The Effect of Turbulence on Dissolved Oxygen in Water

Lesson Focus: This lesson focuses on the importance of dissolved oxygen to a healthy aquatic ecosystem and how dissolved oxygen in water can be increased. This lesson also illustrates how controlled experiments are prepared and conducted.

Learning objectives: Upon completion of this lesson, students will be able to identify:

1. The importance of dissolved oxygen to aquatic life.
2. Minimal level of dissolved oxygen that is necessary to sustain a healthy aquatic ecosystem.
3. Ideal levels of dissolved oxygen to support populations of some common aquatic animal populations.
4. Controlled, manipulated, and responding variables in a controlled experiment.

Enduring Understandings for the lesson:

- Students will understand the importance of dissolved oxygen to a healthy aquatic ecosystem.
- Students will also understand the importance of conducting controlled experiments, and students will be able to identify the different variables that are included in a controlled experiment.

Georgia Performance Standards Addressed:

S6CS1. Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
S6CS2. Students will use standard safety practices for all classroom laboratory and field investigations.
S6CS8. Students will investigate the characteristics of scientific knowledge and how it is achieved.
S6CS9. Students will investigate the features of the process of scientific inquiry.
S6CS10. Students will enhance reading in the field of science.
S6E3. Students will recognize the significant role of water in earth processes.
S6E5. Students will investigate the scientific view of how the earth's surface is formed.
S6E. Students will describe methods for conserving natural resources such as water, soil, and air.

Grade Level: 6th Grade

Materials:

- LaMotte Dissolved Oxygen testing kits (available at www.LaMotte.com)
- Copies of the dissolved oxygen test instructions

- Four-10 gallon aquariums, aquarium filter pump, fan, thermometer, and an aquarium aerator.
- Copies of the Dissolved Oxygen/Controlled Experiments worksheet
- Copies of informational handouts for each student.
- LCD projector available to use with a classroom computer that has internet access.

Time needed: Two full 40 minute class periods are needed to adequately cover the objectives of this lesson. More could be required based on the extensions or details that the teacher chooses to include

Background Information:

Dissolved Oxygen- Dissolved oxygen is oxygen gas that is dissolved in water. The amount of dissolved oxygen (DO) found in water can vary due to several factors such as water temperature, level of pollutants and whether the flow is slow or rapid just to name a few. Fish and other aquatic organisms need dissolved oxygen to survive. The amount of dissolved oxygen needed for survival of individuals and for sustaining healthy populations of aquatic organisms varies by species. Fish tend to need more dissolved oxygen than other species of animals. Aquatic plants and algae even require dissolved oxygen to survive. During the night or even on cloudy days, plants and algae perform respiration, which requires oxygen, when they are not producing oxygen as a product of photosynthesis. The level of dissolved oxygen in a stream, river, or body of water tends to change throughout each day and each season.

Dissolved oxygen is measured as milligrams of dissolved gaseous oxygen per liter of water (mg/L), or parts per million (ppm). Dissolved oxygen in water can range from 0 to 14 parts per million. Generally, the colder the water temperature the higher the dissolved oxygen, which creates a great habitat for animals. Streams and rivers require dissolved oxygen (DO) levels at a minimum of 5-6 parts per million (ppm) to support a healthy and diverse aquatic ecosystem. However fish and macroinvertebrates are known to survive at dissolved oxygen levels as low as 3.0 ppm in warm water temperatures due to their adaptations for survival under these conditions.

There are a variety of factors that can increase the level of dissolved oxygen in water. Dissolved oxygen naturally enters the water from the atmosphere and will continue to enter the water until it becomes saturated. When aquatic plants and algae are exposed to sunlight they produce oxygen as a waste product of photosynthesis. The structure of a stream or river affects dissolved oxygen. The more turbulence that a stream or river displays, such as waterfalls or rapids, the more oxygen is absorbed into the water. Also, turbulence on the surface of a body of water caused by wind tends to increase levels of dissolved oxygen. Artificial aeration such as with an aquarium bubble stone will increase DO levels, sometimes dramatically.

However, there are some processes that reduce dissolved oxygen levels in water. All living organisms must respire to survive. Animals such as fish, crustaceans, mollusks, and worms that live in water remove oxygen from the water for respiration. Plants and

algae also need oxygen to respire at night or on cloudy days. As the amount of dead organic material increases in water more oxygen is used by bacteria to decompose that material. These organic wastes can come from agricultural runoff, industrial wastes, or sewage treatment plants. Chemical pollution can also reduce DO levels due to chemical reactions with dissolved oxygen. Nitrates, ammonia, sulfates, and other ions reduce levels of dissolved oxygen when they enter bodies of water.

Two weather factors, temperature and barometric pressure, can also affect levels of dissolved oxygen. As temperature increases, water tends to hold less dissolved oxygen so dissolved oxygen levels in water tend to decrease when it is warmer. And when it is cooler dissolved oxygen levels tend to increase. Also, as barometric pressure increases, the solubility of oxygen increases so levels of dissolved oxygen tend to increase.

Some aquatic organisms are more sensitive to low levels of dissolved oxygen than others. Trout, striped bass, perch, and shad are fish that require 5 to 6 ppm of dissolved oxygen to survive. While trout are spawning, dissolved oxygen should not be below 7.0 ppm. If dissolved oxygen falls below 4.0 ppm some fish and invertebrate populations such as insects and crustaceans will begin to decline. When DO levels are between 3.0 and 4.0 ppm, fish will start coming to the surface and begin piping. Piping is when fish come to the surface and gulp, or gasp, for air. Some crustaceans such as crabs and crayfish can survive in waters with dissolved oxygen as low as 3.0 ppm. Organisms commonly associated with poor water quality such as leeches, sludge worms and other types of worms can live in water with low dissolved oxygen levels.

Controlled experiments- Being able to perform controlled experiments and identify the proper parts of a controlled experiment are a necessary skill for any scientist. In a controlled experiment, certain conditions and requirements must be met to determine a valid conclusion. If an experiment is not performed properly it will create inaccurate or false results and data.

In a controlled experiment, there are always factors (also called variables) that are involved. Only one variable should be changed at a time by the scientist during an experiment. The one factor that the scientist changes in an experiment is called the manipulated variable. All other variables that could affect the experiment should remain constant and are called controlled variables. Any variable that changes as a result of changing the manipulated variable is called the responding variable.

For example, if a scientist is trying to see if adding fertilizer to plants would help them grow more quickly he or she would need to identify the variables at work in this experiment. There are a few variables that should remain constant so that a valid controlled experiment could be conducted. First, there should be some plants that get fertilizer and some that do not. The plants that don't get fertilizer are our control subjects. We measure the effect of the manipulated variable on other subjects against these control subjects. To make sure that only the amount of fertilizer is a factor affecting plant growth, the scientist should make sure that all of the plants are the same

type of plant (roses, tomatoes, etc.), be the same height and age and of similar health, and receive the same amount of water and sunlight each day. Other less obvious factors should also remain constant, such as ambient temperature and intensity or angle of sunlight. The factors that remain constant would be called controlled variables. The one factor the scientist changes should be the amount of fertilizer that the plants get; this would be considered the manipulated variable. The change in the plants' heights would be the variable that changes as a result of changing the amount of fertilizer that each plant gets. This would be called the responding variable.

Before actually designing and conducting the experiment, a scientist should state the problem that he or she is trying to solve. This could be written as a scientific question as well. In the example of the fertilizer, the scientist could ask, "How does adding fertilizer affect the growth of plants?" A hypothesis should also be written. A hypothesis is an "if…, then…" statement that is a possible explanation for a set of observations. Using the fertilizer example, a hypothesis could be, "If plants are given fertilizer, then they will grow faster."

Learning Procedure

1. Begin the lesson by asking students what they know about water quality. Ask if there is any way that they can measure water to judge its quality (maybe through how it looks, smells, tastes, (be careful with including taste – it is usually recommended people don't taste as it can be harmful) and feels)
2. Give each student a copy of the dissolved oxygen/controlled experiments worksheet and have them answer the first question about water quality.
3. Give each student a copy of the 2 handouts - "Information on Dissolved Oxygen" and "Information on Controlled Experiments". Have the students read these handouts and then answer questions 2-7 on their own.
4. Using your classroom computer and a LCD projector, visit www.edlonline.org/learncenter/oxygenmodule.asp. This site shows how fish behavior changes as dissolved oxygen levels change in the water. While visiting this site ask students how they expect fish to behave under different conditions. Have them write their ideas on the worksheet
5. Inform the students they are now going to conduct an experiment. Discuss how controlled experiments are performed, placing importance on identifying the 3 types of variables in an experiment: the manipulated variable, controlled variables and the responding variable.
6. Review safety rules as this test requires the use of some very dangerous chemicals.
7. Have students copy the following data log into their notebooks

Sample name	Turbulence type	Temperature	DO (ppm)
Control	none		
Filter w/o cartridge	"small waterfall"		
Fan	wind		
Aquarium aerator	aerator		

8. Divide students into groups of 3 or 4.
9. Have students begin the experiment by reviewing the procedure for dissolved oxygen testing. They will be conducting a Winkler Titration using a LaMotte Dissolved Oxygen testing kit
10. Demonstrate the first test to the class using water from a 10 gallon aquarium that has been sitting for 24 hours or more – this is your control.
11. Have students repeat the chemical test for the other 3 variables.
    - To simulate a small waterfall use a standard aquarium filter to create the falling water similar to a small waterfall. Remove the cartridge from the filter to prevent any error that the filter could create, this also allows the water to flow faster and more freely.
    - To simulate the affect of wind, place a fan near the surface of the water and let it blow on the water in the aquarium.
    - To simulate aeration, use an aquarium aerator instead of the fan for 24 hours or so.

11. Log your results in a data table. Ask the students which method added the most oxygen to the water. Were they surprised?

Evaluation

Inspect the student's worksheet for proper identification of factors that affect dissolved oxygen in water and for identification of the variables involved in this experiment. Evaluate students' participation in the experiment. Did each student do their fair share of the work? Were their data results within 10% of the instructor's?

Extensions

1. Have students think of other variables they could test that would impact the levels of DO on a water sample such as temperature or pH. Tests could even be created to determine the affect of ambient temperature or atmospheric pressure on the level of dissolved oxygen in a water sample.
2. Have students look for different bodies of water around their school or in their communities and make predictions as to what the levels of DO would be for each.
3. Have students predict what plant and animal life the various bodies of water could support and what adaptations they may have to help them survive.

Resources-

- Wheeling Jesuit University, Classroom of the Future, Water Quality module, www.cotf.edu 10/21/07

- Stevens Institute of Technology, Center for Innovation in Engineering and Science Education, Dissolved Oxygen background page, www.k12science.org 10/21/07
- Environmental Distance Learning, "Even fish need water" learning module, www.edlonline.org 10/21/07
- Environmental Protection Agency, Monitoring and Assessing Water Quality, Volunteer Stream Monitoring Methods Manual , Chapter 5 section 2 Dissolved Oxygen and Biochemical Oxygen Demand, www.epa.gov (10/21/07)
- Chesapeake Bay Program, Dissolved Oxygen Criteria Page, http://www.Chesapeakebay.net 10/21/07
- University of Wisconsin, Green Bay, Lower Fox River Watershed Monitoring Program , Data Monitoring, Dissolved Oxygen Page, www.uwgb.edu
- University of Florida, Institute of Food and Agricultural Sciences Extension, Fact Sheet FA27 "Dissolved Oxygen for Fish Production" by Ruth Francis-Floyd http://edis.ifas.ufl.edu/FA002 10/21/07
- Central New York Near-Real Time Surface Water Quality Network, Data Interpretation, Dissolved Oxygen Page, www.ourlake.org 10/21/07
- Kentucky Water Watch Volunteer Projects, Water Quality Monitoring Project, Chemical Testing, Dissolved Oxygen Page www.state.ky.us 10/21/07

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Worksheet: Dissolved Oxygen/Controlled Experiments

Name-_____ **Date**-_____ Period-_____

Pre-reading- Complete this section before reading the handouts on dissolved oxygen and controlled experiments.

1. How would you describe water in a river or any body of water that is good quality? How does it look, smell, taste (see cautionary note above) and feel? Is there anything in the water that can be measured to see how good it is?

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Post-reading- Complete this section after reading the handouts on dissolved oxygen and controlled experiments.

2. What is dissolved oxygen?

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3. Why is dissolved oxygen important to water quality?

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4. In what unit is dissolved oxygen measured? _____

5. How much dissolved oxygen is needed for water quality to be considered very well?

_____

6. What are 3 factors that increase levels of dissolved oxygen in water?

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7. What are 2 factors that lower levels of dissolved oxygen in water?

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8. What kinds of organisms can live in water with less than 5.0 ppm of dissolved oxygen?

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Web video- visit www.edlonline.org/learncenter/oxygenmodule.asp and read the instructions about moving the fish.

9. Before your teacher moves the fish, predict what will happen when the fish is moved to other tank with a different amount of dissolved oxygen._____

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10. Explain what really happened when the fish was moved to different amounts of dissolved oxygen._____

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Post-experiment- Answer these questions after the class performs the dissolved oxygen experiment on the second day.

9. Write a hypothesis about dissolved oxygen in our experiment.

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10. Name 2 controlled variables in our experiment.

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11. Name the manipulated variable used in our experiment.

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12. Name the responding variable in our experiment._____

13. Was your hypothesis correct? _____

Why or why not? ._____

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