

Introduction

If you have a lot of CPs or orchids, you know that pure water is the second most important ingredient after environment. Without pure water, the plants will slowly die as root systems not used to minerals wither away. There are many ways to get pure water for your plants, such as by buying it from the store, having it delivered, or by distilling or Reverse Osmosis (RO) processing tap water in your home.

After beginning to feel like a slave to the counter top distiller, I looked for other ways to get the water my plants craved. Before running out to buy an alternative to my distiller, I needed to determine my water needs. I water the orchids on the weekends, mist them daily and top off the CP trays as necessary. I use about a gallon per day and 20 gallons on the weekend. Distillation is the only way to get 100% pure water, but a good quality RO system with pre-filters gets pretty close.

Note that both systems have some drawbacks. A distiller boils then cools the water, requiring gas or electricity for heat and electricity for cooling. Very little of the water is wasted. The solutes (dissolved solids) usually cake the inside of the boiling chamber and must be cleaned out periodically. A typical RO system requires nothing other than tap water pressure, but can waste up to 3/4 of the water put through it, dumping it overboard. Rather than buying an automatic distiller, I chose the RO route after seeing a system at Costco for USD\$169.

This system comes with 3 pre-filters (1 sediment and 2 carbon), 18 gallon (roughly 72 liters) per day RO membrane, a 3-gallon pressurized storage tank, carbon post filter and spigot. Simple math shows that the unit takes about 2-1/4 hours to fill this tank.

RO System Components

Osmosis is the tendency for water to cross a selectively permeable membrane from a less concentrated to a more concentrated solution. In Reverse Osmosis Filtration the direction is reversed. Water is forced under pressure to flow tangential to the surface of the membrane. Smaller molecules pass through the membrane to a lower pressure zone. Molecules larger than a certain size are discouraged from passing through the membrane. While a minimum input pressure is required to overcome the natural osmotic pressure of the membrane, input pressure above the maximum rated membrane pressure will damage it.

The pressure on the output side of the membrane is much less than the pressure on the input side. If you already have a home RO system for drinking water, you'll note that the flow is much less than from the regular tap.

An RO system needs either a pressurized storage tank or an atmospheric storage tank and a booster pump to deliver water to the tap. A pressurized storage tank holds the water in a balloon-like sack inside of a metal tank which has been pre-pressurized with compressed air. When you turn on the tap, the balloon is squeezed by the trapped air, forcing the water in the balloon out through the tap.

The maximum pressure of an unassisted pressurized storage tank is equal to the maximum pressure on the output side of the RO membrane (since it is the output water which is pressurizing the tank). As you get closer to filling the tank (and the pressure goes up), fewer and fewer molecules will cross the membrane and the percentage of waste water increases. It is better if you can dump the output of the RO system into an atmospheric (unpressurized) tank then boost the pressure from there. You can also dump the wastewater into another atmospheric tank and use it to water plants which are insensitive (or thrive on) concentrated minerals.

When you buy a RO system, you should check if it shuts off automatically when the storage tank is full. If it doesn't, you will be dumping wastewater continuously.

There are two types of booster pump you can use; one which will pump the water from an atmospheric tank into a pressure tank or one which will deliver it directly to the tap. The latter is called a demand pump. A pressure switch is used to automatically start and stop either kind of pump. Generally, demand pumps are more expensive than booster pumps because of the higher flow rate. However, none but the most expensive demand pumps will approach the water delivery from a household tap.

I built a system that dumps the output of the RO system into a 40 gallon atmospheric tank then uses a low-volume booster pump to move it into a 36 gallon tank pressurized from 20 (empty) to 40 (full) PSI. It is from this tank that the water is drawn. In the United States, most household taps vary from 40-60 PSI, so this range is acceptable. Note: If your household water pressure is higher than this, you should have a regulator installed which will make your fixtures last a lot longer.

Note that RO water held in an atmospheric tank may not be suitable for drinking. Tap water is chlorinated to kill harmful organisms. RO membranes will not remove chlorine or bacteria, so pre-filters do this job. A charcoal pre-filter removes most of the chlorine and a mechanical pre-filter

removes most (but not all) of the bacteria. Since there is still some bacteria left, it can 'bloom' in an atmospheric tank much more readily than it will in a sealed pressure tank. Some higher end RO systems run the output water through an ultraviolet sterilizer just before use to kill any remaining bacteria without adding contaminants. RO water is also very corrosive and should be kept out of contact with most metals; stainless steel is one exception.

The specific components and measurements that I describe may only apply in the United States but the connection directions are universal. Pressurized storage tanks and/or booster pumps should be available from local 'pure water' companies and are also available from well drilling companies although in my experience, they are much more expensive from the latter.

Water Flow

Looking at diagram 1, you can see that water enters the RO system from the regular tap and exits via a float valve into the top of an atmospheric storage tank. Wastewater exits via a float valve into a second atmospheric storage tank where it is used to water plants which aren't bothered by mineralized water. A booster pump draws RO water from the bottom of the atmospheric storage tank and pumps it into the pressure tank. This pump is low flow which makes it fairly inexpensive compared to a high-flow well pump. Note that there is only one connection to the pressure tank; the input and output are Tee'd together. If you don't want to drill a hole near the bottom of the tank, you can drill a hole near the top and run a tube to the bottom of the tank.

As water is drawn from the pressure tank, the booster pump turns on to replenish it from the atmospheric tank. Because the flow rate of the booster pump is much lower than the flow out of the pressure tank, only the volume of water in the pressure tank can be used before waiting for the tank to recharge. You must size the pressure tank larger than the volume of water you intend to use at one time and the atmospheric tank should be larger than this so that the pump won't run dry. Note that a pressurized tank holds about one third water and two thirds air; thus a 36-gallon pressurized tank holds less than 15 gallons of water.

Construction

Most household RO systems use 1/4 inch polyethylene tubing and compression fittings while this pressure tank uses 1 inch PVC pipe. A standard hose bib connects to 3/4 inch pipe.

Polyethylene tubing requires a metal insert and a nylon compression washer when used with brass compression fittings. These are usually sold separately

from the fittings. If you are lucky, you'll be able to locate nylon compression fittings which don't need any additional parts.

To describe the final connections, I'll follow the flow of water. However, I'm going to start with building the sub assemblies that you will be connecting together. The system being described takes in tap water via a saddle valve and outputs RO water to a standard hose bib.

First decide where you will put everything. Your RO system may need to be mounted in a specific orientation and the atmospheric and pressure tanks should be fairly close together. Water weighs 8.8 pounds per gallon (a kilo a liter) so allow for that.

Water enters the atmospheric tank through a 1/4 inch compression float valve, sometimes called a swamp humidifier reservoir valve. The water exits through a 1/4 inch compression x 3/8 inch pipe thread elbow normally used on a distiller with an outboard booster pump. This fitting is made of nylon or another plastic and comes with a plastic nut and rubber washer. I used a heavy duty 40 gallon plastic garbage can for the tank.

Drill a hole in the side of the garbage can near the top to mount the float valve and near the bottom for the exit fitting. For strength, the holes should be drilled at least 45 degrees away from each other. The orientation of the RO system and the two tanks may tell you exactly where to drill. If you are dumping the wastewater, you do not need a second tank.

If you want to save the wastewater, drill a second tank only for the float valve. Since the wastewater output pressure from the RO unit is equal to the input pressure, the wastewater can be driven a considerable distance and the tank could be mounted so that water can gravity feed to a low volume drip system (you will need an exit fitting). This is an exercise left to the user.

Note where the rubber washers go, which is on the side opposite of the nut holding them to the wall of the tank. If the nut is inside, the washer is outside. If they are on the same side, you will shred the washer when you tighten the nut.

Now it is time to plumb the pressure tank. Assuming it has a 1 inch output on the bottom and you want a standard hose bib as the output, you will need some adaptors. It may take multiple adaptors connected together to get from one size to another or even to connect two pieces of pipe. Different stores seem to carry different fittings and no one has them all. The input is 1/4 inch compression and the output is 3/4 inch FPT (female pipe thread). Assuming you use the same or similar tank that I did, here is how to plumb it.

You will need a five to ten foot length of 1 inch PVC pipe. Use thick wall meant to hold constant pressure. Pipe used for sprinkler systems is not meant for this use. A lot of threaded fittings are used instead of cementing everything. It is more expensive, but this lets the system be taken apart for repairs. All of the fittings are 1 inch unless noted. Use Teflon tape on all male threads, wrapped in the same direction that the pipe will turn when screwing it into a female fitting. Tighten threaded fittings with a wrench until they are snug but not overly tight. You will still be able to see some threads sticking out.

1. Cut a piece of pipe long enough to go from the center of the tank to the outside. Cement a slip x MPT fitting (slip means it slips over PVC pipe, MPT is male pipe thread) on both sides. You can also cement a slip x FPT x FPT on one end if you wish. This will replace the FPT x FPT x FPT Tee in step 4.
2. Cut a piece of pipe long enough to go from the bottom of the tank to the top of the tank. On one side, cement a slip by MPT fitting and on the other side, cement a 1 inch slip by 3/4 inch FPT (female pipe thread) elbow. You may have to use a 1 inch slip x 1 inch FPT elbow and a 1 inch FPT to 3/4 inch FPT adaptor.
3. Cut a short piece of pipe and cement a slip x MPT onto one side and a slip x FPT elbow onto the other.
4. Into one side of a FPT x FPT x FPT Tee, screw in the adaptors needed to get to a 1/4 inch FPT. This may be a 1 inch to 3/4 inch then 3/4 inch to 1/4 inch, or 1 inch to 1/2 inch and 1/2 inch to 1/3 inch. Use whatever is available.
5. After the cement has dried (see the label for directions), screw the first pipe into the fitting on the bottom of the tank. Screw the Tee to this pipe, ensuring that the Tee will be parallel to the floor and the side with the 1/4 inch FPT will be towards the back of the tank when the tank is upright. Screw the short pipe with the elbow into the empty side of the Tee with the elbow facing up then screw the pipe with the 3/4 FPT elbow into this elbow. The hose bib now is screwed into the elbow top of this pipe. The pipe going up the side of the tank needs to be secured to the tank for support. I tied the top to the pump mount on the top of the tank. You can also use small blocks of wood epoxied to the tank with tie wrap mounts screwed to them. Screw a 1/4 inch compression x MPT fitting into the 1/4 inch FPT adaptor in the Tee at the bottom of the pressure tank.
6. Screw the hose bib into the elbow at the top of the tank.
7. Adjust the air pressure in the pressure tank to match the value of the booster pump's pressure switch. Follow the directions carefully since mismatched settings can be deadly if the tank explodes.

This completes the preparation of all of the sub assemblies and you are now ready to connect them. The instructions which came with the RO unit should tell you how to connect the input and wastewater outputs, so I won't describe them here.

Here is how to make leak-free compression fitting connections with Polyethylene tubing. Make sure the ends of the tubing are cut square. If you are using metal compression fittings, place a metal insert into the end of the tubing, slide the compression nut over the tubing with the threads facing the end, followed by the nylon compression washer with the small side of the taper facing the end of the tubing. Push them back about an inch then insert the tubing into the compression fitting. Push the tubing so that it seats inside the fitting then slide the compression nut forward and screw it finger tight to the fitting. Now give it an extra full turn with a wrench. If you are using a nylon compression fitting, just insert the tubing until it bottoms and tighten the fitting finger tight.

Following the flow of water, make the following connections.

- The output of the RO system to the float valve at the top of the atmospheric tank.
- The output of the atmospheric tank to the input of the booster pump.
- The output of the booster pump to the pressure switch.
- The pressure switch to the bottom of the pressure tank.

Turn on the RO system input valve. It will take several minutes before water will flow out of the system and into the atmospheric tank. Check for leaks and tighten any fittings as needed. It may take several hours to several days to fill the atmospheric tank. Watch for leaks at the output at the bottom.

Once the atmospheric tank is filled, turn on the pump and again check for leaks. Tighten fittings as necessary and allow the pressure tank to fill, checking the pressure periodically to ensure it is not overflowing. If the tank is overflowing, you may need to adjust the pressure switch.

Turn off the input to the RO system and dispose of the first two tankful of water. After the pressure tank is filled and the pump has stopped, dump the water in the pressure tank; repeat. If more water is left in the atmospheric tank, use the pump to drain it, or pour it out. This ensures that the system is cleared of manufacturing contaminants. Before watering your plants, you should test the output water to make sure the RO system is working.

Appendix A – Components and Suppliers

- 1 inch Rigid PVC pipe and fittings, compression fittings – Home Depot, Orchard Supply Hardware, hydroponic and garden supply stores.

- 1/4 inch PVC tubing (do not use vinyl drip system tubing; it will not make a good seal and may swell under pressure) – Parker Parflex grade E5 1/4" OD, .040 wall tubing in multiple colors is available from American Hose & Fittings <http://www.americanhose.com/> +1 (253)872-8080 or (800) 877-8041
- Booster/Demand pump with 40 PSI pressure switch – Manufactured by PJD & Assoc 740 Spice Islands Dr, Sparks, NV 89431-7101, +1(702)358-4200. Model CDP 6800. Retail: Aqua Technology (800)478-7342 Fax: +1(805)773-4409 (www.aquatechnology.net/ or purewater@earthlink.net). You can also use pumps and pressure switches from Shurflo – www.shurflo.com.
- Polypropylene 1/4 inch compression x 3/8 inch pipe thread elbow. Part no. P4ME6 for USD\$2.25 available from Aqua Technology.
- Pressure Tank – Sears Craftsman Captive Air Tank. Sold in the water filter/well pumps department. Stock number 390.291657 (36 gallon) Online pictures: <http://www.wellmate.com/catalog/eseries.html>
- RO Systems – Nature's Way <http://rosystems.com/> (advertises in *Carnivorous Plant Newsletter*); Premier Manufactured Systems (sold by Costco) <http://www.premierh2o.com/> +1(602)931-1977 - Fax +1(602) 931-0191, Sears, Home Depot, plumbing supply houses.
- Swamp Humidifier Reservoir Valve – Home Depot, SKU #048643119215

