Sea Water: Temperature, Density, and Salinity

Subject: Aquatic science, Chemistry, Geology, Meteorology, and Oceanography

Grade Level: 9^{th} - 11^{th}

Rational or Purpose: Students are to consider sea water movement in a column and why the movement of water is important for ocean species. This could lead to a discussion on global ocean currents, also known as thermohaline circulation. As part of the effects due to global warming, the circulation is becoming slower by melting glaciers. The input of freshwater dilutes the sea water and minimizes the salinity gradient. If the circulation continues to slow down, ocean species will not have enough food and oxygen for survival.

Materials:
Food coloring (2 colors)
Two 1000mL beakers per group
Table salt
Student worksheet

Lesson Duration: 60 minutes

TEKS Objectives:
112.45. Chemistry.
(C) (12A-C)

112.46. Aquatic Science.
(C) (4A)

112.49. Geology, Meteorology, and Oceanography.
(C) (11A)

Background Information:
Global ocean circulation is important for the transportation of oxygen, food, and nutrients. It is driven by two major factors: temperature and salinity. Ice sheets and glaciers in North and South Poles are melting at a rate that worries some scientists. As the ice melts, the surface water becomes more diluted and less saline. Since the surface water is less saline, it is also less dense, thus, the sinking of the surface water is going to be reduced. If the problem persists, global ocean circulation could potentially stop. If this were to happen, many organisms could become endangered due to insufficient supply of oxygen and food.

Activity
This lesson aims to build a clear concept of density by comparing freshwater and salt water. Students will understand how temperature and salinity affect sea water's density. Students will be able to draw conclusions on the effect and significance of differences in density on, transportation of oxygen, food, and nutrients, and thermohaline circulation.

Procedure

1. Each group is given two beakers: one with water and one with salt water. They are labeled as Beaker 1 and Beaker 2. Clearly tell the students about the mission of this activity, which is to identify which beaker is water and which is sea water.

2. Students will have about 5 minutes to discuss some experiments they could do to observe differences between the two beakers.

3. After group discussion, ask the students to answer the first question on the student worksheet, "What do you think are some differences between the two beakers?" List all students' answer on the board.

4. The teacher will go through the specific features that are different between these two solutions. If students' explanation is not specific enough, ask students how they would test to determine any differences.

5. The teacher will focus on the density difference between fresh water and salt water. Many students may have misconceptions about the density difference. They may think that salt water is less dense than fresh water. Some students are not sure which solution is denser. The teacher should acknowledge any misconceptions at this stage and use appropriate strategy to resolve them.

6. A suggestion to enforce the concept of density difference is to explicitly show the equation for density: **Density = Mass / Volume**. *(The following part can be done by using an experimental setup or by drawing the apparatus on blackboard.)* The students will be given two balances, two beakers of water, and a box of table salt. Tell the students that the two beakers of water are completely identical, in terms of weight, density, and volume. To create salt water, salt must be added to one of the beakers. Ask students if the salt water or fresh water has a greater mass. Greater mass contributes to the increase in density; therefore, salt water has a greater density.

7. The teacher will discuss the vertical circulation of sea water. Before this, there needs to be a discussion about how temperature affects salinity. Most students should know that warm/hot water dissolves solutes much faster than cold water. That means warm water has a greater ability to take up salt. In other words, warm water should be more saline. In the real world, the Sun heats up the surface of the ocean, water evaporates and salts are left behind, causing the surface to be more saline and become denser. As the surface sea water sinks, the bottom part of the sea

water will rise.

8. Tell the students that water circulation is very important to ocean organisms. Ask students to guess the effects of the circulation. The circulation is very important to the transportation of oxygen, food, and nutrients between the surface and the bottom of the sea.

9. Salinity gradient, or the difference in salinity, is the major driving force of the sea water circulation. If the circulation stops, many ocean organisms will suffer and die due to insufficient oxygen and food. This great impact will harm humans' food source at the same time. Currently, there are factors that slow down the circulation. More rainfall and increased run-off pump freshwater into the oceans. The salinity of the sea surface will decrease. As the salinity gradient minimizes, the circulation slows down. Ask students what causes the increase of rainfall and run-off.

10. When atmospheric and sea temperature are rising gradually, the rate that the water cycle turns over increases. More rainfall could happen in certain areas while drought plagues other areas. Extreme weather will become more likely. Alternatively, urbanization also has a huge impact on the natural cycle of water. When we cut down trees or clear land of vegetation, there are less plants to absorb water after rainfall. That results in more water flowing into the rivers and entering into the oceans.

11. If time allows, the teacher can introduce the thermohaline circulation, also known as the "Conveyor Belt". The belt circulates around the Earth. There are several locations where top, warm, saline sea water converts to deep, cold, less saline sea water. All the locations are at or near either North Pole or South Pole. What scientists worry about is that the melting of ice sheets and glaciers is slowing the circulation of these conveyor belts. The freshwater input from melting ice is decreasing the salinity gradient at the Poles. When it slows at a considerable rate, it will negatively affect the biosphere. However, there isn't any short-term action we can do to relieve this problem.

12. It is an important message to convey to students that oceans react slowly to human's impact on the environment. Once the oceans start to react, we will need tremendous steady effort to relieve any problems that arise. When scientists give statistics that average ocean temperature increased for less than 1 degree Celsius, it means a huge amount of energy has been absorbed by the ocean. Moreover, ocean species are very sensitive to ocean's temperature, pressure, and salinity. A minimal change in human's perspective would have a large impact on them.

Name: _____ Date: _____

SALINITY INVESTIGATION

For each group, there are two beakers. One contains water and one contains salt solution (salt with water). Your mission is to find out which beaker contains water and which contains salt solution.

Note: You are not allowed to taste or boil the solution to find out which is which.

If the liquid in the two beakers are not the same, some other properties will not be the same too. What properties, do you think, are different from each other?

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A refractometer is an instrument to detect salinity when scientists are out at the ocean. However, we do not have this instrument with us at this section. The only material that we have to help us find out the answer is food coloring (blue and red).

Think of a method and provide reasonable explanations for your method. Briefly write down the steps and expected observations in the following space.

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Actual Observations:

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(Continue on the back if you need more space.)