Solar-Powered Water Desalination

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Experimental Procedure

Making the Desalination Devices

In this part of the science project, you will make two desalination devices.

1. Look at Figure 3 to get an overview of what you are making. Fit the stem of a funnel inside the short end of a straw. The easiest way to do this is to push the straw with a constant steady force while also twisting a little bit. Push the straw as far onto the funnel stem as it will go. Securely tape the straw to the funnel. Repeat for the second straw and funnel.
2. Push a straw-funnel assembly through the hole near the bottom of each container so that the funnels are on the inside of the containers. Adjust the straw-funnel assemblies so that the funnels face up. Put some modeling clay around the hole, on the *outside* of the container, to hold the funnel in place. Your setup should now look similar to Figure 3. Do not worry if the funnel will not stay in place. The next steps will solve that.

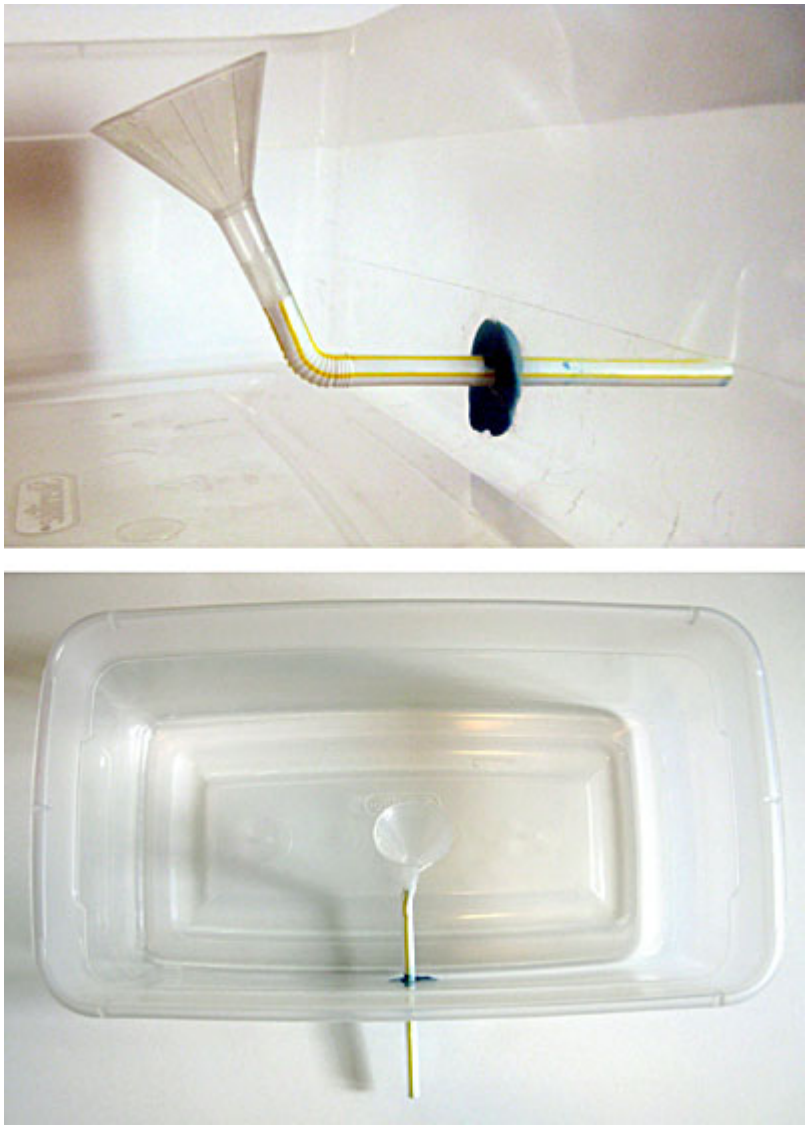

Figure 3. After putting the straw-funnel assembly in the hole in the container and securing it using some modeling clay, your setup should look similar to the one shown here. The top picture shows a close-up from the side and the bottom picture shows an overall view from above.

3. Look at Figure 4 to get an overview of what you are making in the next couple of steps. Start by putting the long end of each straw through the hole in a plastic collection cup. Adjust the straw so that the funnel faces up. Put some modeling clay around each hole, on the outside of each collection cup, to keep each cup in place.
4. Now you will need to do some tinkering to get everything positioned correctly:
    a. The straw should slope down slightly from the box to the cup. This will allow gravity to help the water you collect flow from the straw to the cup. If there is no slope, the water will collect in the straw rather than in the cup.
    b. If the straw is too long for the funnel to face up *and* the straw to slope down towards the collection cup, cut a little bit off of the long end of the straw and test the setup again. Keep cutting a little bit of the straw off and re-assembling until it is right.
    c. Do not worry if the collection cups do not sit completely flat.
5. Cover the opening of one container with a single large piece of plastic cling wrap. To seal the container closed, pull the wrap tightly over the opening and tape it in place at the four corners of the container. Repeat for the second container.
6. Set a washer on the plastic cling wrap, right above the funnel. Do this for each desalination device. Adjust as needed so that the washer creates a low point in the cling wrap right above the funnel, but make sure it is not so low that the cling wrap touches the funnel. For an example of this, see Figure 4.
    a. If the plastic cling wrap is touching the funnel, not all of the condensation will go down into the funnel. To fix this, either lower the funnel (such as by cutting the straw) or raise the cling wrap (by taping it tighter).
    b. If the cling wrap is so tight that it does not form a low point where the washer is, un-tape it in places and re-tape it more loosely.

Figure 4. Place the washer on the cling wrap, right above the funnel. Make sure that the cling wrap is not so low that it is touching the funnel. The top left picture shows the entire setup at this point. The top right picture shows a close-up of the collection cup and washer. The bottom picture shows a close-up of just the washer and funnel.

7. After you are done adjusting your setup, cover each collection cup with plastic cling wrap and secure the plastic tightly with a rubber band, as shown in Figure 5. This prevents your desalinated water from evaporating.
    a. Make sure that there are no gaps or holes in the cling wrap.

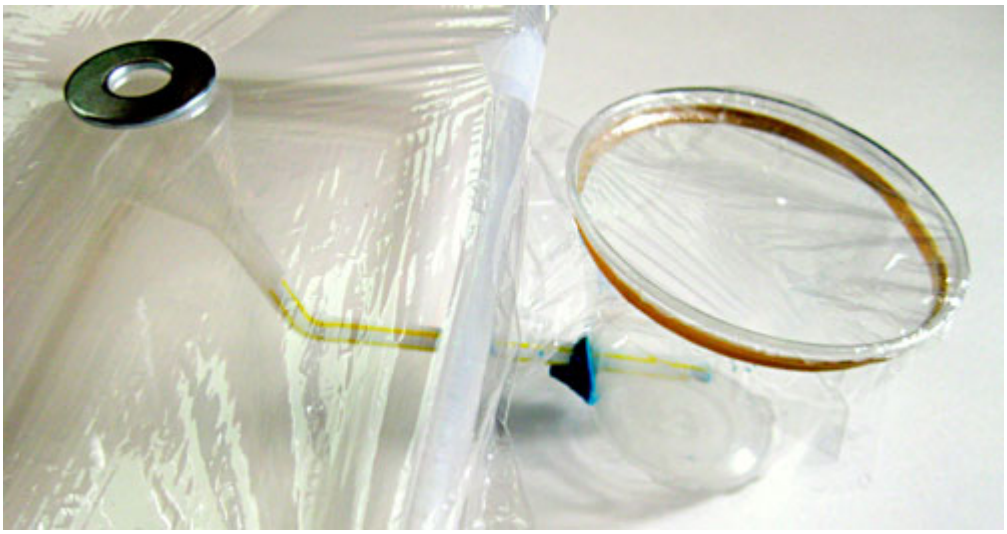

Figure 5. Secure a piece of cling wrap on to the top of each collection cup using a rubber band, as shown here.

8. Cover the *outside* bottom of one desalination container with black construction paper and cover the other one with white construction paper. Tape the paper in place.
    a. Arrange the construction paper so that it goes up about 2 to 3 cm on the sides of each container.
    b. You may need to cut a small slit in the construction paper for the straw to get through.
9. Make up a single batch of saltwater for both desalination containers.
    a. Add 1 tablespoon of salt to the tripour beaker and fill it with tap water to the 500 mL mark. Mix with a spoon until the salt is dissolved. Each of the desalination containers will need 250 mL of saltwater.
10. For each desalination container, remove the washer, gently remove the tape on one corner, lift the cling wrap, and pour in the saltwater. Add enough so that it just barely covers the bottom of the container, approximately 250 mL per container.

a. Be careful not to let any saltwater spill into the funnel or onto the construction paper.

11. Put the cling wrap back in place, making sure it is taped on all four corners of each container. Put the washer back on top of the plastic wrap directly above the funnel.
12. Your desalination devices should look similar to the ones in Figure 6 below. They are now ready for testing!

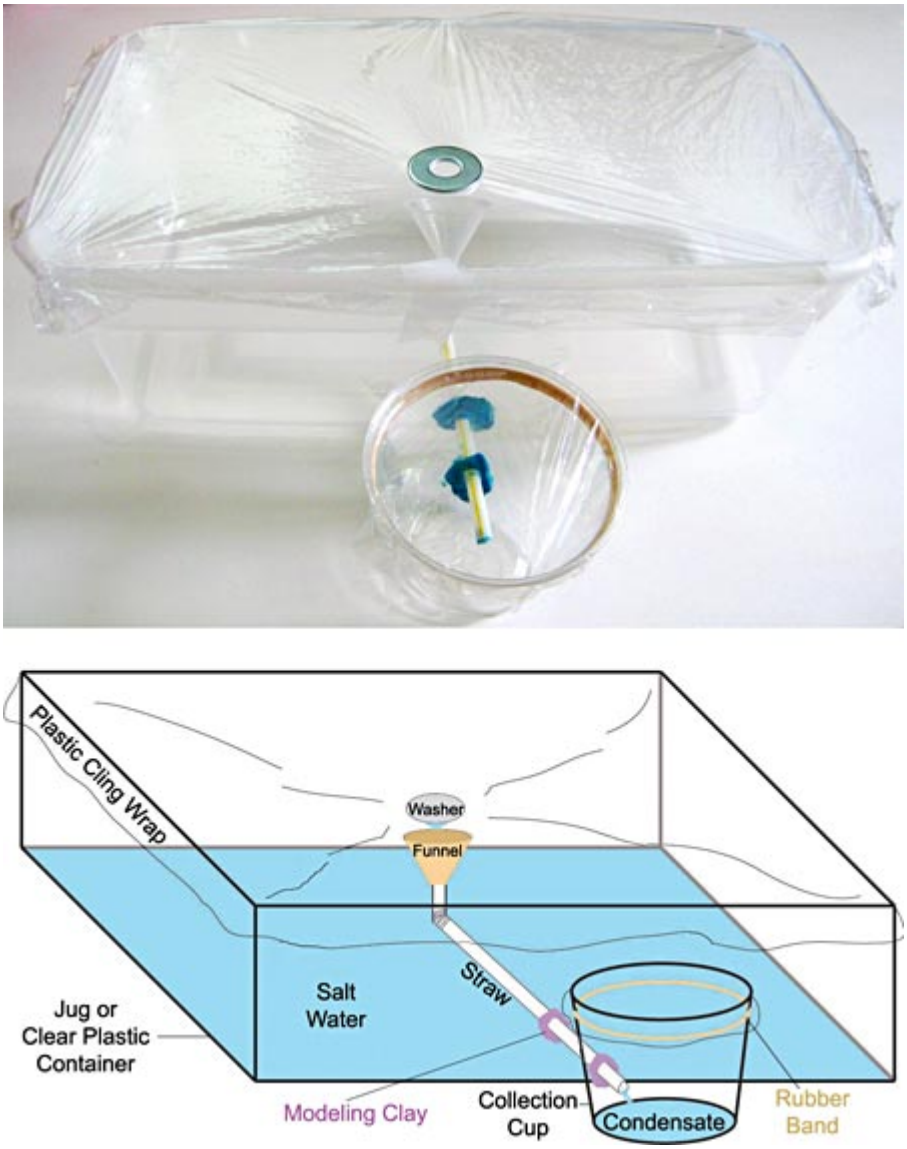

Figure 6. When your desalination devices are ready for testing, they should look similar to the one in the top picture (except yours should have black or white construction paper on the bottom). The diagram on the bottom shows what the desalination devices should look like during testing as condensation is collected. (The construction paper is not shown in the diagram.)

Testing the Desalination Devices

In this part of the science project, you will test the performance of the desalination devices.

1. Carefully take the desalination devices outside to an area that will receive direct sunlight for at least four hours.
2. Prepare your desalination devices for testing and do a final check to make sure that everything is in place and ready.
    a. One device should have black paper on the outside bottom of the container, the other should have white paper.
    b. Both devices should contain 250 mL of salt water.
    c. Plastic cling wrap should completely seal the top of the devices. If it does not, water vapor may escape and your results will not be reliable.
    d. On each desalination device, a washer should be sitting on top of the plastic wrap directly above the funnel. This should cause the plastic wrap to sag slightly such that water that condenses on the plastic wrap rolls down the plastic, towards the washer, and drips into the funnel.
    e. Get rid of any large wrinkles that do not flow down to the washer. Wrinkles can prevent the condensation from smoothly rolling down to the collection point.
    f. Make sure that the funnel in each device is facing up, directly below the washer, and not so high that it is touching the cling wrap. If the funnel is touching the cling wrap, either lower the funnel or raise the cling wrap by taping it higher.

g. Make sure that the modeling clay has sealed the holes to prevent evaporative losses. Add extra modeling clay if needed.
h. Check that the straws slope down towards the collection cups. Even a mild slope is enough to work.

3. In your lab notebook, record the time. Measure and record the temperature near the desalination devices. You can use this information later to determine how temperature affects the condensation yield.
4. Check on the desalination devices after about 30 minutes. You may see condensation starting to form small drops on the cling wrap right below the washer. However, it may take longer, depending on how sunny and warm it is.
    a. If you see condensation forming small drops, do you see it on both desalination devices, or only one of them? Record your observations in your lab notebook.
    b. If needed, adjust the washer and funnel-straw assembly on each device to make sure that the drops fall into the funnel. Make sure to record any adjustments you make in your lab notebook.
        i. You can arrange the washer so that one edge of it is the lowest point on the cling wrap, and this edge is positioned over the funnel so that condensation drips into it, as shown in Figure 7 below.

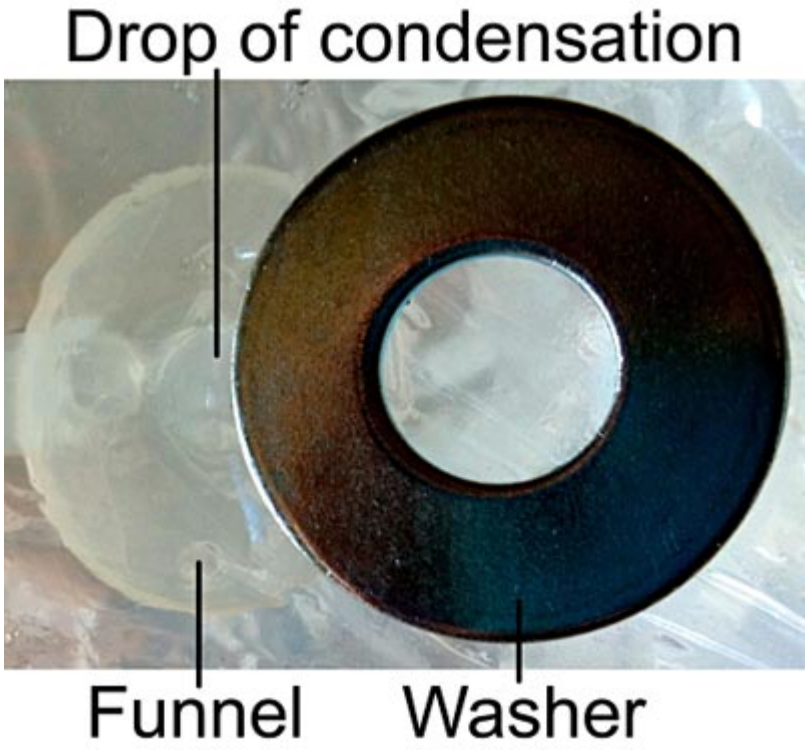

Figure 7. As shown in this close-up picture, you can arrange the washer so that its edge is the lowest point on the cling wrap and is positioned over the funnel, allowing condensation to drop into it.

5. Continue checking on your desalination devices every 30 minutes to make sure that they are still in the sunlight and that the condensation drops are falling into the funnel.
    a. If the desalination devices are not in the sun, gently move them to a sunny location.
    b. Does it look like one desalination device is making more condensation drops than the other? Record your observations in your lab notebook.
    c. If it is warm enough, the modeling clay may melt a little. If it does, just make sure that the holes are still sealed by the modeling clay. Add more clay if needed.
    d. If it is windy, you may want to check on your desalination devices more frequently to ensure that everything is still in place and functioning properly.
6. Leave your desalination devices in the sunlight for *at least four hours* before stopping your experiment.
    a. In your lab notebook, record the time when you stop your testing. How long were your desalination devices in the sunlight?
    b. Again, measure and record the temperature near the desalination devices.
7. Open the large cling wrap covering on each device and try to get any condensate that is still in the straw to go out and into the collection cup. You can do this by gently blowing into the straw.
8. To determine the condensate yield of each desalination device, carefully disconnect the collection cup, remove its cling wrap covering, and pour the collected condensate into the 25 mL graduated cylinder.
    a. What was the condensate yield of each device? Record your results in your lab notebook.
9. To determine whether the collected condensate is still salty, taste a little bit from each device. Record your observations in your lab notebook.
10. Repeat this experiment at least two more times on different days for a total of three trials. This will help ensure that your results are consistent and reproducible.

    a. Between trials, carefully rinse out each desalination device with tap water and let them dry along with all of the other desalination device components.
        i. Use the same amount of saltwater in each device and trial.
        ii. For each trial, perform the testing for the same length of time.
11. After you have tested both devices in three trials, make a bar graph of your condensate yield results.
    a. On the x-axis of the graph, list your desalination devices. You can average the results for each device for the three trials, or you can show all three trials separately.
    b. On the y-axis, put the condensate yield in milliliters.
12. Analyze your results.
    a. Did one color of desalination device consistently have a higher condensate yield than the other? If so, why do you think this is? What does this tell you about the features an effective solar desalination device should have?
    b. Was the collected condensate ever salty?
    c. If the temperature near the desalination devices varied a lot between your three trials, do you see a correlation between the temperature and the condensate yield?
13. Taking 3 liters as the minimum required amount of drinking water per person per day (NAS, 2004), how many devices would you need to produce enough water for your survival needs?
    a. You can divide the condensate yield by the testing time to get an average collection rate (mL/hour). You will need to think about how many hours of sunlight there are in your area. Would it change with the season?

Frequently Asked Questions (FAQ)

FAQ for this Project Idea available online at https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvEng_p022/environmental-engineering/solar-powered-water-desalination#help (http://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvEng_p022/environmental-engineering/solar-powered-water-desalination#help).