



Environmental Science

It isn't easy being green ...

Project Area:
Environmental Science

Skill Level:
Intermediate to Advanced

Learner Outcomes:

- ⇒ Understand the difference between eutrophic and oligotrophic water.
- ⇒ Know causes of eutrophication.
- ⇒ Recognize the effects of eutrophication, including “dead zones.”

Tennessee Science Curriculum Standard GLEs:

- S1. Embedded Inquiry 0607.Inq.1-5, 0707.Inq.1-5, 0807.Inq.1-5
- S2. Interdependence 0607.2.1-3
- S3. Flow of Matter & Energy 0707.3.1-2
- S7. The Earth 0707.7.6

Success Indicator:

Describe the causes and effects of eutrophication.

Science Skills: Develop hypothesis, experimental design, observe, collect data, interpret.

Life Skills: Observing, Reasoning

Tags: water quality, eutrophication, algae, ponds, nutrients, dead zones

Materials:

- ⇒ Three large clear containers (e.g., clear 1 L soda bottles or large mason jars)
- ⇒ Water from a local pond or stream (try to find clear water)
- ⇒ Fertilizer (liquid or granular) with equal N:P ratio (e.g., 10-10-10)
- ⇒ Oxygen detector or test strips (optional)

In this activity, students will learn how nutrients can cause water quality problems like pond scum.

Introducing the Activity:

Ask your students: Have you ever seen “pond scum”? Where and when? What did it look like? What did it smell like?

Introduce key concepts about “pond scum.”

- ⇒ Algae are microscopic organisms that perform photosynthesis like plants. Contrast photosynthesis and respiration: Photosynthesis uses the sun’s energy for growth, consuming carbon dioxide and releasing oxygen. Respiration needs organic carbon (e.g., plant matter) for energy and consumes oxygen and releases carbon dioxide.
- ⇒ Photosynthesis requires a pigment called chlorophyll — this is what gives the algae their green color (just like plants!).
- ⇒ Just like plants, algae need nutrients to grow, especially nitrogen (N) and phosphorus (P). They can only grow as much as they have N and P. So normally, there are only a small amount of algae in lakes, and they are nice and clear. These lakes are “**oligotrophic.**”
- ⇒ When too much N and P get into the water, the algae can grow unchecked. They overgrow. This process is called **eutrophication**, and the lakes are “**eutrophic.**” (Pronounced “YOU-TRO-FICK”)

Ask your students: Where do nutrients come from?

- ⇒ Discuss sources: Fertilizer from lawns and farmers’ fields, animal manure. Have them fill in some of the answers on the worksheet.

Ask your students: Why would too much algae be bad?

- ⇒ Discuss **water fouling** (bad taste, odor); it is not aesthetically pleasing (looks yucky); fish and other wildlife might have a hard time swimming and breathing.

Explain how eutrophication leads to **dead zones**. When the overgrown algae die, bacteria start consuming them, using up all the oxygen in the water. When the oxygen is gone, fish and other aquatic life will die. There is an interactive flash animation that shows this process that you can share with your students or give them to explore on their own:

<http://coseenow.net/files/2008/11/eutrophication.swf>

Have your students fill in the diagram in the handout describing the processes involved in forming dead zones. ANSWER KEY: 1.E, 2.C, 3.A, 4.F, 5.B, 6.D

Resources:

<http://coseenow.net/files/2008/11/eutrophication.swf>

Great Lakes Food Web, *Michigan Environmental Education Curriculum*.

<http://techalive.mtu.edu/meec/module08/FoodWeb.htm>



Pond in a Bottle

This activity involves three mock “ponds” made of pond water in a mason jar (or 2 L soda bottle). Find pond water that is fairly clear to start with. You can bring in a bucket yourself or take students to collect it if there is a pond or creek nearby.

Predict: Ask students to predict the effects of adding a little vs. a lot of nutrients to some pond water. If you are comparing other variables (see “extensions” below), ask them to predict the effect of these variables on algae growth. Discuss the importance of experimental controls.

Investigate:

Students will create several scenarios: One pond with no nutrients added, one with a small amount of nutrients, and one with a lot of nutrients. These might represent scenarios in which you have no nutrients coming into the creek; a small amount of nutrients (e.g., from a small home garden); and a lot of nutrients (e.g., for example, from an agricultural field that had too much fertilizer applied). House plant fertilizer (e.g., Miracle Grow) may be substituted for garden fertilizer.

Procedure:

1. Label your containers 1, 2, and 3. Fill each with an equal volume of pond water.
2. Add nothing to pond #1: This will be your control (no additions).
3. Pond #2 will represent low nutrient inputs: Add 1 teaspoon of fertilizer for every gallon of pond water.
4. Container #3 will represent high nutrient inputs: Add 5 teaspoons of fertilizer for every gallon of pond water. Use a camera to take a picture. Record your observations below: What does the water look and smell like? What color is it? How clear is it?

Note: Several weeks of incubation are required before results of this activity can be seen. Experiment setup can be done in class, and the students’ jars can sit in the classroom window, or they can take them home and make observations there.

Make Observations:

Ask students to record their observations on a weekly basis. Use the chart in the handout to record how the bottles look and smell. How much green growth? Any bubbles? Does it smell?

Oxygen measurements (optional): If you can measure oxygen (e.g., water quality testing kit, test strips, oxygen meter in a science lab), include the measurements in the students’ observations. They should see that oxygen will increase initially as the algae start growing but then plummet as the algae die and the dead zone plummets.

Discuss and Apply:

- ⇒ Are there ponds or streams near your house that show signs of eutrophication? What do you think the most likely source of nutrients is (e.g., agricultural fertilizers, animal manure, lawn fertilizers, etc.)?
- ⇒ If a “dead zone” forms in these ponds, what types of organisms will be affected? How would it affect you?
- ⇒ As we increase agricultural production to feed a growing human population, do you think eutrophication and dead zones will increase or decrease? Why or why not?
- ⇒ What are some ways we can reduce the amount of nutrients entering the waterways?

Extension and Variations:

In the basic experiment, students test different amounts of nutrients. You can also have the students test other variables that might affect how algae grow. Here are a few ideas to consider, or ask students to come up with their own:

- ⇒ *Temperature:* Make two identical “ponds” — store one in the fridge and one at room temperature. Algae will grow faster at higher temperatures.
- ⇒ *Sunlight:* Make two “ponds” and store one in the windowsill and one in a dark cupboard. Algae need light to photosynthesize, so only the sunlight pond should have growth.
- ⇒ *Different types (i.e., ratios) of fertilizer:* For example, try 10-10-10 and 24-8-4. (HINT: Since freshwater algae are usually limited in phosphorus, a higher “P” [middle number] should result in greater algal growth.)
- ⇒ *Different water sources:* Pond water vs. rain water vs. tap water. (HINT: Tap water shouldn’t contain many organisms, so there should be little or no growth.)



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Have you ever seen a stream, pond or lake that is bright green? Wonder why that happens, and how it affects the fish and other aquatic life?

Algae (or phytoplankton) are microscopic organisms that grow in lakes, ponds, streams and other waters. They perform photosynthesis and contain chlorophyll like plants. They are an essential food source for fish and other aquatic organisms. They are the start of the aquatic food web.

Normally, algae are **limited by nutrients** — They can only grow as much as they have nutrients. When there is only a small amount nutrients, there is only a small amount of growth, and the waters are relatively clear (you may not even see the algae, but they are there!) These ponds or lakes are called "**oligotrophic**" and are great for swimming and aquatic life.

When water gets more nutrients (for example, from fertilizer running off of lawns or fields), the algae are no longer kept in check. When you fertilize your plants, they grow bigger. In a similar way, nutrients will fertilize the algae. They will grow too much, causing your lake or pond to turn bright green! We sometimes call this "**pond scum**." The scientific term is "**eutrophic**" (pronounced "YOU-TRO-FICK").



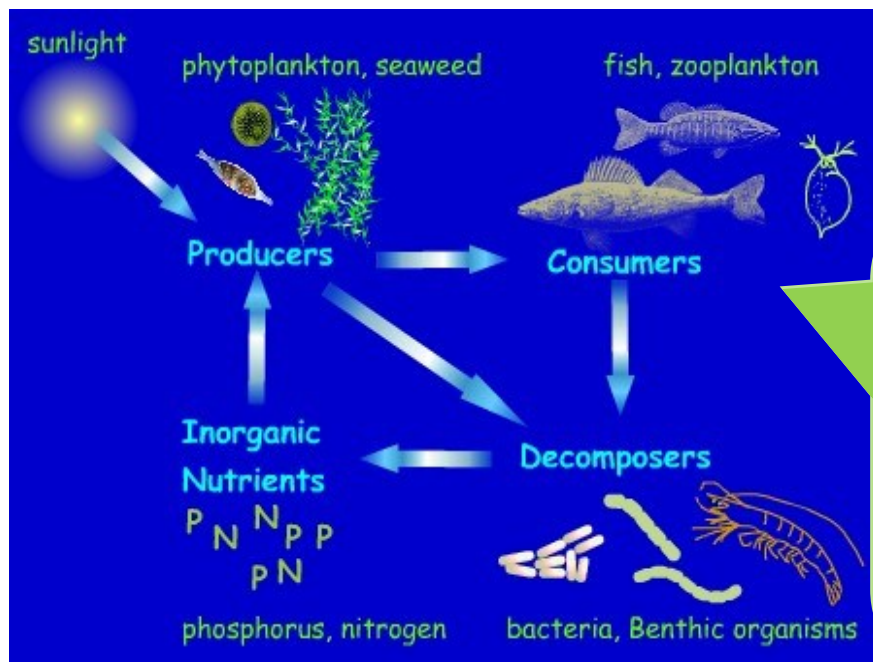
Words to Explore:

- ⇒ Algae
- ⇒ Nutrient
- ⇒ Oligotrophic
- ⇒ Eutrophic

Did You Know?

"Eutrophic" means "well fed."

("Eu" means well or good and "trophic" means nourishment.)



Learn More!

Check out this animation!

<http://coseenow.net/files/2008/11/eutrophication.swf>

See ALGAE in ACTION!

<http://techalive.mtu.edu/meec/module08/PhytoplanktonMovies.htm>



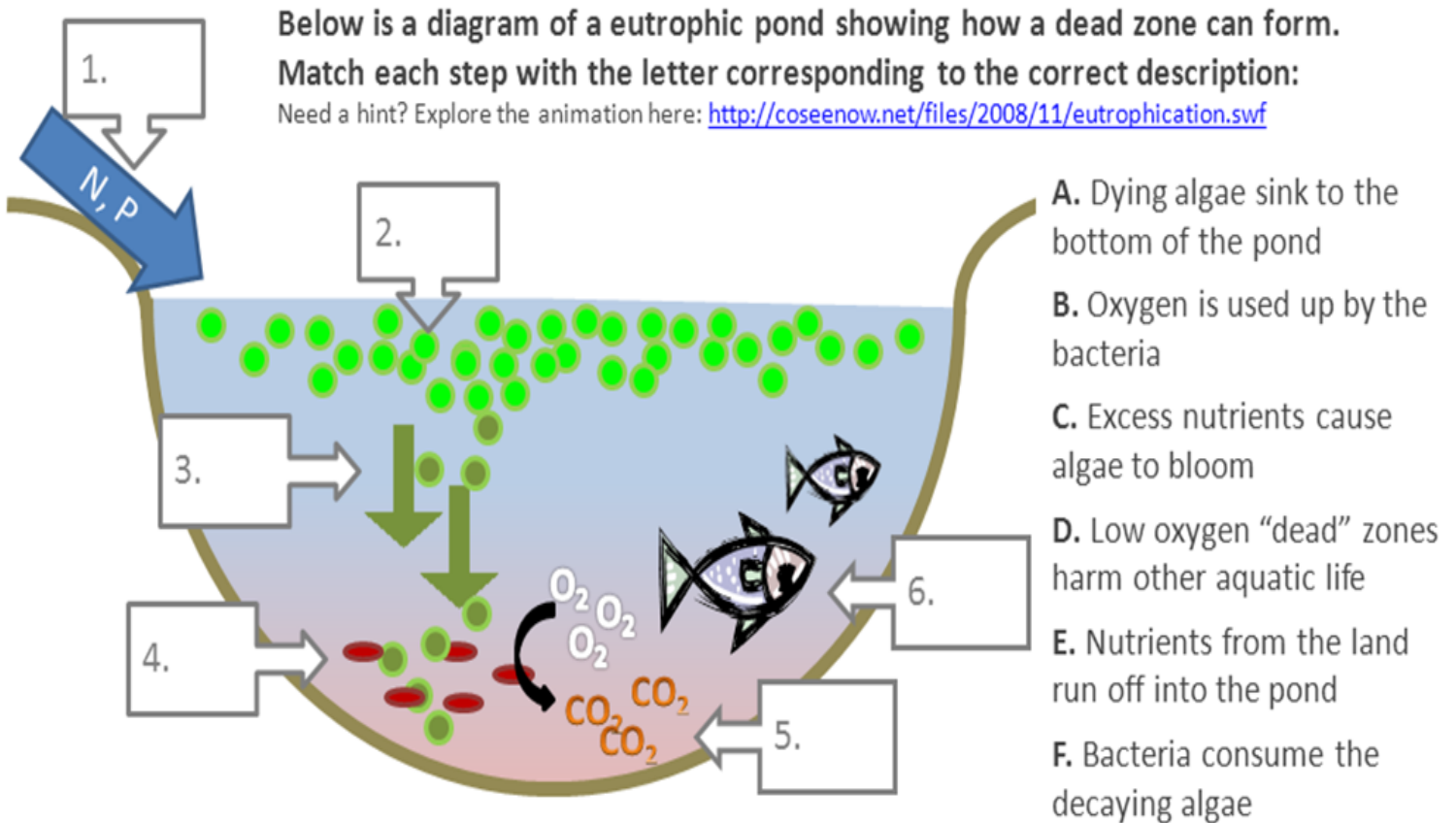
Talk About It: Where do the nutrients come from?

Write three sources of nutrients:

1. _____
2. _____
3. _____

What affect does eutrophication have on water quality and aquatic organisms?

All that algae can make the water smell and taste bad. This is called **water fouling**. Even worse, eutrophication can create **dead zones**, or patches of water with low or no oxygen.





Activity: Pond in a Bottle

Find out what happens when nutrients are added to a pond.

Materials:

- ⇒ Three large clear containers (e.g., clear 1 L soda bottles or large mason jars)
- ⇒ Water from a local pond or stream (try to find clear water)
- ⇒ Granulated fertilizer with equal N:P ratio (e.g., 10-10-10)

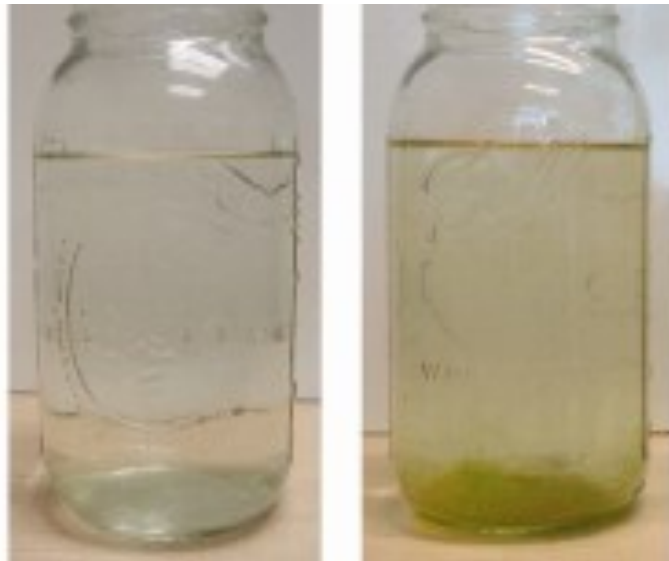
1. Label your containers 1, 2 and 3. Fill each with an equal volume of pond water.
2. Add nothing to pond #1: This will be your control (no additions).
3. Pond #2 will represent low nutrient inputs: Add 1 teaspoon of fertilizer for every gallon of pond water.
4. Container #3 will represent high nutrient inputs: Add 5 teaspoons of fertilizer for every gallon of pond water. Use a camera to take a picture. Record your observations below: What does the water look and smell like? What color is it? How clear is it?
5. Make a prediction: What do you think each bottle will look and smell like after a month?

Pond #1, no fertilizer: _____

Pond #2, a little fertilizer: _____

Pond #3, a lot of fertilizer: _____

Cover the bottles loosely with some foil or a cloth so air can still get in and out. Put them in the sunlight for 30-60 days. Observe once a week. Take a picture if you can. Fill out the observation sheet on the next page.



Example of mason jar "ponds."



Activity: Pond in a Bottle

Observation sheet. For each container, record the color, smell, clarity, bubbles and any other things you notice about your bottle ponds.

Date	Pond #1	Pond #2	Pond #3

Reflection:

What happened in each of your bottles?

How long before you saw algae grow in each bottle?

What would happen if you put fish in each of your ponds? What would each be like as a habitat for fish or other organisms?

What would happen if you tried this with tap water instead of pond water?
