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Preparing Rainwater for Potable Use

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Rainwater harvesting can provide a realistic source of water for homeowners living in remote areas or those who for one reason or another prefer not to use their groundwater inside the house. Local groundwater may have problems common in many parts of Arizona: high mineral content, naturally occurring elements such as arsenic and fluoride, and contaminants from various sources, such as overflowing septic tanks, and agricultural, industrial or mining activities. Homeowners may have low-yield or seasonally dry wells and wish to avoid trucking in water. They may be unwilling or unable to drill or deepen a well. They may prefer rainwater for its taste, softness or other desirable qualities. In these situations, homesteaders may find large-scale rainwater harvesting a practical alternative. Large systems can provide potable water for an entire household.

This publication aims to cover the basics of the handling and treating of rainwater for potable use. From roof to point of use, rainwater must go through a series of capture, storage and treatment steps before it is drinkable. These steps involve roof, gutters and tank(s); pipes, pumps and pressure devices; and pre-filtering, filtering and treatment devices. Treatment is necessary to remove contaminants, such as pathogens, organic material, dust particles, and metals, that may come in contact with rainwater from the air, roof surface, or other pathways. Bird droppings are the most common source of pathogens, while metals may be leached from less than optimal harvesting system components. To use rainwater for drinking, cooking, bathing, cleaning, etc., homeowners must be willing to take responsibility for their own water treatment.

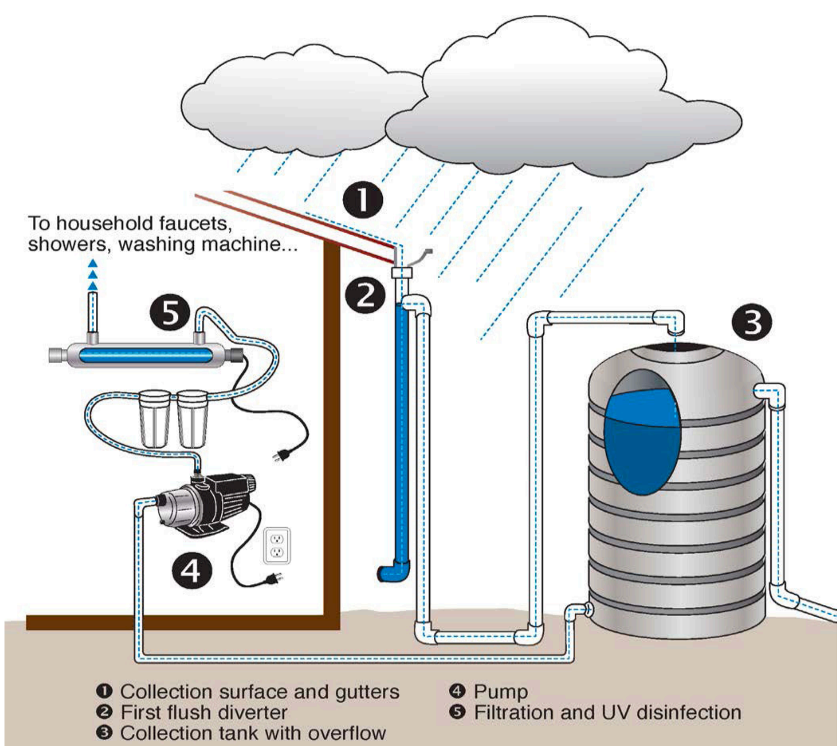


Figure 1. Basic Parts of a Rainwater Capture and Treatment System. Diagram by John Polle.

Basic Parts of a Rainwater Capture and Treatment System

The basic components of a rain harvesting system are (1) roof and gutters (2) pre-tank filtration (3) storage tank, (4) pump, and (5) filtration and disinfection system (Figure 1). This fact sheet will cover how these components are used to produce potable water from harvested rainwater.

For more details on basic rain harvesting systems, see the publication Rainwater Collection -- Basic Components of a Rainwater Storage System Fact Sheet in the Resources section below.

Handling Rain from Catchment to Storage Tank

Roof conditions

Roof surfaces and gutters are sources of contaminants from birds, bugs and other animals, plant litter, pollen, dust, mold and/or algae. Homeowners should trim back overhanging tree branches and bushes to prevent animals from gaining access to the roof and minimize plant litter. It is also helpful for preventing animal access to keep overhead wires away from roofs or have a licensed electrician install barriers such as cones or disks. Maintenance of the rainwater collection system should include regularly cleaning of leaves and debris from the gutters.

Some roof types and components are inappropriate for collecting rainwater because rainwater may pick up contaminants in the roofing materials or leach metals from lead flashings and nails used in older roofs or from more modern copper flashing and downspouts. Wooden shingles are porous and can be a fertile medium for the growth of mold and fungi, or they may be treated with chemicals that are not safe for human consumption. See Appendix A for a list of roof types recommended and not recommended for rain harvesting.

Gutters and piping

For large rain harvesting systems, think big! Large gutters, downspouts and pipes that take water from downspouts to the cistern(s) allow water and unavoidable debris to flow quickly and easily through the system (Figure 2). This prevents clogging that can cause water to back up and overflow from gutters, especially during intense 'monsoon monster' rain events. For example, a large system could have 6-inch wide gutters, 5-inch diameter downspouts and 4-inch Schedule-40 PVC pipes. Piping should be NSF/ANSI Standard 14. Downspout screening and 'leaf eaters' are not recommended as they tend to create clogs and can be difficult to clean out.

Figure 2. Large diameter downspout pipes keep water flowing smoothly.

Pre-tank screening and filtering (Pre-filtration)

An important first step in your potable rainwater system is to filter or screen out debris, large particulates, and concentrated contaminants before they can enter the cistern(s). Pre-filtration is important to protect pumps and pipes, reduce the burden on the subsequent filtration and/or disinfection processes, and produce better overall water quality.

First flush diverters

As the name suggests, first-flush diverters are devices that divert the first flush of rainwater away from the cistern(s). At the start of a rain event, water coming off a roof is at its dirtiest (Figure 3). A first flush diverter can be as simple as a vertical pipe intersecting the cistern's input pipe. Water from the gutters flows first down the diverter pipe. When water fills the diverter pipe, it will

Figure 3. A first flush diverter. The angled pipe on the left brings water from the roof. The vertical pipe, along the left side of tank, diverts the first, dirtiest water. The horizonatal pipe on the right is the inlet pipe taking cleaner water to the tank.

begin flowing into the input pipe, delivering cleaner water to the cistern. First flush devices should remove about 10 gallons of water per 1,000 square feet of roof area. Multiple first flush diverters can be installed if there are multiple downspouts. Diverters should have easily accessible clean outs where debris collects.

Roof washers

Roof washers are first-flush systems capable of cleaning large amounts of water (Figure 4). Many types of roof washers are commercially manufactured and can be quite expensive. Roof washers must be cleaned after each heavy rain or at least 3-4 times a year depending on the debris load. New roof washer models have screens that can be lifted out for cleaning. Diverter pipes work for most installation, but roof washers may be needed where debris loads are a problem.

Cistern inlet strainer baskets

Cisterns can be fitted with strainer baskets made with fine screens (e.g., 18 mesh sieve). They fit into the inlet/inspection port at the top of the cistern and snap out for easy cleaning (Figure 5). An efficient way to keep debris out of a cistern, they also keep out mosquitoes. Strainer baskets must sit above the water, so the overflow should be placed below the bottom of the basket. Some water harvesters do not use first flush diverter pipes or roof washers, relying on only a basket strainer at the cistern inlet. Regardless, strainer baskets require cleaning after each rain event.

Figure 4. WISY Vortex fine filter roof washer attached to two downspouts. The vertical pipe on the left is outflow for 'debris' water discharged by the unit at about 90% water efficiency. Photo courtesy of Rainwater Management Solutions.

Figure 5. Basket strainer fits into a cistern manhole lid. Photo courtesy of Oasis Water Harvesting.

In-Tank Protection

The cleanest water in any tank is the top 6-12 inches and the dirtiest water is found 'settled' in the lowest 0-6 inches. For this reason, cistern outlets should be installed 6 inches or higher from the bottom of the cistern (Figure 6).

Calming Inlet

Using an upturned PVC pipe adaptor at end of an inlet pipe allows water to flow upwards as it enters the tank which calms and aerates rainwater and prevents the agitation of sediment on the tank floor (Figure 6).

Floating Filt

A filter on an outlet line from a tank, draws rainwater from just below the water's surface. At this depth, water is cleanest as any particulates either float on the surface or settle at the tank's floor (Figure 6).

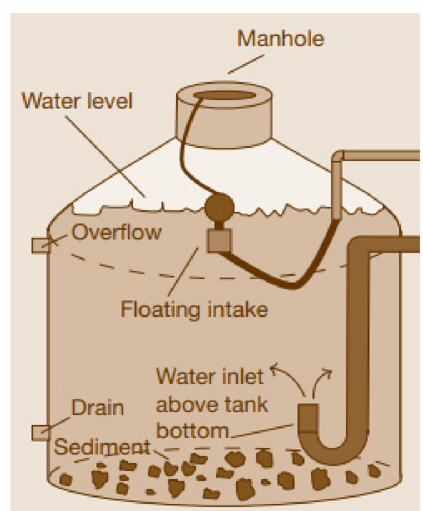


Figure 6. Pump outlet below the water's surface helps keep floating debris in the tank from entering the pipe. A calming inlet keeps water from agitating sediments on the tank's floor. Courtesy of Oregon Smart Guide to Rainwater Harvesting.

Figure 7. Top: White overflow pipe comes out of large steel tank. Photo courtesy of Oasis Water Harvesting. Insert: Mozy flap valve screen keeps out critters and mosquitoes. Photo courtesy of the Blue Mountain Company.

Figure 8. A 300-gallon tank, on the left, serves as a settling tank before water goes to three linked 5,000-gallon tanks. Photo courtesy of Thad Johnson.

Overflow screening

Every cistern needs an overflow pipe in the event of a large rain event which completely fills the cistern. The outlet of an overflow pipe needs to be screened to prevent animals and insects from crawling up the pipe into the cistern (Figure 7). An unscreened pipe is a conduit for pollution and mosquitoes.

Make sure screening materials are 18x18 mesh or finer to prevent mosquitoes and most other insects from getting to stored water through overflow pipes.

Multiple cisterns

Rain harvesters with more than one cistern connected in a series can use the first tank as a settling tank and take water to filtration from the last cistern in the series. The larger sediment is left (or "settled") in the first tank (Figure 8).

Cleaning cisterns

Cisterns can develop problems, such as algae growth, that require tank cleaning and/or disinfection. Ensuring that the cistern is sealed tight against light infiltration will prevent algae growth in the tank. Light protection comes with the inspection port/inlet strainer baskets in some brands of cisterns. Disinfection is part of regular maintenance for large tanks. For more information on disinfecting large storage tanks, see Water Storage Tank Disinfection, Testing, and Maintenance Publication, AZ1586, in Resources below.

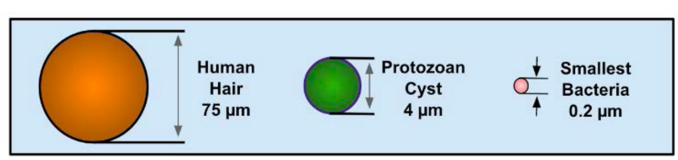
Between Storage Tank and Water Treatment

Regardless of the pre-storage filtration system, sand, grit, algae, rust or other particles that are not caught in filters and/or strainers are removed by filtration after water leaves the cistern.

Typically, a pump is installed between the cistern outlet and the treatment/distribution system. Depending upon the particulates leaving a storage tank in order to protect the pump and treatment components, one or more cartridge filters can be installed in-line before water enters the pump. Cartridge filters are rated by the size of the smallest particles they can block. Fine filters are rated in microns (μm). For example, a 30-micron filter can block particles 30 microns or larger (Figure 9). Coarser filters may be rated by mesh size. For comparison, a 100-mesh filter can block particles as small as 149 microns. Smaller size filters can clog easily with large sediments; therefore, a step-down approach is recommended. A 60-micron filter could be followed by a 40-micron filter, followed by a 20-micron filter. Overall filtration costs are greatly reduced in this way, as larger sediment filtration increases the capacity and lifespan of subsequent finer-filtration components, especially activated carbon filters. Some pumps come with their own pre-filter to protect pump parts.

Prmps and Pressure Tanks

A pump is necessary to deliver water from the storage tank, through the water treatment, to the points of use, such as faucets or toilet. The important pump selection factors are 1) flow rate required for your household, 2) pressure or head required, 3) pump style and its electrical requirements, and 4) pump location. Flow rate refers to the amount of water coming out of your faucet in a certain amount of time, usually how many gallons flow out in one



A micron is a unit of measurement of length equal to one-millionth of a meter. It is used to describe the pore size of water filters.

Figure 9. Micron size examples

Table 1. Flow rate and water pressure for potable rain harvesting systems

Flow rate	The desired rate of flow, measured in gallons per minute (gpm), depends on what household fixtures are installed and how many of them are used at the same time.	Households can need from 4-gpm to 26-gpm flow rates. Different pumps produce flow between 1 and 22 gpm. UV units require at least a 12 gpm flow rate.
Water pressure	Water pressure is the pressure water is put under to move it along pipes. Pressure is measured in pounds-per square inch (psi).	Utility household water pressure is ideally delivered at pressures between 40 and 60 psi. Various smaller pumps deliver water at a maximum of 50 - 80 psi.

Figure 10. All-in-one pressure boosting pump designed for domestic water supply applications. Photo courtesy of Rainwater Management Solutions.

minute. Water pressure, on the other hand, is force exerted on the water to get it from point A to point B. In pumpless systems, the force depends on gravity. In most modern potable water systems, the force is exerted by a pump.

The two types of pump systems typically used for rainwater harvesting are pressure tank-type pumps, used in conjunction with a pressure tank, and constant pressure pump (Figure 10) systems. For pressure tank-type pumps, a ½- to ¾-horsepower pump generally provides enough power for a typical household. The size of the pressure tank determines the amount of water available for use before the pump is activated. These pumps are generally centrifugal pumps and may require a separate pressure switch. Constant pressure or on-demand pumps (also called pressure booster pumps) are easy to install, operate and take up less space because they do not require a pressure tank or pressure switch. These pumps can be placed indoors in a pump house, utility roof, or garage.

Water Treatment: A 3-Prong Method

Treating pre-filtered rainwater to drinking water standards

1. 5-micron cartridge sediment filter
2. 3-micron activated carbon filter
3. Ultraviolet light (UV) lamp

The three-prong water treatment method (Figure 11) can create potable water from most rain harvesting systems, removing debris and chemical and microbial contaminants. It consists of particle filtration, activated charcoal filtration, and ultraviolet disinfection and is placed after a pressure tank or on-demand pump.

Filtration

Cartridge sediment filters for finer filtration

The first step in the recommended three-prong home water treatment method is fine particle filtration. Fine particle filtration removes microorganisms, sediment, metals, and organic matter. Hard water can interfere with the functioning of a filter, which makes rainwater— a soft water—easy on filters.

The fine particle filtration component is a 5-micron cartridge sediment filter, which removes particles that are 5-microns or larger. It is important that water sent through this filter should be prefiltered to remove large particles, as described in the previous section of this publication. In addition, a spin-down filter can be added ahead of a 5-micron filter to remove large particles, using centrifugal force to separate them from the water.

Figure 11. One configuration of the 3-prong system. Photo courtesy of Viqua Water Filtration Systems.

FILTER FACTS

A filter is basically a screen that catches particles found in water while allowing water to run through it. Filters are commonly rated by micron size. Some filters use mesh sizes, instead of microns, usually designating coarser filters. Mesh sizes can be converted to micron sizes (e.g. a 100-mesh size is equal to 149 microns).

Filters with smaller screen or pore sizes trap more debris, but the small size restricts water flow, and the filters clog sooner and must be cleaned or changed more often. The amount of particulate matter on your collection surface also determines how often you need to clean or change a filter. Filter technology has advanced considerably and will continue to evolve.

Filters can be made of paper, polypropylene, or non-corrosive metal, among other materials. Some filters have a recommended pressure range. For example, some filters will not tolerate water pressures lower than 30 psi, or higher than 70 psi. Small pumps in typical household systems can deliver water in the 40 to 80 psi range. Filters typically used for households fit in housings that are 10 or 20 inches long. Longer filters accommodate larger flow rates. Indoor fixtures in a normal household require a flow rate of about 6 to 12 gpm. Fine filtration sediment filters must be changed regularly (Figure 12). Heavily used sediment filters can clog and become a breeding ground for bacteria. Loss of water pressure may indicate the need to change a sediment filter. Filtering units with clear housings make sediment build-up easy to see.

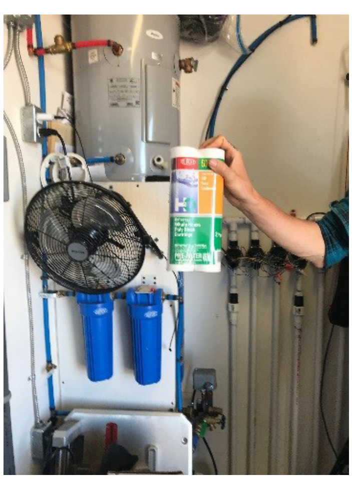


Figure 12. Sediment filters need to be changed every three months. Photo courtesy of Derek "Handeeman" Howlett.

Activated Carbon Filtration (ACF)

Activated carbon filtration (ACF) is step two in the recommended 3-prong water treatment system. ACF works by filtration and adsorption. Water from the fine filtration sediment filter is sent through an ACF rated at 3 microns or smaller. ACF is typically made from carbon-based materials such as coal, fruit pits, or coconut husks. Because of their makeup, ACF filters can also attach or "adsorb" some dissolved organic contaminants, such as pesticides, gasoline and oil residues, water soluble organic substances from animal and plant residues, and disinfection byproducts that may be present in chlorinated water.

The most effective ACFs are rated at 1 micron. They can also remove any protozoa or cysts that might have gotten through the particle filter(s), but the rate of flow through the filter is slowed by the small pore size. Activated carbon filters come in two types: granular activated carbon and carbon block. Activated carbon granules are typically packed in a loose bed and enclosed in a cartridge or pressure vessel. A carbon block consists of carbon granules formed into a tightly packed block that increases contact time and has a finer filtration capacity than loose granules.

Disinfection

Ultraviolet (UV) Light

Ultraviolet light has been used widely in Europe for drinking water disinfection since the early 1900s. UV light is the third prong of your home water treatment system. Following particulate filtration and ACF, water flows through a glass tube past an ultraviolet lamp, inactivating bacteria and viruses (Figure 13). Research has found that UV light also inactivates harmful protozoa such as Cryptosporidium and Giardia, by breaking down their cell walls, thus preventing them from reproducing. However, UV light is only effective if it hits its target. Microorganisms hiding in the shadows of tiny particles will escape disinfection. This is the reason water must be filtered through a 3-micron or smaller ACF before it enters the UV disinfecting chamber.

UV units are rated by their flow rate. Typical residential units may have a 4-gpm to 26-gpm flow rate. The flow rate of the unit you select depends on how many water-using fixtures are in your home and may be used at the same time. It is best to purchase a unit that disinfects at least 12 gpm. The ACF in line prior to the UV unit will ensure that this rate is effective.

Note that UV light bulbs must be changed at least every 1,000 hours of operation, after 14 months of use, or following manufacturer recommendations. Do not rely on your eye to let you know the bulb is still working at an adequate level. The quartz glass sleeve surrounding the UV light must also be cleaned regularly.

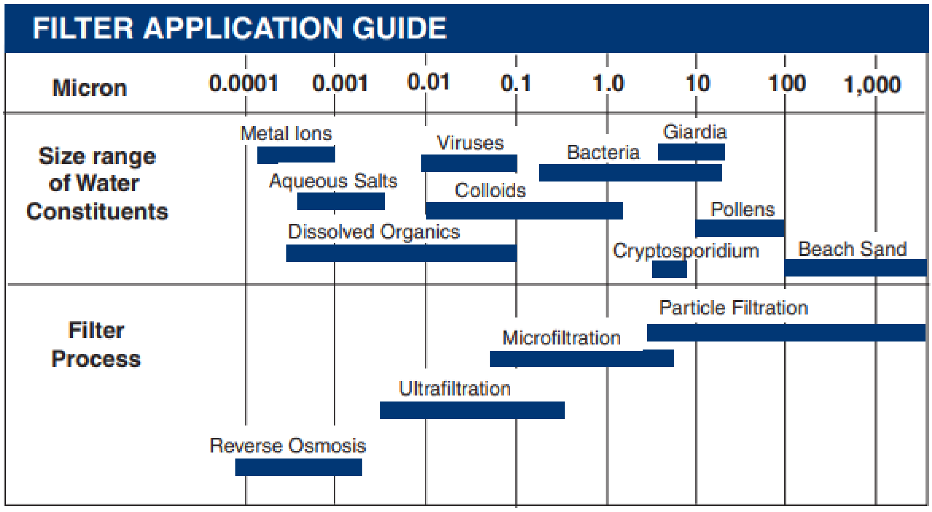


Figure 13. Filter sizes and uses. Adapted from Water Quality Improvement Center.

Figure 14. Left: A rainwater installation with an on-demand pump, a 10-micron sediment filter, a 5-micron activated carbon filter, and a UV lamp. Photo courtesy of Chris Maxwell-Gaines.

Figure 15. Right: Due to purity of the captured rain in this system, one sediment filter and a UV lamp are all that is needed. A Grundfos MQ 3-45 on-demand pump, under the floor, is coupled with a pressure tank to reduce the pump's on/off cycles. Photo courtesy of Thad Johnson.

Ceramic Filters

Some rain harvesters prefer to use commercially produced ceramic candle filters in place of a UV unit, saving on electricity and the cost of replacement bulbs (Figure 16). Ceramic water filters work by allowing water to flow through millions of half-micron sized pores in a convoluted pathway. The ceramic is impregnated with colloidal silver to ensure complete removal of bacteria and larger protozoans in the water and to prevent growth of bacteria within the filter itself. Many ceramic candle filters are made with an internal activated carbon core which increases the adsorption capabilities of the filter. Filters can last many months or years depending on the turbidity of the water, making ceramic filters an affordable option.

Chlorination (not recommended)

Many rain harvesters believe that a small amount of chlorine bleach is an easy and inexpensive way to disinfect water in a rainwater tank. In fact, the amount of chlorine

Figure 16. Following a pump and two spin-down filters, a 6-candle ceramic filter (far right) is the last component in this Aqua AXIS rainwater purification system. Photo courtesy of Neal Gist, Ozark Permaculture LLC.

it takes to treat rainwater is very small, only a few parts per million (ppm). To ensure that the water is not over-treated, it is critical to know the chlorine demand of the water before treating it with chlorine bleach. The chlorine demand, which depends on the chemical composition of the water, will indicate the amount of time chlorine must be in contact with the water. Because chlorine can be toxic if mishandled, the homeowner must be extremely careful with it. When combined with organic matter, chlorine forms disinfection byproducts (DBPs) that have been linked to cancer in laboratory mice. Rectal and bladder cancers in humans have been linked to heavy chlorination, possibly from exposure to chlorination DBPs. Despite chlorine's huge role in the development of effective water treatment, home water harvesters should use chlorine bleach (or other chlorine-or-iodine-based chemicals) to treat drinking water only in emergency situations. An emergency alternative is boiling water Boiling filtered rainwater vigorously for two minutes will kill any harmful organisms. Boiled water must be protected from contamination after it is cooled.

If chlorination is your best option, there are automated systems with in-line liquid chlorine dosimeters that measure out the correct amount of liquid chlorine. These systems include a storage tank to allow enough contact time for the chlorine to kill pathogens. They must also include large activated carbon filters in the outflow pipes to remove DBPs. Caution is still needed in handling the liquid chlorine.

Solar disinfection

Solar disinfection, SODUS, uses sunlight to disinfect water. Water left in direct sunlight in glass containers for six hours is effectively disinfected, reducing coliform bacterial levels by as much as 99.5%. Like standard UV disinfection, however, the water must be clear to allow sunlight to penetrate; thus, sediment filtration is needed before SODUS. In addition, SODUS does not change the chemical quality of the water.

Additional Treatment Options

Reverse Osmosis

Though many proponents of rainwater harvesting believe the three-prong approach, described above, is sufficient to treat most rainwater to potable standards, there are those who prefer to use a reverse osmosis (RO) system after placed in-line after the 3-prong system: a sediment filter, followed by an activated carbon filter, followed by a disinfection unit. Reverse osmosis can remove dissolved solids that activated carbon filters cannot remove, including radioactive particles and other pollutants down to one hundredth of a micron in size. Reverse osmosis also removes dissolved solids, including calcium, magnesium, arsenic, nitrate, lead, and other inorganic constituents present in small concentrations in most rainwater, but in more problematic concentrations in mining areas.

Reverse osmosis may not be necessary for your home treatment as it could waste significant amounts

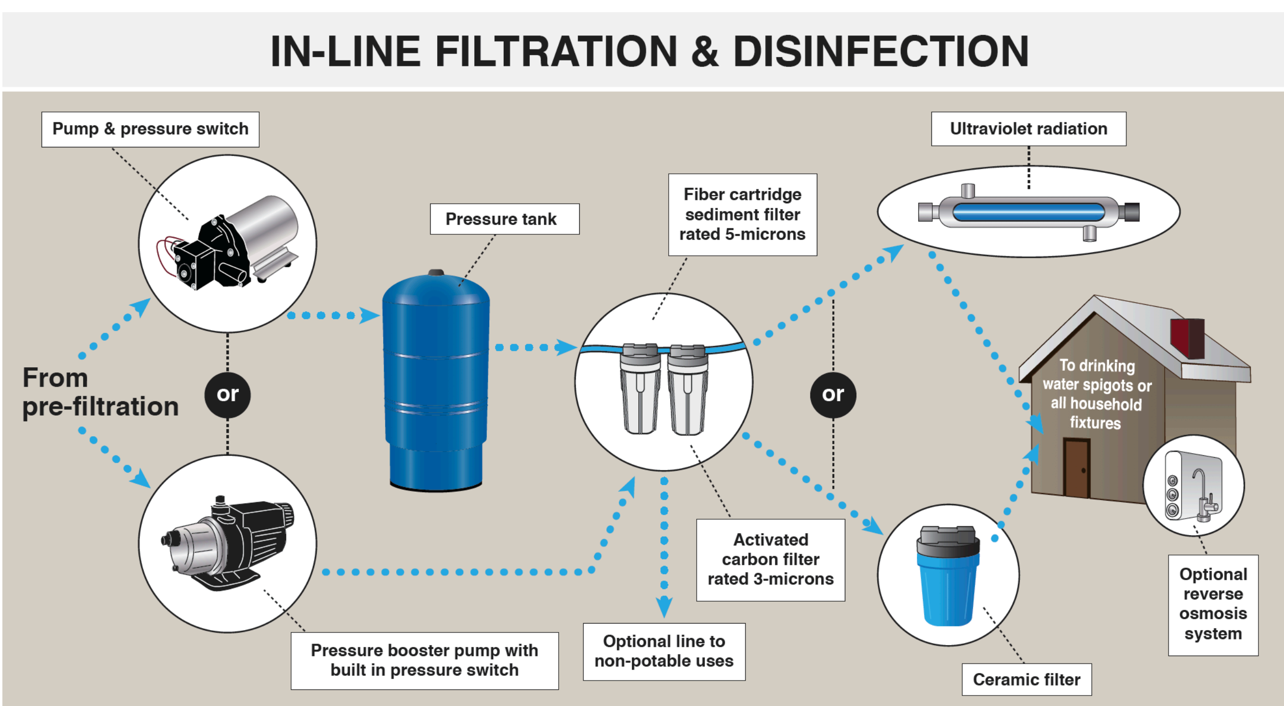


Figure 17. Various paths for treatment and disinfection of rainwater to drinking water standards. Diagram by John Polle.

of rainwater. Before considering a RO system, test the rainwater in your system for contaminants such as lead and arsenic. If your main concern is drinking water, then consider a point-of-use RO unit for the kitchen sink.

Although there are basic components for any system to treat rainwater to potable standards, their specific type and configuration can be different in different situations. Figure 14 shows some of the variations. Ultimately, the design depends on household needs, capabilities and preferences, among other factors.

Low-cost treatment alternatives

Solar distillation systems use the heat of the sun to evaporate water in a closed system. The steam leaves contaminants behind as the collected water re-condenses, almost totally free of contamination.

Bio-sand filters, which use layers of sand and gravel to trap and eliminate pathogens and other impurities, can serve as a pretreatment method before fine filtration and disinfection. In addition, moringa tree bark can be used as a filter medium.

Ceramic pot filters enhanced with colloidal silver are a low-cost treatment using locally-sourced materials. See in References: Potters for Peace's Ceramic Water Filter Project.

Maintaining Your Home Water Treatment System

Rainwater harvesting for potable use requires active monitoring and maintenance. These are some questions to help you decide if you can harvest and treat your own water:

- Are you physically capable of cleaning the system, including gutters and cisterns, or can you afford to pay for this service?
- Can you afford to pay someone to take on maintenance tasks or emergency repairs?
- Can you afford replacement parts, such as UV bulbs?
- Can you take responsibility for the safety of electrical components?
- Can you take responsibility for monitoring and troubleshooting the system, for example checking pumps or pressure tanks and maintaining the correct water pressure?

Treatment system maintenance schedule/costs:

- Change the sediment filter every month (around $3)
- Change the charcoal filter every three months (around $10)
- Replace the UV light bulb every fourteen months (around $75)

Conclusion

Rainwater collection for household potable use requires investment and commitment, but depending on your situation, it can be the solution to many serious water supply problems, especially in rural areas without access to utility-supplied water or with very deep groundwater levels. The typical system can seem complicated and there are some things you should know about your needs before you start. Although rainwater is high quality water, it must be treated for potable use in the home. Sediments and pathogens that can get into your rainwater through multiple paths must be removed. There are various ways to accomplish the right level of treatment; however, pre-filtration, filtration, and disinfection are three essential steps to producing clean drinking water. Testing your rainwater can help you decide what level of treatment, if any, you need beyond these three steps. Filtration is changing all the time and new configurations are being explored by both commercial installers and do-it-yourselfers for different budgets. When done properly, treating rainwater at home can provide autonomy, water security, and the pleasure of having a free water supply.

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VirginiaRainwater Harvesting & Use Guidelines. Virginia Department of Health http://newsletters.wetlandstudies.com/docUpload/RainwaterHarvestingAndUseGuidelines.pdf

Lee JY, Kim HJ, Han MY. Quality assessment of rooftop runoff and harvested rainwater from a building catchment. External Water Sci Technol. 2011;63(11):2725-31.

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Virginia Water Resources Research Center. Evaluation of Rooftop Rainfall Collection-Cistern Storage Systems in Southwest Virginia Cdc-pdf [PDF – 49 pages]. 1998.

Potters for Peace, Ceramic Water Filter Project: https://www.pottersforpeace.org/

Additional Resources

University of Arizona Publications

Rainwater Collection -- Basic Components of a Rainwater Storage System Fact Sheet
https://extension.arizona.edu/pubs/rainwater-collection-basic-components-rainwater-storage-system

Rainwater Collection -- Passive Water Harvesting
https://extension.arizona.edu/pubs/rainwater-collection-passive-water-harvesting

RainScapes: The Ultimate in Water-Efficient Landscaping
https://extension.arizona.edu/pubs/rainscapesHarvesting

Rainwater for Landscape
Use http://cals.arizona.edu/pubs/water/az1344.pdf

Layperson's Guide to Arizona Water
https://wrrc.arizona.edu/publications/laypersons-guide-arizona-water/laypersons-guide-arizona-water

Water Wise, Cochise County Cooperative Extension
https://waterwise.arizona.edu/harvest-rain

Water Storage Tank Disinfection, Testing, and Maintenance
https://extension.arizona.edu/pubs/water-storage-tank-disinfection-testing-maintenance

Rainlog.org, a cooperative rainfall monitoring network for Arizona maintained by citizen scientist data contributors.
http://Rainlog.org

An Arizona Guide to Water Quality and Uses Janick F. Artiola, Ph.D. Gary Hix, RG, Charles Gerba, Ph.D., and James J. Riley, Ph.D.
https://extension.arizona.edu/pubs/arizona-guide-water-quality-uses.

Water Facts: Home Water Treatment Options, AZ1498 Artiola, Janick, Farrell-Poe, Kitt, Uhlman, Kristine
https://extension.arizona.edu/pubs/water-facts-home-water-treatment-options

Other organizations

Coconino County Sustainable Building Service Provider Directory

https://www.coconino.az.gov/DocumentCenter/View/18429/Resource-Directory-New-Format--?bidId=

The Center for Rainwater Harvesting
http://www.thecenterforrainwaterharvesting.org/

American Rainwater Catchment Systems Association
http://www.arcsa.org/index.asp

Arizona Department of Water Quality
https://www.azdeq.gov/

Brad Lancaster | Rainwater harvesting author and expert
http://www.harvestingrainwater.com/ 9.

Extension a Part of the Cooperative Extension Service
https://drinking-water.extension.org/drinking-water-treatment-filtration/

Greywateraction.org
https://greywateraction.org/rainwater-harvesting/

Oasis Design
https://oasisdesign.net/about/artludwig/

Oasis Rainwater Harvesting
http:/ oasisrainwaterharvesting.com/

The Online Rainwater Harvesting Community
http://www.harvesth2o.com/index.shtml

R.A.I.N.
http://www.rainfoundation.org/

Books on Rain Harvesting

Rainwater Harvesting for Drylands and Beyond, Volume 1: Guiding Principles to Welcome Rain into Your Life and Landscape, 2nd Edition Revised, 2013 by Brad Lancaster (Author)

The Texas Manual on Rainwater Harvesting, Texas Water Development Board, third edition, 2005, Austin, Texas http://www.twdb.texas.gov/publications/brochures/conservation/doc/RainwaterHarvestingManual_3rdediti on. pdf

Rainwater Collection for the Mechanically Challenged, Tank Town Publications, Dripping Springs, Texas, 2004 by Suzy Banks with Richard Heinichen (Authors)

Videos on Rain Harvesting

Handeeman You Tube Channel Derek Howlett
https://www.youtube.com/Handeeman/videos

Homesteadonomics You Tube Channel
https://www.youtube.com/user/homesteadonomics

Aquamate
https://www.youtube.com/channel/UCCUzOIh16CXvLNlJa8s1efQ

Acer Water Tanks
https://www.youtube.com/channel/UCpuqDsaSv7pJCx78Yx-BO7g

Oasis Rainwater Harvesting
http://oasisrainwaterharvesting.com/videos/

Rain Harvesting Supplies and Services

Acer Water Tanks Acerwatertanks.com 877-223-7785

Aquamate Water Tanks North America https://www.aquamatetanks.com/ 844.320.8265

Innovative Water Solutions https://www.watercache.com

Oasis Water Harvesting Sierra Vista http://oasisrainwaterharvesting.com/

Rick Weisberg, 520-234-7681

Rainwater Management Solutions https://rainwatermanagement.com/

Southern Arizona Rain Gutters http://www.southernarizonaraingutters.com/#rain-harvest-solution 520-299-7246

Appdenix A

Rainwater Harvesting Roof Surfaces.

Information modified from Jesse Savou, ARCSA https://www.bluebarrelsystems.com/blog/roofing-materials-for-rainwater-harvesting/

Roof Surfaces Recommended for Potable Use	
Standing Seam Metal	Interlocking panels run vertically from the roof's ridge to the eave with seams that are raised above the roof's flat surface. Water runs off without seeping between panels.
EPDM Ethylene propylene diene monomer	A rubber-like compound used in roofs in the U.S. since the 1960s. One of the most common types of low-slope roofing materials. This is relatively inexpensive, simple to install, and fairly clean to work with when compared to conventional built-up roofs.
Slate or Tile	Slate is a good surface to harvest rain from as long as it is kept clean and does not deteriorate. These materials do not include asbestos tiles, which have been mainly used as siding in the past but could potentially be found on some roof surfaces.
Composition tiles	Particles like those coming from composition shingles can be easily filtered out.
Corrugated metal	Corrugated metal also makes an efficient collection surface, however, most corrugated material is galvanized, which will leach some zinc into the rainwater. Many people collect from galvanized roofs with no problem, but this is something to be aware of. Collect a sample of rainwater and use a home test kit or send it to a lab to make sure zinc levels are below allowable limits for drinking water.
Roof Surfaces Not Recommended	
Asphalt	Crumbling asphalt roofing material debris can be separated during filtration, but this type of shingle can also leach petroleum products into the water. These contaminants can also be removed from the captured rainwater, but it is preferable to keep them from entering a system in the first place.
Unprotected metal	Can contribute to heavy metal levels that are unacceptable. Some modern metal roofs may be exempt especially if they include protective coatings.
Tar and gravel	This type of roof can overwhelm filtration necessary for potable rain harvest.
Wood shingles	Wooden shingles are porous and can be a fertile medium for the growth of mold and fungi. They are also treated with chemicals that are intended to protect the wood but are neither intended nor acceptable for human consumption.

Appendix B

Rainwater is 'soft' because it lacks minerals found in most water. Users of rainwater report a variety of advantages of soft water: softer clothes, softer hair, sparkling faucets and toilets, neutral taste and better tasting vegetables from their rain-watered gardens.

Clean rain normally is slightly acidic, with a pH value between 5.0 and 5.5. Groundwater pH may vary from acidic to basic depending on the aquifer chemistry and other factors. Pure water is neutral at 7.0 pH. Tomato juice typically has a pH of about 4.5 and baking soda has a pH of 9. The pH scale goes from 0 to 14.

The slight acidity and relative lack of minerals also makes rainwater more corrosive than other water. This means it quickly picks up minerals, organic chemicals, and other substances from whatever it touches. This includes substances floating in the air, such as sulfur dioxide and nitrogen oxides produced from the burning of fossil fuels in power plants and automobiles. Acid rain is the result, with a typical pH value of 4.0.

Because of rainwater's tendency to pick up and hold on to potentially harmful substances, it must be treated before it can be put to potable use.

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(520) 458-8278 x2139	
Watershed Management Group	http:// watershedmg.org/ (520) 396-3266
University of Arizona, Water Resources Research Center	https://wrrc.arizona.edu/ (520) 621-9591

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This information has been reviewed by University faculty.
extension.arizona.edu/pubs/az1863-2021.pdf

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extension.arizona.edu/pubs