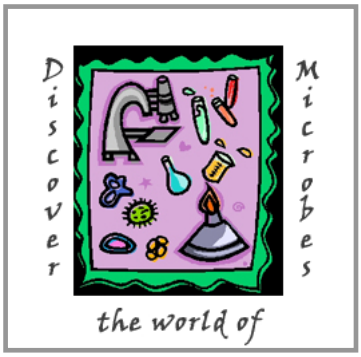
Microbial Discovery Activity

Effect of Nitrate and Phosphate Levels on the Growth of Algae



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Intended Audience

K-4	
5-8	X
9-12	X

Activity Characteristics

Class room setting	X
Requires special equipment	
Uses hands-on manipulatives	X
Requires mathematical skills	X
Can be performed individually	
Requires group work	X
Requires more than (45 min) class period	X
Appropriate for special needs student	X

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Introduction

Abstract

Nitrate and phosphate are useful as fertilizers in agriculture and gardening. Nitrate and phosphate aid agricultural production by producing more abundant crops. However, since the mass production of ammonia during the 1940's by way of the Haber process, it has been noted that a phenomenon known as "nitrate pollution" may occur. This pollution can be demonstrated by conducting this simple experiment. This experiment demonstrates two main ideas. The first is a test of what levels of nitrate and phosphate allow for optimum algal growth. The second demonstrates at which levels of nitrate and phosphate algal blooms may occur, causing harm to an aquatic ecosystem (Freeman, 2002).

Core Themes Addressed

General Microscopy Concepts	
Microbial Cell Biology	
Microbial Genetics	
Microorganisms and Humans	
Microorganisms and the Environment	X
Microbial Evolution and Diversity	
Other -Common properties of life; Cellular components	

Keywords

Nitrate: NO_3^-, a compound essential to fertilizing plants. It is, however, a common (dangerous) contaminant of groundwater. For more information, see www.nitrate.com/nitrate1.htm

Phosphate: PO_4^{3-}, a compound necessary for the growth of plants. It is one of the main nutrients found in fertilizers. For more information, see http://en.wikipedia.org/wiki/Phosphate

Algae: Photosynthetic organisms that live in many habitats, ranging from aquatic environments to the hot desert sands. They are an essential organism for the production of oxygen, as well as an important food source. However, too much algae (known as an algal bloom) can have an adverse effect on an ecosystem, causing many problems. For more information, see http://www.nmnh.si.edu/botany/projects/algae/AlgIntro.htm

Chlorella: a unicellular alga found in soil, water, and tree bark. Botanical names are *Chlorella pyrenoidosa, Chlorella vulgaris*

Learning Objectives

By completing this activity, the student will be able to:

1) Given three *Chlorella* cultures with different concentrations of nitrate and phosphate, students will determine the effect of nitrate and phosphate levels on the growth of algae.
2) Given three cultures with different concentrations of nitrate and phosphate, students will evaluate the nitrate and phosphate levels at which an increase in algal growth occurs in a closed system.

National Science Education Standards Addressed

This lesson is aligned with the following National Science Standards:

Science as Inquiry-In completion of this activity, students develop skills related to conducting experiments and understanding scientific inquiry. Students complete a procedure and record data to determine the effect of nitrate and phosphate on the growth of algae.

Life Science-In completion of this activity, students will discover the effect of nitrate and phosphate on the population of algae, and also make inferences regarding the potential effect on an aquatic ecosystem.

Personal and Social Perspectives-This lesson will aid students in developing an understanding of populations, resources, and environments. Also, students will develop understanding of natural hazards (the effect of excessive fertilizer on an aquatic ecosystem).

Teacher Handout

Effect of Nitrate and Phosphate Levels on the Growth of Algae

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Student Prior Knowledge

It is recommended that students have prior knowledge of algae's ability to carry out photosynthesis. Also, students should be familiar with laboratory safety.

Teacher Background Information

Students should be made aware of the negative impacts that runoff of fertilizers may cause, including an increase in algae. Discuss with students the cycle by which an increase in algae leads to an increase in heterotrophic bacteria and Archaea. When these decomposers are working hard on degrading the dead algae, they use up oxygen in the water, thus creating a "dead zone." This creates a lack of oxygen available for other plants and organisms (Freeman, 2002).

Class Time

Day 1	30 Minutes
Day 2	10 Minutes
Day 3	10Minutes
Day 4	10Minutes
Day 5	2 Hours

Teacher Preparation Time

20 minutes should be set aside for setup of laboratory.

Materials and Equipment

- Nine 15 ml test tubes with screw caps
- distilled water
- graduated cylinder
- three 10 ml plastic pipettes
- three plastic automatic pipettors
- 2 flasks for fertilizer solutions
- 10% nitrate/phosphate fertilizer solution (use liquid fertilizer with a high nitrate/phosphate content) [need about 50 ml]
- 20% nitrate/phosphate fertilizer solution [need about 50 ml]
- *Chlorella* algae culture (Ward's)
- eye dropper
- Light source

Methods

1. Label the first 3 test tubes "distilled water" and fill with 10 ml distilled water. These are the control tubes.
2. Label the second three test tubes "10% nitrate/phosphate solution" and the third three test tubes "20% nitrate/phosphate solution". Fill all 6 test tubes with 10 ml of the appropriate solutions.
3. Gently mix the *Chlorella* culture. Using the dropper, place 10 drops of the *Chlorella* culture into each tube. Shake each tube gently to mix the contents.
4. Place the caps on the test tubes tightly and lay them on their sides in a well-lit area where they will be undisturbed for the five-day period.
   Note: A light source may be used to provide a well-lit area.
5. Check the test tubes every day for the next five days. Record the observations on a data table.

Growth of *Chlorella* can be determined by an increase in the density of the algae as well as an increase in the darkness of the green color in the tubes. Record your results on a data table each day.

Safety Issues

Students will be working with chemical fertilizers. Be sure to emphasize the importance of not ingesting the organism or any solutions. Also, provide students with eye protection, and maintain an eyewash station/bottle in the laboratory.

Suggestions for Assessment

Students will be informally assessed by teacher observation on their successful setup of the experiment. Students will be formally assessed based on the relevancy of their hypothesis and the accuracy of their follow-up questions.

Supplementary Information

1. Possible Modifications: This lesson is ideal for students in grades 5-12. However, this lesson may be modified for grades K-4 by setting up one experiment for the whole group, as well as assisting students in creating an "If...then..." hypothesis as a class.

2. References: Freeman, S. (2002). Biological Science. Prentice-Hall: Upper Saddle River.

3. Appendices

Student Handout

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Introduction

Nitrate and phosphate are useful as fertilizers in agriculture and gardening. Nitrate and phosphate aid agricultural production by producing more abundant crops. However, since the mass production of ammonia during the 1940's by way of the Haber process, it has been noted that a phenomenon known as "nitrate pollution" may occur. This pollution can be demonstrated by conducting this simple experiment. This experiment demonstrates two main ideas. The first is a test of what levels of nitrate and phosphate allow for optimum algal growth. The second demonstrates at which levels of nitrate and phosphate algal blooms may occur, causing harm to an aquatic ecosystem (Freeman, 2002).

Student Background Knowledge

It is recommended that students have prior knowledge of algae's ability to carry out photosynthesis. Also, students should be familiar with laboratory safety.

Vocabulary

a. Nitrate: NO_3^-, a compound essential to fertilizing plants. It is, however, a common (dangerous) contaminant of groundwater. For more information, see www.nitrate.com/nitrate1.htm

b. Phosphate: PO_4^{3-}, a compound necessary for the growth of plants. It is one of the main nutrients found in fertilizers. For more information, see http://en.wikipedia.org/wiki/Phosphate

c. Algae: Photosynthetic organisms that live in many habitats, ranging from aquatic environments to the hot desert sands. They are an essential organism for the production of oxygen, as well as an important food source. However, too much algae (known as an algal bloom) can have an adverse effect on an ecosystem, causing many problems. For more information, see http://www.nmnh.si.edu/botany/projects/algae/AlgIntro.htm

d. *Chlorella*: a unicellular alga found in soil, water, and on tree bark. Botanical names are *Chlorella pyrenoidosa*, *Chlorella vulgaris*

Safety Considerations

Use caution when working with chemicals and living organisms. Be sure not to put any items in or near your mouth. Also, wear protective eye covering at all times.

Materials check list (Per group)

Nine 15 ml test tubes with screw caps	
distilled water	
graduated cylinder	
3 10 ml pipettes	
3 plastic automatic pipettors	
10% nitrate/phosphate fertilizer solution (use liquid fertilizer with a high nitrate/phosphate content)	
20% nitrate/phosphate fertilizer solution	
Chlorella algae culture (Ward's or other biological supply house)	
Light source	

Procedure for Participants

1. Label the first test tube "distilled water" and fill it 3/4 full with distilled water. This is the control tube.
2. Label the second test tube "10% nitrate/phosphate solution" and the third test tube "20% nitrate/phosphate solution". Fill both test tubes approximately 3/4 full with the appropriate solution.
3. Gently mix the *Chlorella* culture. Using the dropper, place 10 drops of the *Chlorella* culture into each tube. Shake each tube gently to mix the contents.
4. Place the caps on the test tubes tightly and lay them on their sides in a well-lit area where they will be undisturbed for the five day period.
5. Write a hypothesis, keeping the following questions in mind: Which treatment will show the greatest increase in algal growth? Which concentration of nitrate/phosphate provides the optimum conditions for growth of algae? Write your hypothesis in the space provided below:
6. Results: Record your observations in the following table.

   Evaluate growth using the following scoring system:

   0 no growth
   \+ slight growth
   ++ moderate growth
   +++ heavy growth

Day	Control	10% Nitrate	20% Nitrate
1			
2			
3			
4			
5			

Extension Questions:

1. Do the data collected support your hypothesis? Why or why not?

2. What changes did you observe in the tubes containing distilled water? Explain.

3. At what level of fertilizer, 10% or 20%, did the most growth occur? Why?

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

5. How could the increased use of nitrates and phosphates (fertilizers), adversely affect an aquatic ecosystem?

6. What are some natural sources of nitrates and phosphates?

7. Go to other resource materials and investigate nitrogen and phosphorus cycling in the environment.

8. What are some typical levels of nitrate and phosphate in aquatic environments?

9. What were the concentrations of nitrate and phosphate in the 10 and 20% fertilizer solutions?

10. Why did you use three tubes for each treatment instead of just one?