Every living thing on Earth depends on water to live. Most of the water on Earth is saltwater, which means humans cannot drink it. Instead, we must rely on the small amount of freshwater available. As humans continue to burn fossil fuels, freshwater coastal sources, like groundwater, are becoming more threatened by the effects of climate change. One such effect is saltwater intrusion which is the movement of saltwater into sources of freshwater, making the water too salty for humans and many land animals to drink. To find out how this is happening and what we can do about it, we talked to researchers from the Coastal Hydrology Lab, a research group at Dalhousie University that studies coastal water issues.

Julia Cantelon, a Ph.D. student studying groundwater on Sable Island, explains saltwater intrusion like this: when you mix oil and water, the oil always separates and sits on top because it is less dense than the water. Freshwater is less dense than saltwater, so in coastal environments, the fresh groundwater will sit on top of saltwater (refer to Activity Introduction for an explanation of liquid density). However, some effects of climate change, like sea-level rise, storm surges, and erosion, can cause saltwater to mix into the freshwater layer.

On Sable Island, the fresh groundwater feeds into the surface ponds, providing animals, like horses and seabirds, with drinking water. Julia has found that low-lying areas are at a higher risk of saltwater intrusion than higher areas, especially after large storm events. After Hurricane Juan, saltwater entered some of the freshwater ponds. Sadly, these ponds have not yet recovered, decreasing the amount of freshwater available to the animals.

Kiera Dolan, a Masters student in the lab, is studying similar events on the nearby island of Prince Edward Island (PEI). The people of PEI rely on pumping fresh groundwater from wells for their entire water supply. The wells connect to the freshwater layer of groundwater. Like on Sable Island, sea-level rise, storm surges, and erosion, can allow saltwater to move further inshore and enter people’s wells.
How Do We Adapt to and Prevent the Effects of Saltwater Intrusion?

The first way is to prevent saltwater intrusion from occurring in the first place. This means that we should try to decrease the effects of sea-level rise, storm surges, and erosion. Nature already has many ways of doing this. For example, naturally occurring barrier islands (long, narrow islands) can help protect larger nearby islands. As waves come in off the ocean, they hit the barrier island first. This makes the waves smaller and weaker by the time they arrive at the larger island which decreases erosion and saltwater intrusion on the main island. Barrier islands can also be man-made. Off the coast of PEI, an artificial oyster reef was created by putting hard materials on the seafloor and allowing oyster larvae to grow. Kiera is researching the ability of the oyster reef to act as a barrier island. She hopes to find that the reef is reducing erosion on the island and preventing saltwater intrusion.

Once saltwater intrusion has occurred, fixing it is an entirely different story. In a well, freshwater is added from the top, pushing the saltwater out. You can also create new wells near the coast where the salt occurs naturally to pull the salt water away from the active/used wells (pumped for freshwater). However, these are both difficult and expensive solutions. Fortunately, this is an active area of research and new solutions are uncovered every day. Barrett Kurylyk, the head of the lab, mentions that coastal engineering is a fundamental part of the solution. Scientists conduct research to determine the cause of a problem, while engineers build solutions to the problem.

What Can You Do to Help?

As community members, we can also get involved and do our part. One way you can prevent saltwater intrusion in wells is to think about the amount of water we use. Most of the water used in the Maritimes comes from groundwater wells. Conserving freshwater, such as having a shorter shower and using other freshwater sources like collecting rainwater to water your garden, helps take off the pressure from wells. Using less water will lessen the chance that saltwater intrusion will occur. Barrett mentions that many local environmental organizations deal with saltwater intrusion and erosion. They may have resources for you to use, or simple ways to volunteer.

Saltwater intrusion is a complex problem that is connected to climate change. But smart water usage, natural coast protection, and clever engineering solutions can go a long way to ensuring we can adapt and thrive in our coastal communities.
What Does It Look Like to Study Saltwater Intrusion?

Julia Cantelon is a Ph.D. student looking at how large storms on Sable Island cause saltwater intrusion. Her favourite aspect of her research is working in the field. She notes, “I really enjoy... working with the data [I collect] to help me understand the ... current state of the freshwater system on Sable Island and what processes are affecting groundwater and what that might mean for long term sustainability of freshwater on Sable Island.”

Kiera Dolan is a Masters student looking at how an artificial oyster reef can prevent coastal erosion off the shore of PEI Island. Her favourite aspect of the project is the community impact by stating that “this is real life for the people on Lennox Island. They deal with [erosion and climate change] every day and while I’m not solving their problem, I can help contribute in a way that might be able to help down the line.”

Barrett Kurylyk is the head of the Dalhousie Coastal Hydrology Lab. Growing up, he was always interested in coastal science, and eventually became involved in research on the impacts of climate change on coastal zones at Dalhousie. Barrett has also found a sense of pride in helping people. He tells us that “It’s fundamentally more rewarding to see your research help people, by highlighting their problems or solving them.”

Saltwater Intrusion Activity

Recommended for Science, Grade 2
(Learners will investigate liquids, solids, and mixtures)

Activity Summary
Learners will learn how freshwater and saltwater interact when saltwater intrusion occurs.

Learning Goals
1. To understand how density affects the interaction of saltwater and freshwater.
2. To demonstrate how saltwater intrusion can occur when saltwater is added to a freshwater environment.

Introduction
1. What is density?
   a. Density is a word that describes how much an object or substance weighs (its mass) in relation to the amount of space that object or substance takes up (its volume). Simply put, it is the amount of mass per unit of volume. High density objects are heavy and compact, for example, a brick. Low density objects are light and take up a lot of space, for example, a pillow.

   b. If we were to compare one litre of freshwater to one litre of saltwater, we would find that saltwater is heavier than freshwater. Why? Saltwater has lots of extra salt, ions, and other things that add mass to the water, making it denser. This is why when you add saltwater and freshwater to the same cup, freshwater will sit in a layer above saltwater.

Materials
- Measuring cup
- Teaspoon
- 250 ml freshwater (tap water)
- 500 ml seawater (ocean water or add 35 grams of salt to one liter of freshwater)
- One 750 ml clear cup and one 500 ml clear cup
- Pipette or funnel
- Blue and red food colouring (from your local grocery store or break open a marker and use the sponge inside)
- Paper tape
- Marker
Methods

1. Put 250 ml of freshwater into a 750 ml cup and 500 ml of saltwater into another cup. Label the freshwater cup “freshwater” and the saltwater cup “saltwater”.

2. Add a few drops of red food colouring to the freshwater cup. Stir until it is fully mixed.

3. Add a few drops of blue food colouring to the saltwater cup. Stir until they are fully mixed.

4. Slip the narrow end of the funnel into the cup of freshwater, so the tip touches the bottom of the cup. Carefully pour about 250 ml of saltwater into the funnel. Observe what happens. Answer Discussion Question 1.

5. Now pour some saltwater directly into the top of the freshwater cup, which already has both saltwater and freshwater layers. Observe what happens to your layers. Answer Discussion Question 2.

6. Cover the top of the freshwater cup with your hand or a lid and give a firm shake. Observe what happens to your layers. Answer Discussion Question 3.

Discussion Questions

1. What happened when you added saltwater to the freshwater cup? Describe what you saw. Why did this happen? Explain, relating your answer to density.

2. What happened when you added saltwater on top of the freshwater? Describe what you saw.

3. What happened when you shook the cup? How does this relate to saltwater intrusion? Describe what you saw.

Question for the Future

What questions did the activity leave you with? How could you find the answers?

References

The research feature is written based on Barrett Kurylyk, Julia Cantelon, and Kiera Dolan, interview by Kristen Tymoshuk, Halifax, NS, December 2, 2021.

Saltwater Intrusion Student Worksheet

Name: _______________________________________________________

Discussion Questions

1. What happened when you added saltwater to the freshwater cup? Describe what you saw. Why did this happen? Explain, relating your answer to density.

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2. What happened when you added saltwater on top of the freshwater? Describe what you saw.

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3. What happened when you shook the cup? How does this relate to saltwater intrusion? Describe what you saw.

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Question for the Future

What questions did the activity leave you with? How could you find the answers?

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