

CLASSROOM ACTIVITY

Oceans of Drinking Water

Key Learning Topics

- Water Cycle
- Desalination

Overview

Day Zero is the day that Cape Town was predicted to run out of water. The city averted the crisis through education and conservation, but the problem has not been completely solved. Desalination could be part of the solution given the proximity of Cape Town to the South Atlantic Ocean. Desalination refers to the removal of salts and minerals from water. In this activity, students will investigate the process of desalination. They will use the results from their investigation to explain how desalination plants can produce fresh water each day to meet the fresh water needs in cities around the world.

Target Audience

Grades 5–9
Chemistry, Engineering, Math

Activity Duration

45–60 minutes class period(s)

Essential Question

How can we make saltwater drinkable for drought-struck regions?

Materials

- Oceans of Drinking Water Lab Investigation, one per student
- Salt (Two tablespoons per group)
- Bottled water (8 oz bottle per group)
- Plastic wrap (one sheet per group)
- Rubber band (one per group)
- Spoon (one per group)
- Small plastic container cut from water bottle (one per group)
- Larger container bowl size cut from milk gallon (one per group)

- Coin (one for each group)
- Hot glue

Background Information/Links

At the end of January 2018, Cape Town South Africa was 2 1/2 months away from running out of water. This event was known as Day Zero, and the government set it to April 12, 2018¹. A plan was put in place to conserve water by one-third. A significant part of the solution was diverting water earmarked for agriculture to the city. They also increased water tariffs, eliminated public water use in pools and laws, and implemented a new water-pressure system². They were able to put Day Zero off through their efforts and benefited from more rain the next year. However, the problem hasn't been solved, and conservation alone will not fix Cape Town's drought issues.

One possible part of the solution is desalination. In Carlsbad, California, one of the world's largest ocean desalination plants, produces 50 million gallons of fresh water each day, meeting nearly one-third of all water needs in San Diego County³. San Diego County⁴ and Cape Town South Africa have almost the same population⁵. The clean water produced in Carlsbad is about the same amount of water that was needed ration to help prevent "Day Zero."

Procedure

Introduction–10 min

- Introduce students to an example of a water crisis in South Africa and how people came together to avoid "Day Zero" using the following video: <https://time.com/5103259/cape-town-water-crisis/>
- Provide the following prompts for students to discuss with a partner after viewing the video:
 - What do you think your life would be like if you needed to conserve water by one-third? Could you make do with 30 gallons of water a day? (It is estimated the average person uses about 80–100 gallons of water per day!)
 - Use this guide from the U.S. Geological Survey as a guide for how much water is used for daily tasks: <https://water.usgs.gov/edu/qa-home-percapita.html>

¹ News 24, Day Zero now on April 12 for Cape Town, Jenni Evans, January 23, 2018, on the internet <https://www.news24.com/SouthAfrica/News/day-zero-now-on-april-12-for-cape-town-20180123> (August 20, 2019)

² City Lab, Cape Town's 'Day Zero' Water Crisis, One Year Later, Christian Alexander, April 12, 2019, on the internet <https://www.citylab.com/environment/2019/04/cape-town-water-conservation-south-africa-drought/587011/> (August 20, 2019)

³ Claude "Bud" Lewis Carlsbad Desalination Plant, 50 Million Gallons a Day The Pacific is Now on Tap, On the internet <https://www.carlsbaddesal.com> (August 20, 2019)

⁴ World Population Review, San Diego County California Population 2019, On the internet <http://worldpopulationreview.com/us-counties/ca/san-diego-county-population/> (August 20, 2019)

⁵ World Population Review, Cape Town Population 2019, on the internet <http://worldpopulationreview.com/world-cities/cape-town-population/> (August 20, 2019)

Classroom Activity—20 min

- Divide students into groups and provide a material set for each group.
- Distribute the Oceans of Drinking Water Lab Investigation. Explain to students that they will be investigating the process of desalination. They will then make a connection to how desalination plants can produce fresh water each day to meet the fresh water needs in cities around the world.
- Introduce or revisit the water cycle to students using the video from Ocean Today: <https://oceantoday.noaa.gov/watercycle/>. Ask students to sketch out the water cycle and annotate the relationship between the water cycle and desalination process as they conduct their investigation.
- Review the activity procedure and materials with students and ask if there are any clarifying questions before they begin.
- Move about the room and monitor the student activity. Make sure that when students are filling the larger container the saltwater level does not go above the level of the smaller bowl. It should be dry inside.
- Once students have completed the setup, have them leave the containers in a sunny location or under a heat lamp.
- Have students write the answer to the prediction prompt, “What do you think you will find when you come back tomorrow?”

Sample answer:

Students will likely say there will be water in the small container, and it will not be salty. They may further realize the water left in the larger container will have a higher salt content than before.

Evaluation—10 min

- Invite students to solve the following problems in their lab investigation. Answers are noted below.
 - **Question 1:** Cape Town’s population of 3.8 million rationed from 87 liters a day to 50 liters a day. Would 50 million gallons of water a day be enough to make up the water shortfall? Show all work and explain the meaning of your numbers. (note one us gallon is 3.78541 liters)
- **Question 2:** If the ratio of clean water to saltwater in Reverse Osmosis is 1:2, and 100 gallons of seawater are put into the process then how much freshwater is produced? Show all work and explain the meaning of your numbers.

Sample Answer:

Set up the proportion $1:3 = x:100$, $x = 33.33$ gallons of clean water.

Lesson Summary—5 min

Have students examine their containers and complete the synthesis activity. Invite students to share out how their investigation modeled how desalination plants in the South Atlantic Ocean could produce fresh water each day to meet the fresh water needs of Cape Town.

Oceans of Drinking Water

Day 1

Day Zero is the day that Cape Town was predicted to run out of water. The city averted the crisis through education and conservation, but the problem has not been completely solved. Desalination could be part of the solution given the proximity of Cape Town to the South Atlantic Ocean. Desalination refers to the removal of salts and minerals from water. In this activity, you will investigate the process of desalination. And then make a connection to how desalination plants can produce fresh water each day to meet the fresh water needs in cities around the world.

First, sketch out the water cycle.

Annotate the relationship between the water cycle and desalination as you conduct the next investigation.

Materials list:

- Salt
- Bottled water
- Plastic wrap
- Rubber band
- Spoon
- Bowl
- Small plastic container (that is shorter than the bowl)
- Coin

Lab Investigation

Oceans of Drinking Water

Procedure

1. Put two spoons of salt into the water and stir.
2. Hot glue or adhere the small container into the large container. Be sure the small container is shorter than the large container.
3. Fill the large container with saltwater making sure the water level does not go over the edge of the smaller container.
4. Place the plastic wrap around the bowl and secure it with a rubber band.
5. Place the coin in the center of the plastic wrap, so it dips the plastic slightly over the small container.
6. Place the container in a sunny spot or under a heat lamp for the rest of the day.

Prediction

What do you think you will find when you come back tomorrow?

Analysis

1. Cape Town's population of 3.8 million rationed from 87 liters a day to 50 liters a day. Would 50 million gallons of water a day be enough to make up the water shortfall? Show all work and explain the meaning of your numbers. (note one US gallon is 3.78541 liters)

2. If the ratio of clean water to saltwater in Reverse Osmosis is 1:2, and 100 gallons of seawater are put into the process then how much freshwater is produced? Show all work and explain the meaning of your numbers.

Oceans of Drinking Water

Day 2

Activity Synthesis:

You may be surprised to find water in the small container. How did that water get there?

Draw a picture showing how the water cycle worked in this experiment.

What do you think about the salt content of the water left in the bowl? Is it higher or lower? Why?

How could desalination plants in the South Atlantic Ocean produce fresh water to meet the fresh water needs of Cape Town?

National Standards

Next Generation Science Standards

MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Standards for Technological Literacy

Ch4S5 – The effects of technology on the environment

Common Core State Standards for English Language Arts

CCSS.MATH.CONTENT.6.RP.A.1

Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

CCSS.MATH.CONTENT.6.RP.A.2

Understand the concept of a unit rate a/b associated with a ratio $a:b$ with $b \neq 0$, and use rate language in the context of a ratio relationship.

CCSS.MATH.CONTENT.6.RP.A.3

Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations

CCSS.MATH.CONTENT.6.RP.A.3.D

Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

CCSS.MATH.CONTENT.7.RP.A.1

Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units