Western Engineering Outreach

Solar Powered Desalination

Grades 6-8

Meet Today's ENG HERO!

Clare Robinson – Associate Professor with Western Engineering

Dr. Robinson completed her BEng and PhD in Environmental Engineering at the University of Queensland. She is an associate professor in the Civil and Environmental Engineering department at Western University. Some of her research interests include water quality, supply, and treatment in developing countries; green roofs; and groundwater-surface water interactions in coastal environments.
To learn more about Dr. Robinson visit:
https://www.eng.uwo.ca/civil/faculty/robinson_c/index.html

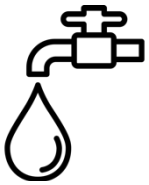
Learning Goal:

- Students will investigate how changing the state of matter of water can separate it into clean drinking water
- Curriculum Connections: Grade 7 - Heat in the Environment, Pure Substances and Mixtures; Grade 8 - Systems in Action, Fluids, Water Systems

Materials Needed:

- White construction paper
- Black construction paper
- 2 clear plastic rectangular containers - able to make a straw size hole in each
- 2 clear plastic cups - able to make a straw size hole in each
- 1 measuring cup that will hold 250 mL (~1 cup)
- 1 bowl or measuring cup that will hold at least 500 mL (~2.5 cups)
- 1 stick modelling clay (if you do not have modelling clay, can try blue sticky tack or something similar)
- 2 funnels (~5 mL if possible, but if not just make sure it is shorter than the height of the sides of the clear plastic container)

- 2 bendy straws
- 2 steel washers (or something similar that can be used to weigh down plastic wrap to cause a slope)
- 2 rubber bands
- Plastic cling wrap
- Tape
- 1 tbsp salt
- 500 mL water
- Thermometer (if possible)
- A sunny location (that gets full sun for at least 4 hours)
- Pencil
- Paper or notebook

Engineering and Science Connections:

What is desalination?
Desalination is the process of removing salt (and sometimes other minerals) from saltwater to produce fresh, potable (safe to drink) water.

Why do we want to be able to desalinate water?
The main focus of desalination is to produce fresh water that humans can use for drinking, cooking, and irrigation. Desalination is currently quite expensive, especially when compared to using water from fresh water sources. But as the population grows and as water supplies begin to diminish due to climate change and contamination, more fresh water is needed (UN Environment Programme, 2019). Desalination could provide fresh water that meets that need.

It is important to note that there are also challenges associated with desalination. Brine (very salty water) is a by-product of the desalination process. Often, the brine by-product is polluted with chlorine and copper, which when the brine is returned to the ocean, has an impact on the oxygen and organisms. However, research shows that there are opportunities to use brine in other ways, for example, salt or metal recovery (UN Environment Programme, 2019).

Currently, the most common, desalination technologies include reverse osmosis and thermal desalination. Reverse osmosis is a technology where the water is passed over a series of membranes to remove the salt and minerals. Thermal desalination uses heat to evaporate and condense the water to purify it (IDE Technologies, n.d.). Today's activity uses the same principles as thermal desalination.

Key Terms:
Solar Power - energy obtained by harnessing the sun's rays
Evaporation - the process of turning liquid into a vapour

Surface Area - the measurement of the surface size
Water Vapour - water suspended in air
Condensation - water vapour converted into liquid water
Water Purity - water that is free from contamination
Yield - the amount of something produced in a process

Video Recommendation:

Can Sea Water Desalination Save the World? https://www.youtube.com/watch?v=bfr82RB72U8
What does desalination mean? https://www.youtube.com/watch?v=mUtYUTTC_Bg

Activity:

Before beginning, think about the following questions:

- Why is desalination important?
- What are some ways that you can separate mixtures?
- How are you harnessing the power of the sun?

Today you will be making an apparatus that will filter the saltwater into clean drinking water. The following is a suggestion for a potential solution, but you can adjust your own design how you like and to use the materials you have available at home.

Explanation of terms:
Desalination Container - where the desalination process takes place. The sun will cause the water to evaporate leaving behind the salt. The water will accumulate on the plastic cling wrap lid. It will run down the plastic wrap into the funnel because of the slope caused by the weight of the washer. From the funnel, it will run through the straw into the collection cup.
Collection Cup - where the condensate will collect.

Note. These instructions are to make two separate devices: one with a white construction paper base and one with a black construction paper base. This will allow you to compare how colour impacts the yield.

Making the Desalination Device

1. Create a hole in the clear, plastic container that is large enough for the straw to fit through. The hole needs to be part way down the side of the container to allow the straw to be sloped down from the funnel through the hole in the side of the container and into the collection cup. Refer to the diagram below for reference.
2. Cover the outside bottom of one of the desalination containers with black construction paper and cover the other one with white construction paper. Tape the papers in place.

   a. Arrange the construction paper so that it goes about 2 to 3 cm up the sides of each container.
   b. You may need to cut a small slit in the construction paper for the straw to get through.
3. Fit the stem of one funnel inside the short end of one of the straws. Push the funnel in as far as it will go. Securely tape the straw to the funnel. Repeat for the second funnel and straw.
4. Poke a hole in each of the clear plastic cups near the bottom. Refer to the diagram below for reference.
5. Push one of the straw-funnel assemblies through the hole in the container so that the funnel is on the inside of the container. Adjust the straw-funnel assembly so that the funnel faces up. Repeat for the second set. Note, the funnel will not be sitting directly on the bottom of the container. The short end of the bendy straw will be holding it up.
6. Put some modeling clay around the hole on the outside of the container to hold the straw in place. Do not worry if the funnel will not stay in place yet. The next steps will solve that.
7. Place the long end of the straw through the hole in one of the plastic collection cups. Adjust the straw so that the funnel inside the container faces up. Repeat for the second set.
8. Place some modelling clay around the hole on the outside of the collection cup to keep each cup in place.
9. Now you will need to do some tinkering to get everything positioned correctly:
   a. The straw should slope down slightly from the container to the collection cup. This will allow gravity to help the collected water flow from the straw into 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 downwards 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.
10. Cover the opening of the 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.
11. Set a washer on top of the plastic cling wrap, right above the funnel. 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.
   a. If the plastic cling wrap is touching the funnel, not all of the condensation will go down into the tunnel. 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 plastic cling wrap is so tight that it does not form a low point where the washer is, re-tape it more loosely.
12. After you are done adjusting your setup, cover each collection cup with plastic clip wrap and secure it tightly with a rubber band. This prevents your desalinated water from evaporating.
   a. Make sure there are no gaps or holes in the plastic cling wrap.
13. Make up a batch of saltwater to add to the desalination containers.

   a. Add 1 tablespoon of salt to the 500 mL bowl or measuring cup 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.
14. For each desalination container, remove the washer, gently remove the tape on one corner, lift the plastic cling wrap and pour the saltwater into the bottom of the container. Add enough so that it just barely covers the bottom of the container, approximately 250 mL. You may need to adjust depending on the size of your container.
   a. Be careful not to let any saltwater spill into the funnel.
15. Put the plastic cling wrap back in place, making sure it is taped on all four corners. Put the washer back on top of the plastic cling wrap directly above the funnel. Repeat for the second container.
16. Your desalination devices should look similar to the one in the diagram below. They are now ready for testing!

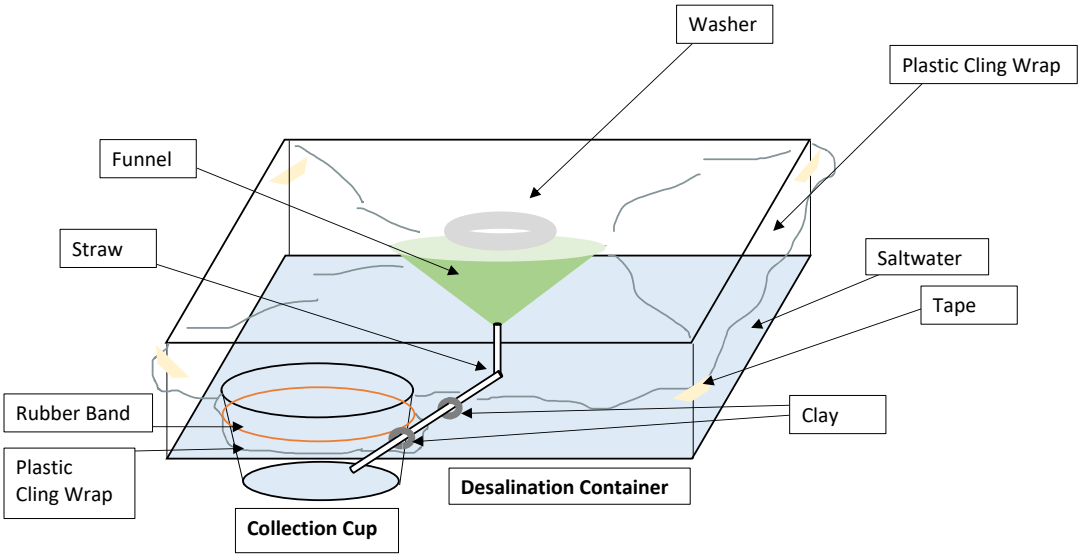


Figure 1. Note, this diagram does not have the construction paper shown on it to make it easier to see the rest of the components.

Testing 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.
3. In a notebook, record the time. If you have a thermometer, 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 plastic cling wrap right below the washer. However, it may take longer than 30 minutes depending on how sunny and warm it is.
    a. Continue checking on your desalination devices every 30 minutes or so to make sure that they are still in the sunlight and that the condensation drops are falling into the funnel.
    b. If the sun has moved and the desalination devices are no longer in direct sunlight, gently move them to a sunny location.
    c. If it is really warm, the modeling clay may melt a little. If it does, just make sure that the holes are still sealed. 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.
5. Leave your desalination devices in the sunlight for at least four hours before stopping your experiment. Record times and temperatures in your notebook.
6. After at least four hours has passed, open the large plastic cling wrap covering on each device and try to get any condensate that is still in the straw into the collection cup. You can do this by gently blowing into the straw or gently sloping the straw even more towards the collection cup.
7. To determine the condensate yield of a device, carefully disconnect the collection cup, remove its plastic cling wrap covering, and pour the collected condensate into a measuring cup. Repeat for the second collection cup into a different measuring cup. How did the devices compare?
8. To determine whether the collected condensate is still salty, taste a little bit from each device.

What Did You Learn?

- Why do you want to make sure there are no holes or gaps in the plastic cling wrap or clay?
- Which colour of construction paper yielded more condensate?
- To get the average collection rate, you can divide the condensate yield by the testing time (mL/hr). How many hours of sunlight are there in your area? When is the sun the strongest and does that change with the season? How does this impact how much water you can desalinate?
- The average person needs about 3 L of drinking water every day (Mayo Clinic, 2017). Based on that, how many devices would you need to produce enough water for your survival needs?

Future Learning

- What other ways can you think of to try and desalinate water? Do you think a different set up than the one you built today would work better? Try building it and test it out! Make sure to keep notes so you can properly compare the results.

- If you want to find out more about desalination, you can visit these websites that provided some of the information used in this lesson:
    - IDE Technologies [n.d.]. *What is Desalination?* Retrieved from https://www.ide-tech.com/en/solutions/desalination/what-is-desalination/?data=item_1
    - Teach Engineering [n.d.]. *Ocean Water Desalination*. Retrieved from: https://www.teachengineering.org/lessons/view/cub_desal_lesson01
    - UN Environment Programme [2019]. *Towards sustainable desalination*. Retrieved from https://www.unenvironment.org/news-and-stories/story/towards-sustainable-desalination

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