Water Quality Sampling Lesson Five:
"Water Conductivity and Total Dissolved Solids"

Academic Question:

What does the conductivity test in water indicate?
Why does conductivity measure water quality?

Objectives:

- To define conductivity and its significance in an aquatic ecosystem.
- To test for conductivity.
- To understand how nonpoint source pollution and point source pollution directly affect an aquatic ecosystem.

Key Terms:
Conductivity, electrical current, fresh water, salinity, salts, total dissolved solids

Handouts:
Directions: Calibrating the Conductivity Meter
Conductivity Test Procedures and Worksheet with Answers

Overview: Water Conductivity and Total Dissolved Solids
There are a wide variety of inorganic substances or dissolved solids in water solutions. Common dissolved substances are sodium, chloride, sulfates, calcium, bicarbonate, nitrates, phosphates, iron, and magnesium. All of these materials at certain concentrations are essential for aquatic life and all have the ability to carry an electrical current. These substances affect the flow of materials in and out of the cells of organisms living in the water and they may also be used as energy sources in certain organisms. The dissolved substances in addition serve as parts of the molecules needed for building new cells.

In general, water with high concentrations of dissolved solids is "salty" while water with low concentrations of dissolved solids is considered "fresh." Salinity is the total of all salts dissolved in water, usually expressed in parts per thousand (ppt). Most organisms are adapted to a particular level of dissolved solids. The salt content of water affects the distribution of animals and plant species according to the amount of salinity they can tolerate. For this reason it is unexpected to find a largemouth bass in the Gulf of Mexico (35 ppt), or to see a red snapper in the Brazos River. Pollution may cause the levels of dissolved solids to fluctuate, so some organisms may be harmed during these times because their bodies are unable to adjust. Some examples of activities that can pollute the water are: wastewater discharges that are high in salts, brine waters from oil production activities, irrigation, or clearing the land near a stream, overuse of fertilizers, or the spreading of road salt during icy conditions. Salt pollution can be a direct problem for humans when drinking water supplies have levels of salt over 0.5 ppt. Streams with high salinity may be unsuitable for agricultural or industrial use.

Total dissolved solids (TDS) is defined as the quantity of dissolved material in water, and depends mainly on the solubility of rocks and soils the water contacts. For instance, water that flows through limestone and gypsum dissolves calcium, carbonate, and sulfate, resulting in high levels of total dissolved solids.

A convenient way to measure TDS is to test the conductivity of the sample. Conductivity is a measure of the ability of water to pass an electrical current and is affected by the presence of dissolved solids. As the level of TDS rises, the conductivity will also increase. Discharges to water can change the conductivity depending on the discharge. A failing sewage system could raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity because oil does not conduct electrical current very well.

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Conductivity is measured in micromhos per centimeter (mhos/cm) or microsiemens per centimeter (s/cm), equivalent units of measure that can be used interchangeably. Distilled water has conductivity in the range of 0.5 to 3 mhos/cm. The conductivity of rivers in the United States generally ranges from 50 to 1500 mhos/cm. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 mhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates.

Process:

Activity 1: Conductivity Testing Procedure

1. Gather the following materials:
   - Conductivity pen
   - Small screw driver for calibrating
   - Calibration standard (potassium chloride mixed with deionized water)
   - Beaker or bucket for the water sample
2. Have enough equipment and workstations for students to break into small groups to conduct their activity.
3. At the beginning of class, review nonpoint and point source pollution.
4. Briefly on the board, list examples of nonpoint source and point source pollution. Have students refer back this list when filling out their student worksheets.
5. Pollution that is related to the total dissolved solids (inorganic pollution) should be especially emphasized for this lesson.
6. Teach the students the testing procedure, including the calibration procedure.
7. Have students work through the procedure during group time.
8. Distribute Conductivity Worksheet (5.1) to each student.
9. Have students answer the questions.

Activity 2: Pollution and Impacts on Conductivity

This activity is a set up as a challenge for small groups to create a unique set of conductivity jars for a second group to rank in order.

1. Gather the following materials- one set of each small group
   a. Pollutants such as; motor oil, dish soap, vinegar, sediment, salt, fertilizer, and other such materials (crushed chalk, tums, etc.)
   b. Jars
   c. Droppers
   d. Creek water
   e. Conductivity testing equipment
2. Have groups label jars (A, B, C, D, E, F, etc.)
3. The group should first set aside jar A as the control jar. Fill jar A with pond water. Groups will then make different solutions with materials in each of the jars. It is extremely important that they keeping a log of exactly what material was added to each jar and how much of that material was added. In two of the jars, add more than 1 type material to the creek water.
4. Once the groups have completed their solutions, they should privately determine and record the conductivity of each jar. If they are not pleased with the outcome, they are allowed to make one modification.
5. Have groups rotate tables, so they are working with unknown solutions. They should begin by first making a hypothesis of the order of the conductivity jars from high to low conductivity. Next, the group should test each jar's water conductivity, and compare it to the creek water's conductivity with no additions (the control). Groups should compare their hypothesis to their results and determine how accurate their hypothesis was. The group should check their answers with those recorded on the log of the first group.

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6. Once the groups have completed their testing, have the class rank all the jars in order of increasing conductivity. Discuss what material additions lower conductivity?
7. Look in logs and determine which pollutants or materials impacted conductivity.

Assessment/Evaluation:

1. The Conductivity Worksheet (5.1) may be used in assessing the student's knowledge and understanding of conductivity and the importance of this parameter in evaluating water quality.
2. The student's logs, for Activity 2, may be used in assessing the student's knowledge of the impact of pollutants on conductivity.

Resources:

http://www.tnrcc.state.tx/sbea/tes/lessons99/stormdrain.html
Storm Drain Dumping Lesson Plan
Students will develop an awareness of what happens to water contaminated through neighborhood runoffs.

http://www.epa.gov/owow/nps/qa.html
U.S. Environmental Protection Agency (EPA)
What is Nonpoint Source (NPS) Pollution? Questions and Answers

http://www.epa.gov/owow/nps/facts/point1.html
U.S. Environmental Protection Agency (EPA)
Nonpoint Source Pollution: The Nation's Largest Water Quality Problem

Time Frame: Two 45-50 minute class periods

Grade Level: 8th – 12th Grade

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Directions: Calibrating the Conductivity Meter

Step 1 Remove the cap from the conductivity meter.

Step 2 Rinse the beaker and meter twice with a small volume of conductivity standards.

Step 3 Drip the pen in the solution up to the immersion level (the dark line around the lower part of the meter). Never dip the meter further than that line.

Step 4 Gently stir and wait a few seconds.

- In order to be sure there are no air bubbles trapped on the bottom of the probe, hold the beaker and meter over your head.
- If there are bubbles, tap the probe on the side of the beaker while the bottom of the probe is still under water.

Step 5 Turn the power on.

Step 6 Wait approximately 2 minutes to allow the meter to compensate for the temperature.

- Notice that the reading will be inaccurate if the meter is resting on the bottom of the beaker.
- Be sure to hold the meter away from the beakers' bottom.

Step 7 After two minutes, read and record the meter reading

Step 8 If the conductivity meter is not the same value as the standard solution, adjust the meter using the screwdriver provided in the kit.

- The calibration screw s located on the back of the meter, and while adjusting the meter, remember that there should be no bubbles in the meter, nor should the meter be touching the bottom or sides of the container.
- The meter should be adjusted to read the same value as the value of the standard solution (1440 microSiemens).
- Turn off the meter.

Step 9 Shake the excess standard solution from the meter and replace the cap.

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Conductivity Test Procedures

Step 1 Rinse the sample beaker and the meter twice with the water to be sampled. (Make sure you have removed the cap from the meter before rinsing.)

Step 2 Collect the sample.

- Swirl the meter in the sample five times.
- Check the bottom of the meter to be sure there are no aid bubbles trapped.
- If there are air bubbles, tap the bottom of the meter against the side of the beaker until the bubbles float up.

Step 3 Turn on the meter now and wait 1 ½ minutes and read and record the display on the meter.

- Be sure the meter is at least one centimeter above the bottom of the beaker during the 1-½ minutes.
- Also be sure that the sample and the meter are out of direct sunlight or wind.

Step 4 Record the reading.

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- If there are bubbles, tap the probe on the side of the beaker while the bottom of the probe is still under water.

Step 5 Turn the power on.

Step 6 Wait approximately 2 minutes to allow the meter to compensate for the temperature.

- Notice that the reading will be inaccurate if the meter is resting on the bottom of the beaker.
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Conductivity Worksheet

1. What is the approximate range of conductivity in U.S. rivers? _______________
2. What range of conductivity is necessary to support healthy inland fisheries?
   ____
3. Describe a situation that would result in decreased conductivity –
   ____
   ____
   ____
4. What is the salinity for saltwater? ____________________________
5. List three sources of salt pollution and give two examples of the consequences.
   ____
   ____
   ____
6. Conductivity measures ___________________________________.
7. As the level of total dissolved solids rise, does the conductivity reading increase or decrease? ______________________________.
8. Explain in your own words the significance for testing conductivity.
   ____
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Conductivity Worksheet--Answers

1. What is the approximate range of conductivity in U.S. rivers **50-1500 cs/cm**

2. What range of conductivity is necessary to support healthy inland fisheries? **150-500 µs/cm**

3. Describe a situation that would result in decreased conductivity – **an oil spill will lower conductivity because oil is not a good conductor of electricity.**

4. What is the salinity range for saltwater? **0-35 ppt**

5. List three sources of salt pollution and give two examples of the consequences.
   Wastewater discharges high in salts
   Brine water from oil production
   Irrigation
   Clearing of the land near a stream
   Overuse of fertilizers
   Spreading of road salt during icy conditions

6. Conductivity measures **Total Dissolved Solids (TDS) or the quantity of dissolved material in water.**

7. As the level of total dissolved solids rise, does the conductivity reading increase or decrease? **Increases**

8. Explain in your own words the significance for testing conductivity. **Most organisms are adapted to a particular level of dissolved solids. Pollution may cause the levels of dissolved solids to fluctuate, so some organism may be harmed during these times because their bodies are unable to adjust. Salt pollution can be a direct problem for humans when large concentrations of salt enter their drinking water supplies. Also, some streams and rivers may be unsuitable for agricultural or industrial use.**

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