Small-Scale SOLAR DISTILLATION for Gardeners

BACKGROUND

Solar distillation uses energy from the sun to separate contaminants and ions (like salts) from water. Untreated, impure water absorbs heat to slowly increase the temperature causing evaporation. Evaporated water is condensed and collected as purified water to be used for irrigation purposes. Solar stills can be designed based on available space and water volume needs (Figure 1).

Some of the advantages of solar distillation include that it is relatively inexpensive to build, has low overall maintenance, provides adaptability to changing climate, and has no energy cost or moving parts.

The disadvantages to these systems include the slow rate of water products, the fact that the water is not suitable for large consumption, the difficulty of disposal of wastewater and the dependence on sunlight.

It is best to evaluate the water volume needs of your setup before investing in a solar distillation unit. Literature estimates that a unit can produce approximately 0.06 gallons per day of purified water per square foot of the solar still. For instance, if the unit is the size of a standard plywood board (4 feet by 8 feet) then the square footage is 32 square feet which would produce roughly 1.92 gallons of purified water per day. This estimate varies based on environmental conditions including humidity, daily sunlight and average weather events per year.

Figure 1. Solar drying oven (top) and solar still (bottom) for heat absorption. The unit on the bottom has condensation spout for purified water collection. Photos by M.P. Hayes

MATERIALS

There are many variations and sizes for solar distillation with the focus on how much water is needed for your gardening operation. The following instructions are for a standard solar still with the capacity of 8 quarts of water held in two 10- by 15-inch pans.

- 8-foot pressure treated two-by-four
- ¾- by 23¾- by 19-inch rigid insulation
- ¾-inch by 4-foot by 8-foot sheet of exterior plywood
- Two 1½-inch galvanized hinges
- Silicone caulk and gun
- 27¼- by 22- by 1/8-inch glass
- High-temperature black paint
- Wood glue
- 1-inch PVC or PEX tubing
- Two 10- by 15-inch metal baking pans
- Deck screws (1¼ inch, 2 inches and 2½ inches)

INSTRUCTIONS

1. Mark and cut the plywood pieces according to the cutting list using a circular or table saw.
2. Cut a piece of rigid insulation to fit the plywood base.
3. Screw both the insulation and plywood base to two-by-four supports using the 2½-inch screws.
4. Assemble the front and side pieces of the box. Use the 2-inch screws to join the corners and 1¼-inch screws on the overlapping pieces. Wood glue can be used to reinforce the structure.
5. Set the door as straight as possible by aligning the bottom and side edges before attaching the hinges. The hinges will be at the base of the frame.
6. Paint the inside of the box with black paint to increase the heating capacity. The back door can be painted or covered with reflective foil.
7. If weathering is a concern, a small weather strip can be attached to the door to make it airtight.
8. Drill a hole on the top edge of one side of the box for the ½-inch pipe.
9. Cut the 1-inch PVC or PEX tubing using a utility knife. The tubing should be cut the same length as the base of your unit.
10. Push the tubing through the hole and mount it into place using small screws. The tubing should have a ¼-inch slope to allow for water to run out of the unit.
11. Use caulk on the top edge of the tubing to seal it against the wood.
12. Put a bead of caulk or glue around the top of your frame. The glass should fit flush along the top of the frame. Make sure the front edge of the box is lifted slightly to allow the glass to dry overnight without sliding out of place.
13. Once glass is dry, place baking sheets inside the box and fill with water to start distillation processes.

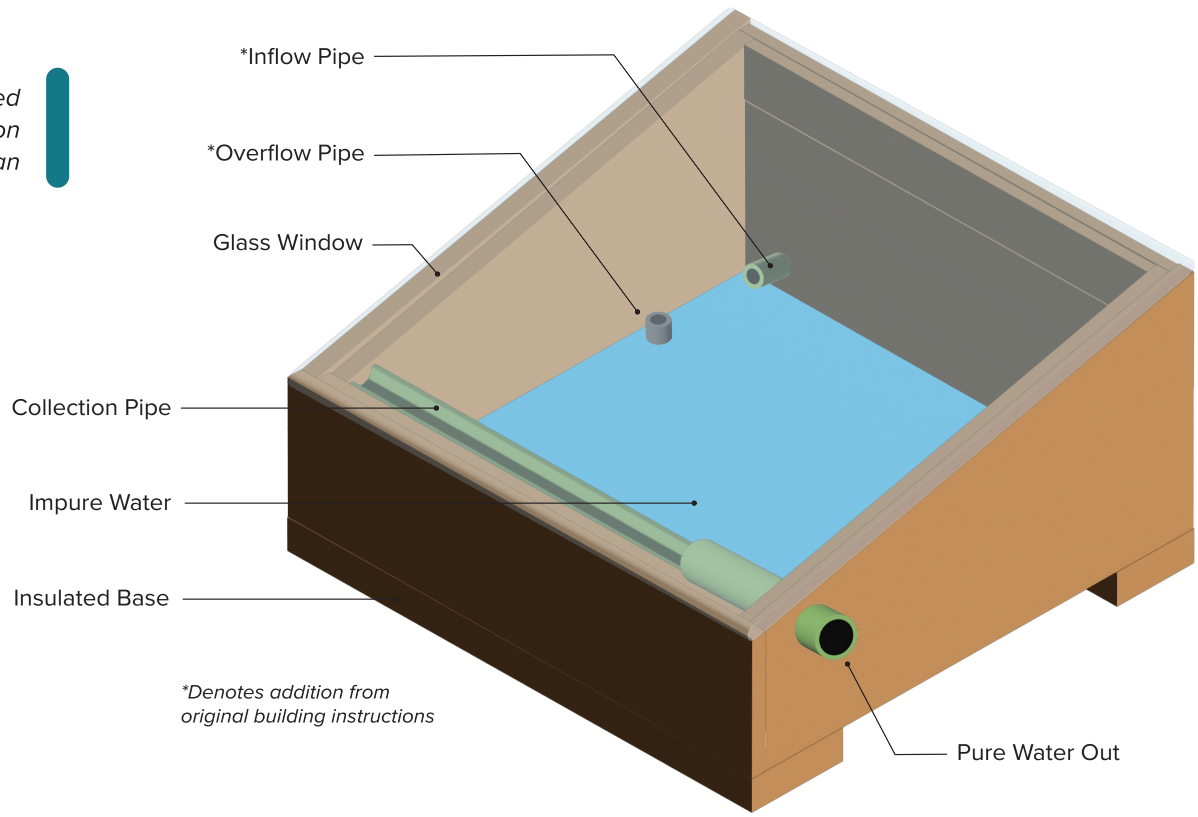

Figure 2. Completed solar distiller. Illustration by Allison Strahan

CUTTING LIST

KEY	NUMBER	DIMENSION	MATERIAL
A	1	¾” x 23¾” x 19”	Rigid insulation
B	1	¾” x 23¾” x 19”	Plywood
C	1	¾” x 5¾” (high side) x 19”	Plywood
D	1	¾” x 5⅝ ” (high side) x 20½”	Plywood
E	2	1 ½” x 3½” x 22½”	Two-by-four
F	1	¾” x 3” x 20½” (long to short edge)	Plywood
G	1	¾” x 5⅞” x 20½”	Plywood
H	1	¾” x 9” x 20½” (to long edge)	Plywood
I	2	¾” x 9⅛” x 5⅛” 26¾”	Plywood
J	2	¾” x 8⅞” x 5⅝” x 24½”	Plywood
K	1	27¼” x 22” x ⅛”	Tempered glass
L	1	1”	PVC or PEX tubing

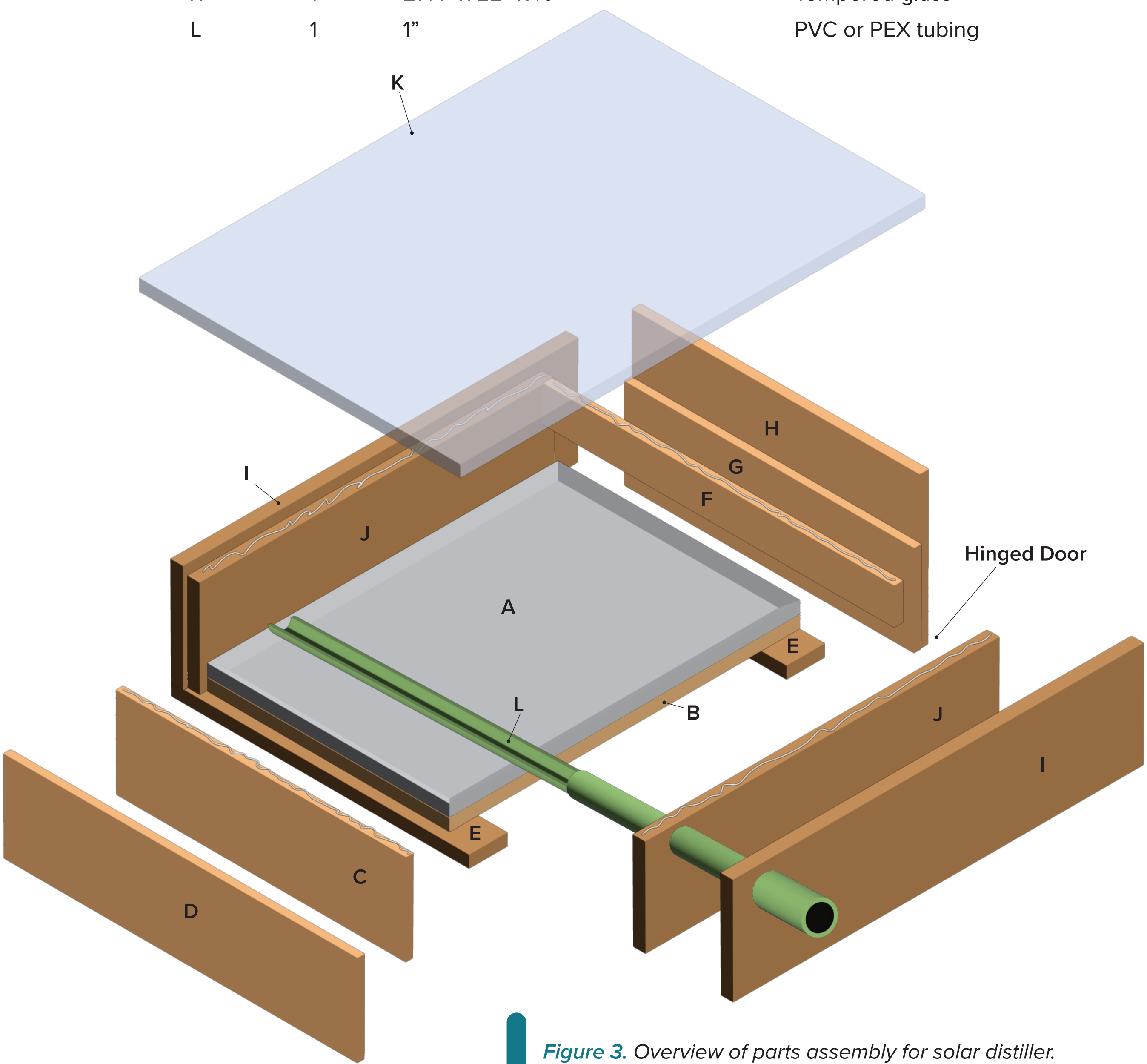

Figure 3. *Overview of parts assembly for solar distiller. Diagram by Allison Strahan*

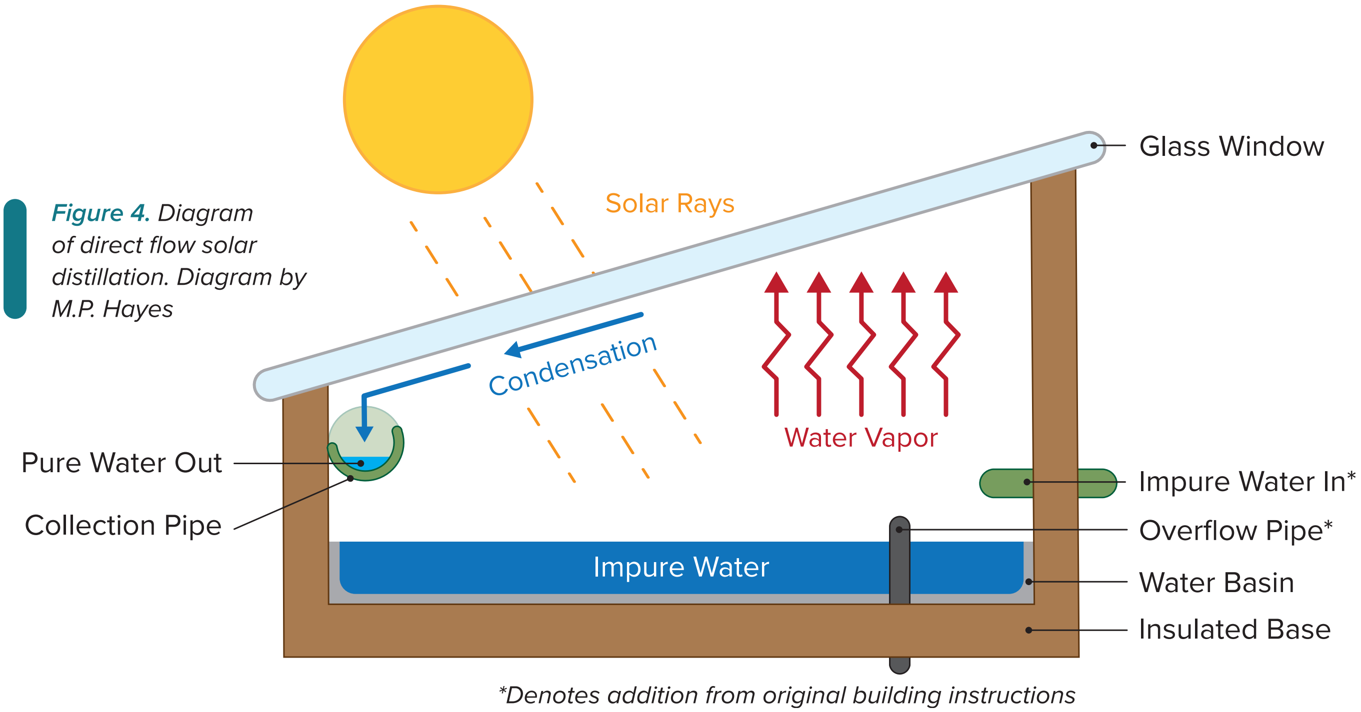

Figure 4. Diagram of direct flow solar distillation. Diagram by M.P. Hayes

HOW IT WORKS

The standard solar still is designed with a high back wall and a shorter front wall to support an angled glass cover. The thickness of glass should be ⅛-inch thick and completely transparent. Plastic covers should be avoided to decrease the risk of exposure to released toxins. The angle of the glass should be 5-10 degrees to effectively capture maximum sunlight (Figure 1, bottom). A greater angle on the glass cover will still produce energy but will decrease the amount of solar rays taken into the unit. The still should have an insulated bottom for a reservoir to hold the impure water. The reservoirs could be made of metal baking trays or troughs that will be the water basin. The water basin should contain an impure water input (if coming from a tap or hose source) and an overflow pipe to keep water levels at a set height. The optimal water level in a solar still for maximum evaporation is ¾ inch but can be adjusted based on needs. If you choose to fit the water basin with inflow and overflow pipes (Figure 4), make sure the pipes are sealed around the edge to prevent water from leaking from the reservoir. Holes can be sealed with a spray foam, caulk or epoxy putty around pipes to close gaps. The solar rays will pass through the glass cover and heat the water to 212 degrees Fahrenheit before evaporating. Water vapors will rise and condense on the inside of the glass cover. Water droplets will run down the angled glass into a water collection pipe. This collection pipe, typically made from PVC or PEX tubing, will need to run across the length of the short side frame. The collection pipe will have an open top and feed to a drainage or outflow pipe for the water to be collected. The drained water can be collected into any containment vessel for use in irrigation.

ASSESSING THE BENEFITS

When deciding if a solar distillation unit will work for your garden or nursery, an emphasis should be put on water volume consumption and space limitations. The final location of the unit should be in direct sunlight and accessible for water collection. To estimate the size of the unit, determine the gallons of water needed per day and divide by 0.06 (the gallons per day per square foot of a solar still) to give you the optimal size of your unit. If this seems unrealistic, pure water can be used to dilute impure water and reduce the amount of contaminants or salts present. For example, if you mix 2 gallons of pure water with 2 gallons of 200 parts per million (ppm) saltwater, the resulting gallons will have a concentration is 100 ppm. This is an effective strategy to mitigate low volumes of purified water from solar distillation units by mixing water to dilute overall concentrations from saltwater intrusion. Additionally, the remaining contaminants and concentrated saltwater left in the still after evaporation will need to be drained periodically depending on the water level in the reservoir. It is a best practice to remove this concentration solution, also known as brine, in small volumes and gradually mix it with a large volume of water down the sink for disposal. This practice is only intended for minimal volumes, such as a cup of brine, and not for large volumes of high-salinity brine. It is best to consult local ordinances before disposing of large volumes of brine solutions.

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