The Effects of Fertilizer and Aquatic Plants on Algae Growth

Lesson Topic
Eutrophication and algal blooms and the role of aquatic plants in mitigating excess algae and improving water quality.

RIEL Biology Element
Multiple modalities

Time Required
Two weeks, (can be adapted)

Standards Addressed
- Discuss how various oceanic and freshwater processes, such as currents, tides, and waves, affect the abundance of aquatic organisms.
- Explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.

Lesson Summary
Students will perform a laboratory experiment to look at the effects of fertilizer and aquatic plants on water quality. Students will make observations regarding algal growth, measure pH, dissolved oxygen and nitrate concentrations over a two-week period. They will analyze data and write a lab report, drawing conclusions about the role of aquatic plants in mitigating algal blooms and increasing water quality in coastal areas.

Materials
Each lab group will need:
- 1 test tube rack
- 4 large test tubes (or small jars/water bottles)
- Cotton balls
- Pipettes
- Graduated cylinder - 50 or 100ml
- Water collected from a natural area (pond, stream, river, ocean)
- Liquid fertilizer such as Miracle Gro or make your own fertilizer solution by adding ¼ cup granular fertilizer to 1 liter of water
- pH test strips
- Water quality test kits for nitrate
- Elodea or other aquatic plants from an aquarium store
- Sharpie

Before the Activity
Teacher should lecture to provide background information as well as introduce new vocabulary and concepts. Include pictures of algal blooms, dead zones (worldwide), red tides, algal blooms in Florida, specific organisms that cause harmful algal blooms (HABs) and their toxins.

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Background Information

Algal blooms can occur in both freshwater lakes as well as bays and coastal areas when there is a high concentration of nutrients from sources like sewage or fertilizer runoff. This is known as **eutrophication**. Eutrophication can occur naturally but is also increased by human activity such as adding fertilizer to lawns, golf courses and crops, livestock manure that is poorly contained, and sewage spills. Most commercial fertilizers contain high levels of nitrogen, phosphorus and potassium since plant growth is typically limited by these nutrients. When the fertilizer washes into a natural body of water, it causes rapid growth of microalgae (phytoplankton) and macroalgae. This excess algae causes many problems. It can block sunlight from aquatic vegetation such as seagrasses. It can lead to **dead zones** which are areas of **hypoxia** in which oxygen levels are too low for aquatic organisms. These are particularly a problem for lakes, bays and coastal waters since **watersheds** drain into these bodies of water. Some species of algae produce toxins which are dangerous to humans, animals and many of the organisms which live in the water. When these types of algae grow excessively, it is known as a harmful algal bloom (HAB).

Submerged aquatic vegetation such as seagrasses as well as intertidal wetlands such as salt marshes and mangroves can take up nutrients, making them unavailable to algae. This can increase water clarity and dissolved oxygen and improve overall water quality.

Additional Resources:

- Harmful Algal Blooms: https://hab.whoi.edu/
- Dead Zones: https://www.epa.gov/nutrientpollution/effects-dead-zones-and-harmful-algal-blooms
- Wetlands and water quality: https://www.nature.org/en-us/about-us/where-we-work/united-states/iowa/stories-in-iowa/power-of-wetlands/
- https://dec.vermont.gov/watershed/wetlands/functions/water-quality

Science and Engineering Practices

- Carrying out investigation
- Obtaining, evaluating, communicating data
- Analyzing and interpreting data

Content Learning Objectives

Students will be able to:

- Follow directions to safely complete a laboratory experiment
- Make scientific observations and collect data
- Analyze data
- Demonstrate graphing skills
- Describe the importance of aquatic vegetation and its role in mitigating excess nutrients

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Teacher Notes

- Pre-lab questions could be given as a homework assignment prior to day 1.
- This sampling schedule can be adjusted to fit your schedule and doesn't have to be limited to or extend to a two-week period.

Assessments

Students will create a lab report and answer questions on the student worksheet.

Nitrogen pollution: https://www.nature.org/en-us/about-us/where-we-work/united-states/new-york/stories-in-new-york/long-island-water-quality/what-is-nitrogen-pollution-/

Lesson Activities

1. **Before the lab:**
   - Go over background information in lecture
   - Collect water from a pond, lake or other natural body of water (do not use salt water, it will kill the Elodea)
   - Purchase Elodea or other aquatic plant that will fit into a test tube.
2. **Day 1 of experiment:**
   - Set up lab stations with materials.
   - Give each student a copy of the student handout (see below)
   - Have students answer pre-lab questions.
   - Students will set up the experiment on day 1 and take initial data measurements
3. **Days 3-9**
   - Students will repeat data collection on Days 3, 5, 7 and 9

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Lab Group Members: _____

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Materials:

- 1 test tube rack
- 3 test tubes
- 4 Cotton balls
- Pipette
- Pond water
- Fertilizer solution
- pH test strips
- Nitrate test kit
- Elodea
- Sharpie

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Procedure:

1. Label each test tube with your group initials, "Water," "+Fertilizer," and "+Fertilizer +Plant"
2. Fill the test tube labeled "Water" ¾ full with pond (or other natural source) water
3. Fill the test tube labeled "+Fertilizer" ⅔ full of pond water and add 10 drops of fertilizer solution.
4. Fill the test tube labeled "+Fertilizer +Plant" ⅔ full of pond water. Add 10 drops of fertilizer solution and a sprig of Elodea.
5. Measure and record the pH of each solution.
6. Measure and record the nitrate concentration of each solution.
7. Loosely plug each test tube with a cotton ball.
8. Place your test tube rack in a well-lit area or near a window.
9. Make observations and measurements on Day 3, Day 5, Day 7 and Day 9. Use the following for observing algal growth in each test tube:
   0 = no growth
   1 = slight growth
   2 = moderate growth
   3 = heavy growth

Pre- Lab Questions:

1. Write a hypothesis for this experiment.

2. Identify the following:
   a. Control: _____
   b. Independent variable: _____
   c. Dependent variable: _____

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Sample	Day 1	Day 3	Day 5	Day 7	Day 9
pH Water					
pH + Fertilizer					
pH +Elodea					
[Nitrate] (ppm) Water					
[Nitrate] (ppm) + Fertilizer					
[Nitrate] (ppm) +Elodea					
Algal growth (0-3) Water					
Algal growth (0-3) + Fertilizer					
Algal growth (0-3) +Elodea					

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Data Analysis:

On a separate sheet of graph paper, graph the following:

- pH over time for each sample
- Nitrate concentrations over time for each sample

Post-Lab Questions:

1. In what test tube did the most algae growth occur? Why?

2. Why do you think a cotton ball was used instead of sealing the test tube with a rubber stopper? (hint: think about what gases are needed for photosynthesis)

3. How did the test tube with the plant compare to the test tube with just the fertilizer? Why?

4. Based on your observations, what can you conclude about the effects of nitrates and phosphates on the growth of algae?

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5. How could the increased use of fertilizer negatively affect an aquatic ecosystem?

6. What could be done to mitigate the effects of excess fertilizer in aquatic ecosystems?

7. What role do aquatic plants, fresh and saltwater marshes and mangrove habitats play in maintaining the water quality of aquatic ecosystems?

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