perform properly.

The lifespan of the distiller depends on several factors, including the quality of the water supply, how often the unit operates, and proper maintenance. With proper maintenance and care, a good quality distiller should last 10 to 15 years. Replacing a heating element or a cooling fan are common repairs for distillers.

Selection Requirements

All distillers should be listed with the Underwriters Laboratories (UL).

Federal, state, and local laws do not regulate household distillation systems. The industry is self-regulated. The NSF (formerly known as the National Sanitation Foundation) and the Water Quality Association (WQA) evaluate performance, construction, advertising, and operation manual information. The NSF program establishes performance standards that must be met for endorsement and certifica-

tion. The WQA program uses the same NSF standards and provides equivalent American National Standards Institute (ANSI) accredited product certifications. WQA-certified products carry the Water Quality Association Gold Seal. Though these certifications and validations should not be the only criteria for choosing a distillation system, they can help ensure effectiveness of the system.

Other important guidelines for consumers purchasing drinking water treatment equipment are discussed in the NebGuide *Drinking Water Treatment: What You Need to Know When Selecting Water Treatment Equipment* (G1488). This NebGuide focuses on various contaminants most likely to be encountered in Nebraska drinking water supplies. It is possible that some water supplies may contain contaminants not addressed here, such as cryptosporidium, giardia, hexavalent chromium, and others. Water distillation may inactivate or remove some of these contaminants as well.

Summary

Drinking water treatment using distillation is one option for treating water problems. Operated properly, distillation can remove up to 99.5 percent of impurities from water, including bacteria, metals, nitrate, and dissolved solids. Operation costs for distillation can be among the highest for home drinking water treatment systems. Selection of a distillation unit should be based on water analysis and assessment of the individual homeowner's needs and situation. Regular maintenance of the unit is a critical factor in maintaining its effectiveness. NSF and the WQA test and certify products. This certification and validation can help guide selection.

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