Salinity & Density - Teacher Notes

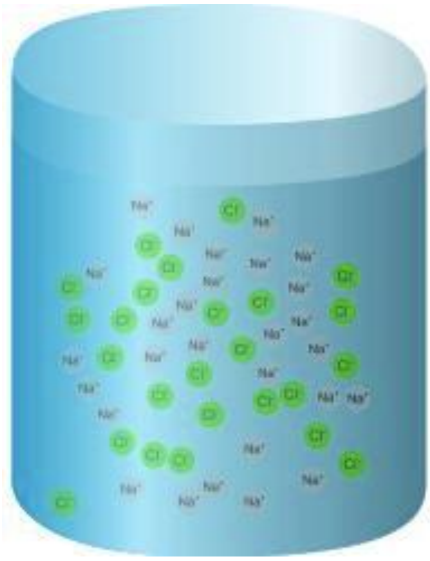
Factors that drive deep ocean currents - Thermohaline Circulation

The great global conveyor belt runs deep under our oceans. It is powered by density differences that result from changes in temperature and salinity. When seawater freezes at the poles freshwater ice is formed and the remaining seawater becomes denser and sinks adding to the downward pull. This current initiated at the poles moves millions of cubic metres of water moving heat around our planet. It is estimated to take hundreds to thousands of years to complete its circuit.

Aim **To demonstrate how freezing water can change its chemistry and density.**

Activity 1 - Freezing out salt

Teachers may prepare the chilled hypersaline water in advance and present separated samples for students to test in the classroom.



Which is the solvent? Water, H_2O

Which is the solute? Sodium Chloride, NaCl

Write an ionic equation for the dissolution of salt in water

$$NaCl\ (s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$$

Materials

- A large container of salty water (Super saturate sodium chloride in cold water)
- A freezer
- Two test tubes
- A dropper of silver nitrate solution

Method

1. Leave the salt water overnight to freeze. Fresh water will form an ice crust leaving more the denser more concentrated salt solution below.
2. Melt a little ice from the crust into one test tube
3. Collect an equal volume of saline solution in the other test tube
4. Put three drops of silver nitrate into each test tube
5. Observe and note your observations

Alternatively a student may be asked to taste melted solid ice after separation with the liquid below and compare it with the liquid portion. (Humans can still taste salt in seawater diluted a hundred times). This observation is subjective and therefore not good enough to be considered clear scientific data.

Observation/results

What did you observe? A white precipitate formed at the base of the saline solution but not in the melted ice. The ice tasted fresh whilst the liquid tasted salt.

Conclusion

What do these results lead you to conclude? An insoluble silver salt was formed in the saline solution. The test does not PROVE that the precipitate is silver chloride but supports that hypothesis that it should be an insoluble silver salt

Did the ice contain salt? No

Discussion

Write an equation for the reaction which occurred. The equation written will depend on ability or prior knowledge of students.

silver nitrate + sodium chloride $\rightarrow$ silver chloride (precipitate) + sodium nitrate

$$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$$

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

What would the above activity suggest would happen to sea water approaching freezing temperatures at the poles? Fresh water would be frozen out to create sea ice leaving the remaining liquid to be more saline.

How could this activity be improved? Repeat and control variables.

Activity 2 The effect of increased salinity on density

<u>Aim</u> To see if saline water is denser than fresh water

Materials To make a supersaturated or hyper-saline solution.

- A small beaker
- Hot water
- Salt (sodium chloride)
- A stirring rod or spoon

Method

1. Carefully pour hot water into the beaker until it is one third full
2. Add the salt
3. Stir vigorously until no more salt can be added
4. Add a little food colouring or dye
5. Leave to cool to room temperature

Materials To test differences in density between salt and fresh water

- A large test tube
- A test tube rack or beaker to hold it upright
- Hyper-saline water
- Fresh water
- A Pasteur or transfer pipette
- Kitchen towel if necessary

An initiative supported by Woodside and ESWA

Salinity & Density - Teacher Notes

Method

1. Pour the coloured hyper-saline water into the test tube until it is half full.
2. Wipe away any splashes of coloured solution.
3. Place upright in rack or beaker (DO NOT MOVE THE TUBE AGAIN UNTIL THE END OF THE EXPERIMENT!).
4. Fill the pipette with fresh water and very gently flow it down the side of the test tube to form a layer about 1cm thick.
5. Leave and observe.

Observation The fresh water floated on/was more dense than the saline layer

Conclusion What happens to seawater when it comes in contact with cold sea ice and chill polar winds? Freshwater freezes out to become ice and the remaining water becomes more saline.

Using the results of our GCB experiments, explain how cold and salinity could drive the Global Conveyor belt. Cold causes water to increase in density and freezing causes salt water to become denser as well. Denser liquid sinks to the bottom of the ocean where it can no longer be mixed by winds and waves and pulls more liquid down after it. The Global Conveyor belt is initiated at the cold ice rich poles. Cold water flows down towards the Antarctic. As it warms it returns to the surface and flows back towards the poles.

Extra for experts. The Global Conveyor Belt is an example of thermohaline convection. What does "thermohaline" mean? Thermo+ heat, haline=salt. The belt is driven by density differences that are the result of differing amounts of heat and salt concentrations

Fascinating Fact

The interface between the underlying dense haline solution and freshwater above refracts light beams. Light is refracted towards the normal in the denser medium. Hunters cut small holes through the ice and stand at the side motionless, waiting for prey. Creatures below cannot see through the interface as light is totally internally refracted. The Inuit can see the seal but the seal cannot see the hunter. It is only when the prey lies directly below the hunter is the hunter visible. If the hunter moves the prey can sense a shadow. Hunters unconsciously adjust their aim to account for light refraction.