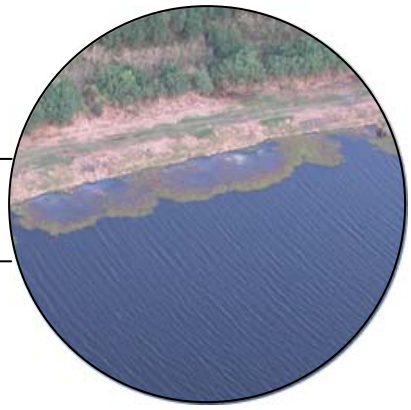
How Dense is SALT WATER?

TEACHER



Activity Overview

Fresh water from the Mississippi River pours into the salty ocean water in the Gulf of Mexico. More than 152,400 cubic meters (m^3) of fresh water are poured every second. This is about equal to the volume of water in 152 Olympic size swimming pools. The interaction of salt water and fresh water affects Louisiana's coastal wetlands as well as aquatic life in the Gulf of Mexico. Due to differences in densities fresh water and salt water do not easily mix but instead form layers. As a result of human activities such as the construction of navigational canals, these layers of salt water have been moving inland from the ocean toward freshwater environments in a process called saltwater intrusion. Saltwater intrusion increases the level of salt in the waters upstream and affects the health of animals and plants not adapted to salt water. These effects have given scientists cause for concern.

In this activity, students will perform an experiment to explore the relationship between mass, density, and salinity. Students will measure the salinity of four saltwater solutions of increasing strength using a conductivity sensor connected to a TI CBL 2™ or Vernier LabPro and a TI-73 Explorer™. Students will find the density of each solution by measuring its mass and volume. Density is mass divided by volume.

Conclusions: Salt water is more dense than fresh water. As salinity increases the density of the saltwater solution increases. Holding volume constant as mass increases, the density of the saltwater solution increases.

Activity at a Glance

Grade:	6–9
Subject:	Science
Category:	Physical Science, Earth Science
Topic:	Density, Salinity

Time Required

- Two 45-minute periods

Level of Complexity

- High

Materials*

- TI-73 Explorer™
- TI CBL 2™ or Vernier LabPro
- TI-73 DataMate
- Conductivity sensor
- Balance
- Graduated cylinder
- Saltwater solutions (prepared by teacher)
- Distilled water
- Cups
- Medicine dropper

TI-73 Explorer™

Conductivity Sensor

* This activity has been written for the TI-73 Explorer™ but you can easily substitute the TI-83 or TI-83 Plus. Also see Appendix A for steps on how to transfer DataMate to your graphing device and how to use DataMate for data collection.

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Concept Background

- Conductivity can be used to determine the salinity of a solution. The conductivity sensor measures the ability of a solution to conduct electric current. Adding salt to distilled water provides ions that conduct the electric current. The more salt in the solution, the higher the conductivity. In this activity, the conductivity sensor will be used to measure salinity in units of mg/L.
- Fresh water is less dense than salt water. Layers of water occur in lakes and oceans based on density. When the fresh water from the Mississippi River reaches the ocean in the Gulf of Mexico, the fresh water is layered on top of the dense salt water in the shape of a wedge.
- Saltwater intrusions occur when the dense saltwater portion of the layered wedge moves inland. The saltwater alters the salinity of freshwater environments. Saltwater intrusions occur as a result of both natural and human causes. The building of navigational canals in coastal Louisiana has led to an increase in saltwater intrusion. Surges from hurricanes also can cause saltwater intrusions.

Preparation and Classroom Management Tips

- It is important to use distilled water in this investigation. Distilled water is available in grocery stores. Make sure to read the product labels and look for the word “distilled.”
- Non-iodized table salt will work well for this activity.
- You will need to prepare four stock solutions. The actual quantity of stock solution to prepare will depend on the number of students in the class. It is recommended that you prepare an ample supply of solutions in case students need to repeat steps. Prepare the solutions as follows:
    - Solution 1: 0 grams of salt for every 1 liter of distilled water.
    - Solution 2: 15 grams of salt for every 1 liter of distilled water.
    - Solution 3: 30 grams of salt for every 1 liter of distilled water.
    - Solution 4: 45 grams of salt for every 1 liter of distilled water.
- If time permits, you can have students make their own stock solutions.
- The sensitivity of the conductivity sensor is limited. The upper range is 10,000 mg/L. Saltwater has a conductivity of about 35,000 mg/L. It is not possible to measure the conductivity of water with a high salinity using this sensor. Students will dilute their solutions by 1/10 using distilled water. This will lower the salinity of the solution to a level that can be measured using the conductivity sensor. Then by multiplying the diluted salinity measurements by 10, students can obtain the actual salinity of the original solutions.
- The conductivity sensor has three sensitivity settings. Make sure students switch the sensors to the 0–20,000 μs setting.
- The conductivity sensor measures in units of mg/L. A common unit for salinity is ppt (parts per thousand). You may have students convert the data into units of ppt.

National Education Standards

Science Standard A: Science As Inquiry

Students should understand scientific inquiry and develop abilities necessary to perform it.

Science Standard B: Physical Science

Students should develop an understanding of properties and changes in matter, motions and forces, and transfer of energy.

Science Standard C: Life Science

Students should develop an understanding of the structure and function of living systems, regulation and behavior, and populations and ecosystems.

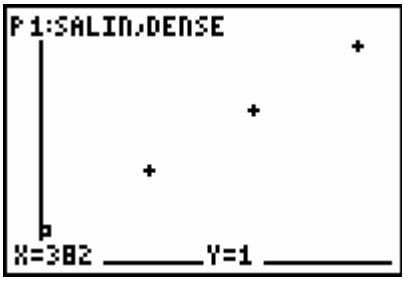
Math Standard: Data Analysis & Probability

Students should develop an understanding about how to collect, organize, display, and interpret data.

- It is important that students measure volume as accurately as possible. Students need to measure exactly 200 mL of solution. Demonstrate proper laboratory techniques including how to read a meniscus in a graduated cylinder. Have students add solution using a medicine dropper to obtain the proper quantity of solution.
- Students must measure mass with as high precision as possible. Use of an electronic balance that can measure to the nearest 1/10 of a gram is recommended.
- Measurements made by students will be different than the values shown on the screen shots in the procedures. The screen shots are included as a guide and it should be expected that students will obtain different values.
- Refer to the Teacher's Guide for Fieldwork in Your Neighborhood: Testing for Density and Salinity in Unit 1 for additional background information.
- Students will make a scatter plot of density and salinity. The scatter plot will reveal the relationship between the two variables. Adding a best-fit line is a widely used modeling method that draws a linear plot as close to as many data points as possible. Based on the best-fit line, predictions can be made when only one variable is known.
- This activity works well with students working in groups or as a demonstration.
- Encourage students to answer the questions in Data Analysis in their journals.
- Create your own student questions for use on your students' TI graphing devices using the Texas Instruments StudyCard applications.

Part C — Measure Density

Data Analysis



Sample Graph

Salinity (mg/l)	Density (g/ml)
38	1.00
15,009	1.01
29,853	1.02
44,874	1.03

Sample data

1 Q. Draw a sketch of the graph created by your graphing device in your journal. Title the graph *Density and Salinity*. Label the X-axis *Salinity (mg/L)* and the Y-axis *Density (g/mL).*

A. Answers may vary. The students should sketch a graph similar to the sample graph above.

Vocabulary

Abiotic Nonliving**.**

Biotic Living or pertaining to life.

Channel A path through a body of water that is deeper than the surrounding water**.**

Consumer An organism that must eat other organisms for energy.

Decomposer An organism that breaks down dead matter.

Density The mass of a substance divided by its volume.

Detrital Cycle The process through which decaying plant or animal matter is broken down and the nutrients it contains are returned to the surrounding system.

Eat Out The removal of marsh vegetation by plant-eating animals that leaves a hole in the marsh.

Ecosystem A community of living things in their environment.

Estuary An area where freshwater and saltwater mix; a coastal region that forms where the river meets the sea.

Food Chain The order of organisms through which energy passes from producers to consumers in an ecosystem.

Hydric Having excessive moisture; a condition of soil that is continuously wet and therefore oxygen-poor.

Marsh A wetland that contains grasses and low-lying plants.

Organism A living thing.

Producer An organism that makes its own food.

Salinity A measurement of the amount of salt dissolved in water.

Saltwater Intrusion The process by which saltwater moves inland toward freshwater environments.

Swamp A wetland that has trees.

2 Q. What is the density of distilled water?

A. Distilled water has a density of 1 g/mL at standard temperature and pressure.

3 Q. Which solution had the greatest salinity?

A. Solution 4 had the greatest salinity.

4 Q. What was the density of the solution with the greatest salinity?

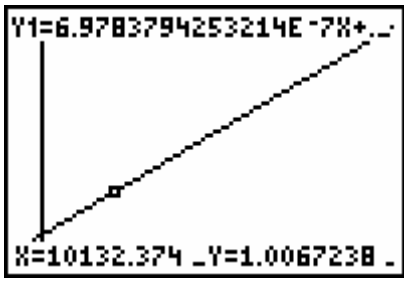
A. Answers may vary. The value should be about 1.03 g/mL.

5 Q. What happens to the density of a solution when its salinity increases?

A. The density of a solution will increase as salinity increases.

Part D — Best-Fit Line of Salinity and Density

Data Analysis



Sample Graph

1 Q. You can use the best-fit line to determine the density if you know the salinity of a solution. To do this, mark the given salinity on your graph, draw a vertical line to the point where this line meets the best-fit line, and read the density value on the Y-axis. Based on your graph and the best-fit line, what is the density if the salinity is 10,000 mg/L?

A. Answers may vary. The density should be about 1.006 g/mL.

2 Q. Describe how you would use your graph to find the salinity of a solution if you knew its density.

A. Draw a horizontal line from the Y-axis (known density) to the best-fit line. The X-coordinate at that point is the salinity of the solution.

3 Q. Based on your best-fit line graph, estimate the salinity of a solution with a salinity of 1.015 g/mL.

A. Answers may vary. The value should be about 20,000 mg/L.

4 Q. Measurements taken from a freshwater stream found a density of 1.005 g/mL. Based on this information and your graph, did this stream have salinity? If yes, what was the salinity of the stream?

A. *The stream did have salinity based on the graph. The salinity of the stream was about 8000 mg/L.*

5 Q. The salinity of an ocean water sample was 35,000 mg/L. Based on your graph, what would the density of the sample be? *Hint: You may have to extend your best-fit line.*

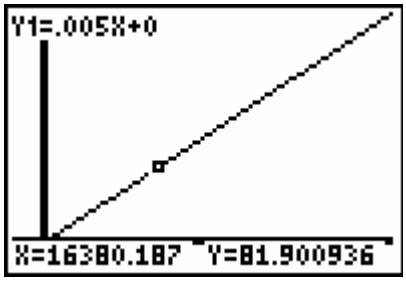
A. Answers may vary. The value should be about 1.025 g/mL.

6 Q. Compare the density of the saltwater sample from Question 5 with the freshwater sample from Question 4.

A. The saltwater sample has a greater density than the freshwater sample.

Part E — Best-Fit Line of Mass and Density

Data Analysis



Sample Graph

1 Q. In this experiment, the volume of solution was always 200 mL. Based on your graph, how did density change as mass increased when the volume was constant?

A. As mass increased density increased when the volume was constant.

2 Q. If fresh water and salt water have the same volume, which liquid would be heavier (greater mass)? *Hint: mass = density x volume*?

A. Salt water would be heavier because it has greater density than fresh water. The greater the density, the greater the mass.

3 Q. When fresh water pours into salt water in coastal Louisiana they form layers. Based on your answer from Question 2, would salt water be the bottom or the top layer? Explain.

A. Salt water would form the bottom layer because it is heavier than fresh water for a given volume.

4 Q. Saltwater intrusions occur when salt water enters freshwater areas. Based on this information and the research article, which would be impacted first by saltwater intrusion, organisms that dwell on the bottom or on the surface? Explain.

A. Bottom dwelling organisms would be impacted first by saltwater intrusion. This is because dense, high-salinity water is found on the bottom of the layer formed between salt water and fresh water. As the intrusion moves into freshwater environments, organisms on the bottom will experience changes in salinity first. Plant and animal species not adapted to survive in saltier water must either shift to areas with lower salinity levels or die.