When Things Heat Up - Stream Side Science

Summary

In this exercise, students will measure the temperature and dissolved oxygen of a stream (or use their findings from the activity What's in the Water?) and discuss what this information can tell us about possible pollution problems.

Time Frame

1 class periods of 70 minutes each

Materials

- Dissolved Oxygen kits *
- Field thermometers *
- Copies of the student worksheets (pdf)
- Copies of the sampling instructions (pdf)
- Waste bottles (e.g., empty pop bottles)
- Clipboards
- Bucket

* For information on equipment for loan or for purchase, contact USU Water Quality Extension at (435) 797-2580 or www.extension.usu.edu/waterquality

Background for Teachers

Purpose

To relate the physical and chemical properties of water to a water pollution issue.

Background

During this activity students will investigate two properties of water in a stream -- the temperature and the concentration of dissolved oxygen in the water. Students will explore how natural influences, human activities and pollution may cause these parameters to change. They will compare their results to Utah's water quality standards and investigate possible ways to restore a polluted stream to healthier conditions.

Temperature and oxygen were chosen for this activity because they are easy to measure, the causes of change are both varied and easy to understand, and also the two properties are related to each other. Fish and other animals living in water can be harmed by high temperatures and low oxygen concentrations. As water gets warmer the "saturation concentration" for oxygen gets lower -- in other words the warmer the water, the less oxygen it can hold. Therefore, when water temperatures increase, fish are often hit with a double whammy of low oxygen as well. For more information about dissolved oxygen or temperature, see the Utah Stream Team Manual or the Further Discussion questions.

This lesson plan is designed to follow the activity What's in the Water?, during which the students measure several abiotic factors in a stream, or the lesson can be conducted as a stand alone.

Intended Learning Outcomes

Use Science Process and Thinking Skills

- Observe objects, events and patterns and record both qualitative and quantitative information.
- Use comparisons to help understand observations and phenomena.
- Evaluate, sort, and sequence data according to given criteria.
- Select and use appropriate technological instruments to collect and analyze data.

Plan and conduct experiments in which students may:
- Identify a problem.
- Formulate research questions and hypotheses.
- Predict results of investigations based upon prior data.
- Identify variables and describe the relationships between them.
- Plan procedures to control independent variables.
- Collect data on the dependent variable(s).
- Select the appropriate format (e.g., graph, chart, diagram) and use it to summarize the data obtained.
- Analyze data, check it for accuracy and construct reasonable conclusions.
- Prepare written and oral reports of investigations.

Distinguish between factual statements and inferences.
Use mathematics as a precise method for showing relationships.
Form alternative hypotheses to explain a problem.

Manifest Scientific Attitudes and Interests
- Raise questions about objects, events and processes that can be answered through scientific investigation.

Demonstrate Understanding of Science Concepts, Principles and Systems
- Know and explain science information specified for the subject being studied.
- Apply principles and concepts of science to explain various phenomena.
- Solve problems by applying science principles and procedures.

Communicate Effectively Using Science Language and Reasoning
- Provide relevant data to support their inferences and conclusions.
- Use precise scientific language in oral and written communication.
- Use proper English in oral and written reports.
- Use reference sources to obtain information and cite the sources.
- Use mathematical language and reasoning to communicate information.

Demonstrate Understanding of the Nature of Science
- Science is a way of knowing that is used by many people, not just scientists.
- Understand that science investigations use a variety of methods and do not always use the same set of procedures; understand that there is not just one "scientific method."
- Science findings are based upon evidence.
- Understand that science conclusions are tentative and therefore never final.
- Understandings based upon these conclusions are subject to revision in light of new evidence.
- Understand that scientific conclusions are based on the assumption that natural laws operate today as they did in the past and that they will continue to do so in the future.

Understand that scientific inquiry is characterized by a common set of values that include logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results and honest and ethical reporting of findings. These values function as criteria in distinguishing between science and non-science.

Instructional Procedures

Classroom Activity:

Ask the students to list all the abiotic factors they can think of in an aquatic system (*e.g., solar radiation, physical structure of the stream or lake, surrounding landscape, weather, and the properties of water itself*).

Tell them they will be testing two of these factors that relate specifically to the water -- dissolved oxygen (DO) and temperature.

Define each of these factors, talk about why these factors are important in an aquatic ecosystem, what can naturally influence these factors, and also what humans can do to influence these factors.

Explain to the students that they will be going to a stream (or other waterbody) to measure DO and temperature. You may want to review the actual testing procedures before going into the field.

NOTE: If you have already done the activity What's in the Water? skip to field activity step five.

Field Activity:

NOTE: these measurements must be taken at the stream site, as storing them will give an inaccurate measurement.

Set up a station for each factor (DO and temperature). You may want to have multiple stations for each factor so your students can work in smaller groups. At each station, provide:

- Sampling instruction sheets (it may be a good idea to laminate these!) and clipboards.
- Waste bottles
- A thermometer or DO kit

Divide the students into groups. Provide each group with clipboards, pencils, and student worksheets. Explain to the students that each group will start at a different station, and rotate so each group will measure both factors.

Have the students follow the instructions for measuring each factor found on the sampling instruction sheets.

Have the students record their results onto the student worksheet.

Have the students compare their results to the state standards for water quality (found on the student worksheet) and determine if the water is in accordance with state standards.

If the results are in violation of the state standards, have the students hypothesize what may have caused this. Alternatively, give the students the following hypothetical situation and again have them hypothesize what may be causing the problem.

"You have returned to the same stream site to test the temperature and DO again. This time your data shows that the temperature is 20o C and your DO level is 4 ppm." What may have happened to change the results? (*Summer versus winter time temperatures, loss of canopy cover, low flows, thermal source, pooled or widened stream*).

For more information, see the Further Discussion questions at the end of this activity and at the end of the activity What's in the Water?

Further Discussion:

1. Are high temperatures or low dissolved oxygen necessarily a sign of a pollution problem in the stream?

   No. Temperatures change throughout the season and will also vary from year to year. During warm drought years, temperatures in most streams will be higher during the summer because of lower flows and warmer air temperatures. Therefore, the first thing to consider is whether you're just observing natural changes in a stream. Stream standards allow for occasional violations because of this natural variation.
2. Would you expect dissolved oxygen to be lower if the temperature is higher?

   Yes. The maximum amount of oxygen that can dissolve in water is called the "saturation concentration." Water can never dissolve a lot of oxygen, and under normal conditions, saturation concentrations will not exceed ~ 12 mg / l (ppm). The amount of oxygen that water will dissolve decreases as the water warms. Therefore, even saturated warm water may have very low concentrations of oxygen (see graph on resource (pdf) page).

3. How could human activities have increased the temperature in your later (or hypothetical) sample?
   Humans can affect the temperature of rivers by discharging heated water. Industrial or energy plants often produce heated water as a byproduct. Also, when we modify the stream banks (riparian area) and reduce the amount of canopy cover, we can have a direct impact on stream conditions without ever dumping in a pollutant.

   Example: Discharge water from energy plants and from some other industrial plants may be considerably warmer than the stream it discharges to. This type of "thermal pollution" is considered a point source (it travels from a source to a stream through a pipe or ditch). Your students should consider any such sources in their community.

   Many other human activities affect water quality through indirect means. Urban development, agricultural areas and logging areas may all result in removal of riparian vegetation along a stream. When the shade from these plants disappears, the stream is exposed to more sunlight and heats up. Therefore, your problem may just be some "brush clearing" activities upstream of your site.
4. How could human activities have decreased oxygen in your later sample?
   Oxygen can only get into water from the surface (mixing with the atmosphere) or from oxygen produced by plants in the water. Oxygen in water is consumed by animal and plant respiration, during various chemical reactions, and during the decay of organic material. Humans can have a profound effect on how much decaying material is in a stream. Grass clippings, runoff from feedlots, and debris from logged areas are just a few of the sources of material which will ultimately decay in the water and in doing so, use up oxygen. In a rapidly moving stream, the water usually mixes with the atmosphere enough to replace this oxygen. In a pooled up or very slow moving stream, especially if it's warm, oxygen can be used up very quickly.

   NOTE: Dumping nutrients into water (e.g., from yard fertilizers), can stimulate plant growth in a stream or lake. When these plants die, you may also see a drop in oxygen.
5. Why would the time of day make a difference when measuring oxygen concentration in a stream?
   We often forget that plants not only create oxygen, but also use it for their cell metabolism. During the night, plants do not photosynthesize but still use oxygen. In streams that have become congested with an overabundance of living plants, oxygen may be very high during the day, but can be extremely low just before dawn because of plant uptake.

Extensions

Give the students the data provided on the teacher resource page (pdf) and have them graph the saturation concentrations of oxygen in relation to temperature.

Have the students graph temperature and oxygen concentration vs. time.

Be sure to point out that factors such as elevation and salt content will affect the ability water has to hold oxygen. At higher elevation, water holds less oxygen and salty water holds less oxygen.

Bibliography

Lesson plan authors: Andree Walker and Nancy Mesner (Utah State University Water Quality Extension)

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Additional resources can be found on the USU Stream Side Science 9th Grade Curriculum web page.

Authors

Ellen Bailey

Andree Walker