"Motion in the Ocean"
Hands-On Water Density Demo
Salt Water/Fresh Water

Activity Description:

This hands-on activity for both informal and formal audiences explores how water moves throughout the ocean, by using colored saltwater and freshwater in recycled tennis-ball tubes. The experiment demonstrates how fluids move depending on their densities. Participants see for themselves what happens when you pour saltwater on top of freshwater. The activity is most suited for students grades 5-12 paired in teams of 2 (or 3 max).

Introduction:

Although everyone knows that seawater is salty, few know that even small variations in ocean surface salinity (i.e., concentration of dissolved salts) can have dramatic effects on the water cycle and ocean circulation. Throughout Earth's history, certain processes have served to make the ocean salty. The weathering of rocks delivers minerals, including salt, into the ocean. Evaporation of ocean water and formation of sea ice both increase the salinity of the ocean. However, these "salinity raising" factors are continually counterbalanced by processes that decrease salinity such as the continuous input of fresh water from rivers, precipitation of rain and snow, and melting of ice.

Global ocean currents are driven in large part by differences in water density, caused by differences in both water salinity ('saltiness') and temperature (warm vs. cold water). These density-driven currents are called the global thermohaline circulation system -- thermo for temperature and haline for salinity.

'The Global Conveyer Belt' (http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=3658) visualization represents how currents move beneath the wind-driven upper ocean. The process begins in the North Atlantic east of Greenland, where cold surface waters get saltier due to evaporation and/or sea ice formation. In this region, surface waters can become dense enough to sink to the ocean depths. This pumping of surface water into the deep ocean forces the deep water to move horizontally until it rises back to the surface. This very large, slow current – is estimated to take on the order of 1000 years to complete a full circuit.

One of the major drivers of these currents is the formation of sea ice. When ocean water in the Arctic or Antarctic gets very cold, it freezes into sea ice. In the process, additional salt is released into the ocean. This saltier water is heavier (more dense) and therefore sinks down. To learn more about ocean salinity and ocean currents, visit https://science.nasa.gov/earth-science/oceanography/physical-ocean/salinity.

Several NASA satellite missions study this process, including Aquarius (2011-2014) (https://www.jpl.nasa.gov/missions/aquarius), which measured salinity, and ICESat-2 (https://icesat-2.gsfc.nasa.gov/), which measures the height of ice sheets, sea ice and glaciers.

Learning Objectives

- Understand that water can have different densities (salt vs. fresh). (Note: This experiment can also be conducted using warm vs. cold water.)
- Understand that water moves depending on its properties.
- Understand that the oceans are inter-connected and that water can move great distances across Earth. Note: This lesson is greatly augmented if it is proceeded by a showing of the NASA Visualization "Thermohaline Circulation: The Great Ocean Conveyor Belt."

Other Resources

- Motion in the Ocean Demo Video
- Aquarius Ocean the Circulation Video
- 'Ocean Motion' website
- 'Go with the Flow' activity

NGSS Standards addressed in this activity:

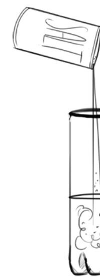
- ***5-PS1-3:*** Make observations and measurements to identify materials based on their properties.
- ***5-PS1-4:*** Conduct an investigation to determine whether the mixing of two or more substances results in new substances.
- ***MS-ESS2-6:*** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Supplies:

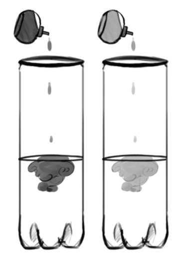
- 2 Tennis ball containers (tall, fitting 3 balls). This is where you'll mix the fluids: one for salt water, one for fresh. Or, one tennis ball tube for the experiment and one beaker, graduated cylinder, or other container to mix fluid.
- 1 container (plastic recycled cup or other vessel) for waste water.
- Salt (~1 heaping Tablespoon per ~450 ml water – or half of the tennis ball container)
- Food coloring (2 different colors – typically, blue and yellow are used.)
- Two inner tubes, such as clear tubing from a hardware store, for fluid transport that are ~ 10 mm diameter (could use clear straws instead)
- Fluid Separator Plug: High density foam 1/2" thick (children's puzzle floor mats) – circular disk cut out to fit diameter of tennis ball container, with two holes cut out (slightly less than 10 mm diameter) for the inner tubes.
- *1 Stirrer*

NOTE: See below section "How to make the Fluid Separator Plug."

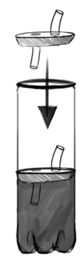
Procedure



- Fill one of the tennis ball containers about half full, with ~450 ml (16 oz.) of room temperature water. Add 1 heaping Tbsp salt, and stir to dissolve.



- Place ~3 drops yellow food coloring (or other color of choice) in salt water and stir.
- Fill the other tennis ball container about half full with ~ 450 ml (16 oz.) of fresh, room temperature water. Place ~ 3 drops blue food coloring (or other color) in water and stir.
  Note: Do not use more than 3 or 4 drops, otherwise you will not see the experiment reaction clearly



- Insert inner tubes into fluid separator plug, then insert assembly (beveled side down) into the fresh water container until it reaches the top level of the fluid, trying not to squeeze out the water. A slight gentle rocking motion works best. (If excess water appears on top of the separator plug, hold inner tube shut with a finger and pour it off, or else pipet it off, or blot it with a tissue.)

- Place finger on top of inner tube to seal it off. (Have your partner help you.)
- Gently pour yellow salt water into the top chamber, aimed at any part of the foam separator except the other hole opening, while partner seals off inner tube. Fill past the top of the inner tube, which your partner has sealed.

- Ask students questions, such as what they think will happen when their partner's finger is released from the tube. Then have your partner take his or her finger off tube and see what happens.
- Let students load and perform the experiment themselves and guess what will happen.

Optional: You demo the freshwater on top and the saltwater on bottom in order to show them how the system is loaded. Allow students to guess what will happen. Then allow students to perform the experiments themselves with the saltwater on top and the freshwater on bottom. Ideally, teams of 2 or 3 will perform the experiment.

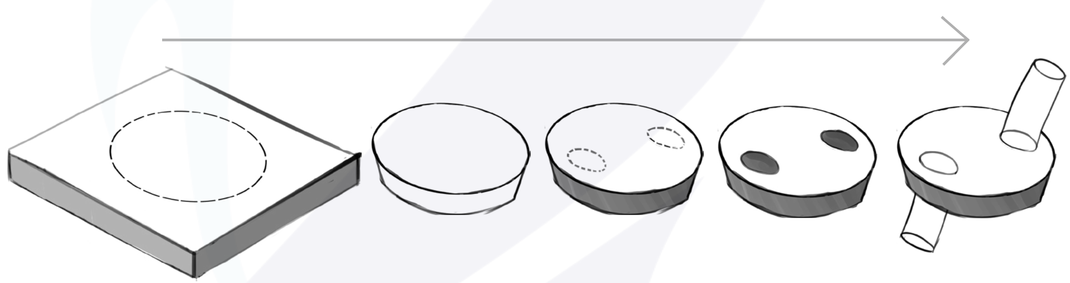
How to make the Fluid Separator Plug

Supplies & Tools:

- ½" thick high density foam (such as a children's puzzle floor mat)
- Pen or pencil
- Scissors
- Boring tool or pointy object like ball pen tip

Procedure

- Using the opening of the tennis ball tube, trace the opening with a pen on top of the foam.
- Cut out the circle using scissors or a cookie cutter, slightly beveling the cut downwards. (When you insert the plug into the tennis tubewv, you will insert it so that the beveled side goes down.)
- Trace two holes on top of the plug using the inner tube as a guide.
- Use a boring tool or a ballpoint pen tip to create two holes for the inner tubes. Make the holes slightly smaller than the tube diameter so that they fit snugly in the foam.



Safety Note:

Be sure to check the inside top rim of the tennis ball container for sharp edges or burs. If necessary, use pliers to round off edges.