Fertile Green: Nutrients and Water

Students observe the effects of nutrients on algae growth in water samples.

Level(s): 6-8

Subject(s): Life Science; Chemistry

Virginia SOLs: 6.5 f,g; 6.7 a,f,g; 6.9 a,c; LS4 a,b,c; LS7 a,b,c d; LS9a; LS11 a,b; LS12 a,b,d,e

Objectives: Students will be able to explain the effects of nutrients on aquatic algae growth and why nutrients are a form of water pollution.

Materials:
- 6 clear plastic containers per student group
- measuring spoons
- water samples from a lake or pond
- plant fertilizer
- tap water
- dissolved oxygen kit (optional)
- digital camera (optional)
- electronic probe for measuring turbidity (optional)

Estimated Time: two 50-minute classes

Background Information: *Water Pollution: Nutrients***,** p.114.

Preparation:
Fill several buckets or other containers with tap water and let them sit for a day or so to allow any chlorine to dissipate. Fill several other containers with water from a lake or pond.

Procedure:
1. Discuss with students that water pollution is any human-caused contamination that lessens its value to humans and nature.
2. Ask students to make a list of all potential sources of pollution that might wash into a body of water during a heavy rain. The list should include nutrients from livestock and crop agriculture, plant nurseries, golf courses, home or business landscapes and home gardens.

3, Divide the class into groups of 2 or 3. Have each group get 6 jars and label them:

#1 tap water (control)
#2 tap water + fertilizer
#3 tap water + double-strength fertilizer
#4 pond water
#5 pond water + fertilizer
#6 pond water + double-strength fertilizer

4. Have students fill each jar with the appropriate water sample and the appropriate amount of fertilizer to jars #2, #3, #5 and #6 (For example, if the instructions for fertilizer use call for one teaspoon per quart, use two teaspoons in the double-strength jars).
5. Set all the jars, without tops, on a windowsill or other place where there is good sunlight (remember a constant temperature is best for good algae growth). ***Students must wash their hands after preparing the jars.***
6. Have each group write a hypothesis of what they think will happen. Have them estimate a time frame for their prediction (such as "2 days", or "2 weeks").
7. Observe the jars every day for a week and then once a week for a month. Record any changes in the jars on a data sheet. You may want to photograph the jars at the beginning and at regular intervals. If possible, check the dissolved oxygen in all 6 jars once a week **at the same time of day** (oxygen levels vary during the day and night). If electronic probes that can measure turbidity are available, compare turbidity levels.
8. At the end of the experiment, have each group write up their results and present them to other groups.
9. Discussion:
   - Which jar had the greatest algal growth? Why?
   - Which jar had the least algal growth? Why?
   - As algal growth increases, what happens to the dissolved oxygen?
   - In the jars with algal growth, what probably happens to the oxygen levels at night? Why?
   - Name land uses and activities that can contribute nutrients to streams
   - What effects do nutrients have on aquatic life?

Assessment Opportunities: Discussion questions can be used for assessment.

Extensions:

1. Collect water samples from streams and/or ponds in various locations and attempt to correlate land use with dissolved oxygen levels.
2. Have students observe algae under a microscope. have students draw the organisms they see and identify them using the attached handout or other guide.

Adapted from **Georgia's Adopt-a-Stream Education Guide,** pp.101-105

Water Pollution: Nutrients
from the **Streamkeeper's Field Guide**

Nutrients such as nitrogen and phosphorous are required by all organisms for basic processes of life, growth and reproduction. Various forms of nitrogen and phosphorous occur naturally in stream water.

In excessive amounts, nutrients overstimulate the growth of aquatic plants and algae. The vegetation can clog waterways, and when it dies and is decomposed by bacteria, dissolved oxygen levels drop dramatically. This lack of oxygen can adversely affect fish and aquatic invertebrates, leading to decreased community diversity.

Sources of excess nutrients include: fertilizers applied to agricultural fields, timbered areas, gardens and lawns; poorly maintained septic systems, sewage treatment plants, industrial effluent; pet, livestock, and other animal wastes; and detergents.

Nitrogen

Nitrogen occurs in natural waters in various forms, including nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3). Nitrate is the most common form tested. Test results are usually expressed as nitrate-nitrogen (NO3-N), which simply means nitrogen in the form of nitrate.

The national drinking water standard for nitrate-nitrogen in the United States is 10 mg/l. However, polluted waters generally have a nitrate-nitrogen level below 1mg/l.

Phosphorous

Phosphorous usually occurs in nature as phosphate, which is a phosphorous atom combined with four oxygen atoms (PO_4^{-3}). Phosphate that is bound to plant or animal tissue is known as organic phosphate. Phosphate that is not associated with organic material is known as inorganic phosphate. Both forms are present in aquatic systems and may be either dissolved in the water or suspended (attached to particles in the water column).

Inorganic phosphate is often referred to as orthophosphate or reactive phosphorous. It is the form that is most readily available to plants, and thus may be the most useful indicator of immediate potential problems with excessive plant and algal growth.

Nutrients in Lakes and Ponds

Students simulate aquatic habitats using lake water and goldfish in glass jars and observe the effects of nutrient loading and nutrient limitation on aquatic life for one week.

Level(s): 6-8

Subject(s): Life Science, Chemistry

Virginia SOLs: 6.7 a,f,g; 6.9 a,c; LS4 a,b,c; LS7 a,b,c,d; LS9 a; LS10 b,c; LS11 a,b; LS12 b,c,d,e; PS g,k,m; PS2 b

Objectives: Students will be able to :

1. describe the characteristics of *oligotrophic* and *eutrophic* lakes.
2. explain the effects of nutrient loading on lake habitats
3. define nutrients as a limiting factor in lake habitats
4. list some possible sources of nutrient inputs into ponds, lakes and streams

Materials:

- 3 one-quart glass jars (or plastic containers)
- masking tape for labels
- 1-2 gallons of recently gathered pond or lake water filtered through a plankton net.
- plankton net (epoxy a small piece of silkscreen fabric over one end of a round plastic tube such as a PVC pipe)
- stereo and/or standard microscopes
- pond life I.D. guides
- 2 goldfish
- 3 aquarium bubblers
- 3 incandescent lights (such as gooseneck lamps)

Estimated Time:

- 50 minutes for setup and initial microscope work on first day
- 10 minutes/day for 3 days
- 50 minutes for final activity on fifth day

Background Information: *Nutrients and Oligotrophic vs Eutrophic Lakes*, p.119.

Preparation: Have materials and microscopes ready for students to use

Procedure:

1. Label the 3 jars as follows:
    - *Goldfish – feed daily*
    - *Food Only – feed daily*
    - *Control – do not feed*

2. Prepare each of the jars as follows:
   - **Goldfish –** Fill the jar with lake or pond water and add two goldfish. Feed the goldfish every day with a pinch of fish food flakes.
   - **Food Only –** Fill the jar with lake or pond water and sprinkle each day with a pinch of fish food flakes.
   - **Control –** Fill the jar with lake or pond water.

3. If possible, use aquarium bubblers to add oxygen to the water in the 3 jars. Set the jars in a visible and safe place. Place an incandescent light such as a gooseneck lamp above each jar. Leave the light on 24 hours a day.

4. Using the microscopes, look at some of the remaining lake water, and the organisms filtered out with the plankton net. Students should record their observations, including drawings of the plants and animals they see. Students should look them up in a guide to pond or lake life.

5. Each day during the observation period, students check the jars for any changes. They should record their observation. Some changes will be visible to the naked eye. Other observations may be made with a hand lens or microscope. Green and blue green algae are likely to appear. Both kinds of algae need the nutrients nitrogen and phosphorous to grow. If there is not enough of these nutrients for algae to grow, the nutrients are said to be *limiting*: that is, the lack of these nutrients prevents algae from growing.
   Note: The goldfish must be fed everyday.

6. On the last day have students answer the questions below. Then have them examine the algae in the jars under the microscope and identify them.

   1. In jar #1, what is the source of nutrients entering the water? (*fish food flakes and fish waste*) Where are the nutrients coming from in jar #2? (fish food) Are there any nutrients in jar #3? (*no nutrients are entering the water*)

   2. Which jar do you think will show the most algae growth? (*jar #1*) Which will show the least algae growth? (*jar #3*)

   3. In which jar has the green algae grown more than the blue-green algae? (probably jar #1 because the fish wastes are providing nitrogen)
   Both green and blue-green algae will grow until all the nitrogen in the water is used up. The green algae will then stop growing. The nitrogen will have become the limiting nutrient for the green algae. The blue-green algae can keep growing after the nitrogen in the water is used up, because the blue-green algae can use nitrogen from the air. Thus, when nitrogen is limiting, the blue green-algae will out-compete the green algae, meaning the blue green algae will grow more than the green algae.

4. In which jar is the blue-green algae growing better?
Blue-green algae will likely grow better in jar #2 when nitrogen is limiting but phosphorous is still available. The blue-green algae will keep growing until all the phosphorous in the water is used up. When the phosphorous is gone, it becomes the nutrient limiting algal growth.

5. What nutrient is limiting in jar #2? What nutrient do you think might become limiting in jar #1 (hint: the fish produces nitrogen in its wastes)? What nutrient appears to be limiting in the control jar (#3)?
Nitrogen is likely limiting in jar #2 because its only source is the fish food. It can be used up rapidly. Phosphorous may be limiting in jar #1 as nitrogen is available through both the fish food and the fishes waste. Either may be limiting in jar #3. Which nutrient is limiting will depend on the original supply of nitrogen and phosphorous in the lake or pond water and on the nutrient content of the fish food.

Note: If you feel that the concept of which nutrient is limiting in which jar is too difficult for your students, you may just want to emphasize the idea that the algae in the jars need nutrients to grow and that with more nutrients, more algae grows. Students should be able to see more algae growing in some jars than in others.

7. Discuss with students sources which might provide nutrients to lakes and ponds.
These might include:
   a. animal waste (livestock, pets, wildlife)
   b. fertilizers (crops, gardens, lawns)
   c. failing septic systems
   d. waste-water treatment plants
   e. atmospheric deposition of nitrogen from car exhaust and other sources

8. Discuss ways that contamination of waterways by nutrients can be reduced.
   a. Establish vegetated buffers along waterways to slow down stormwater runoff and allow it to infiltrate into the ground before reaching the water.
   b. Fence livestock outside of riparian buffers.
   c. Apply fertilizers according to soil test, type of crop being grown and during appropriate seasons and weather.
   d. Inspect septic tanks on a regular basis and pump out when needed.
   e. Upgrade waste water treatment plants to increase efficiency.
   f. Use vehicles with increased gas-mileage efficiency and emission controls.

Assessment Opportunities:
Have students:
1. describe the characteristics of *oligotrophic* and *eutrophic* lakes.
2. explain the effects of nutrient loading on lake habitats
3. define nutrients as a limiting factor in lake habitats
4. list some possible sources of nutrient inputs into ponds, lakes and streams

Extensions:

1. Extend the experiment and study the results for a longer period.

2. Take samples from various sources - different ponds, lakes, streams and rivers – and compare the algal growth among them.

3. Use a test kit to check the levels of nitrogen and phosphorus in various bodies of water.

4. Using a commercial fertilizer, compare algae growth in jars containing different amounts of fertilizer. Can you find at what concentration the nutrients are no longer limiting?

Adapted from **Nutrients in the Great Lakes**, pp.4-8.

Nutrients and *Oligotrophic* vs *Eutrophic* Lakes

Nutrients such as nitrogen and phosphorous are required by all organisms for the basic processes of life, growth and reproduction. Various forms of nitrogen and phosphorous naturally occur in streams, lakes and ponds. In excessive amounts, nutrients overstimulate the growth of aquatic plants and algae. The vegetation can clog waterways, and when it dies and is decomposed by bacteria, dissolved oxygen levels can drop dramatically. This lack of oxygen can adversely affect fish and aquatic invertebrates, leading to decreased community diversity.

Sources of excess nutrients include fertilizers applied to agricultural cropland, gardens and lawns, poorly maintained septic systems, pet, livestock and other animal waste. These are typically carried into local bodies of water by stormwater runoff. Nutrients are also contributed by sewage treatment plants and industrial sources which discharge effluent directly into streams.

Lakes that are low in nutrients are called *oligotrophic*. These lakes have low plant production and very clear water. They are often very deep and have a small surface area. Because they are so deep, wind and waves do not mix the water enough to stir nutrients throughout the lake. Sunlight does not reach the deeper parts, either. There are no oligotrophic lakes in Virginia. Lake Superior is an example of an oligotrophic lake.

Lakes and ponds rich in nutrients are called *eutrophic*. Eutrophic lakes produce abundant plant life and have murky water. They are often shallow and have a large surface area. Because they are shallow, the water in these lakes is easily mixed by wind and waves, making nutrients available throughout the lake. These bodies of water have a healthy diversity of organisms as long as the level of nutrients remains in balance. If overabundant amounts of nutrients are introduced into these waters, algae blooms can lead to fish kills and loss of diversity.

Sources:
The Streamkeeper's Field Guide, The Adopt-a-Stream Foundation, 2001
Nutrients in the Great Lakes Teacher's Guide, Ohio State University