



Understanding Nutrients: Phosphorus Cycle

Adapted from BTNEP/LSU AgCenter: *Nonpoint Source Water Pollution*

Focus/Overview

Understanding the role of phosphorus in aquatic plant growth and the routes this nutrient takes to become a component of nonpoint source pollution is an important step toward learning how to control the impact of this nutrient on our ecosystems.

Learning Objectives

The learner will...

- understand that nutrients like phosphates are essential to life.
- participate in a nutrient game.

Louisiana Grade Level Expectations (Science)

4: GLE-50	Explain how some organisms in a given habitat compete for the same resources (LS-E-C1).
4:GLE-72	Predict and describe consequences of the removal of one component in a balanced ecosystem (e.g. consumer, herbivores, nonliving component) (SE-E-A2).
7: GLE-36	Distinguish the essential roles played by biotic and abiotic components in various ecosystems (SE-M-A1).
7: GLE-37	Identify and describe the effects of limiting factors on a given population (SE-M-A2).
HS Biol: GLE-26	Analyze the dynamics of a population with and without limiting factors (LS-H-D3).

Materials List

- BTNEP poster on Eutrophication (Priority Problem Poster #5).
- Music tape or CD and a player
- Construction paper and tape

Advance Preparation

1. Prepare green name tags of each student. Label half of them ALGAE and divide the remaining name tags equally into two groups labeled SHRIMP and SPARTINA. Cut out the same number of blue squares as you have students – label each with a “P” (for phosphorus). Cut out five brown circles and label each SOIL. Cut out five yellow triangles and label each ORGANIC MATTER. Attach tape to each of these tags so that they are ready for use.
2. Obtain BTNEP Priority Problem Poster #5
3. Choose a music tape and have a player ready.

Background

Nitrogen and phosphorus are essential to life and are cycled through the natural ecological systems in an orderly, balanced way. Both are building blocks for protein and the growth of plant tissue. Without nitrogen and phosphorus, there would be no food chain.

While phosphorus is of great biological importance, it is not very common in the biosphere. Unlike carbon, nitrogen, and oxygen, phosphorus does not enter the atmosphere during its cycle. Instead, phosphorus remains mostly on land in rocks and minerals and in ocean sediments. In these places, phosphorus exists as inorganic phosphate. As rocks and minerals wear down, phosphate is released, where some of it is

BTNEP Connection
Water Quality

Grade Level
4, 7, HS Biology

Duration
1 class periods

Subject Area
science

Setting
classroom

Vocabulary
nutrient, limiting factor

Original Source
“Investigating Nutrients: Nitrates and Phosphates” in BTNEP/LSU AgCenter: *Nonpoint Source Water Pollution*, Activities 5 and 6.



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taken by runoff of storm waters into rivers and streams, and eventually to the ocean, where it is used by marine organisms. Some of the phosphate that remains on the land is taken up by plants, which bind the phosphate into organic compounds. When plants are eaten by animals, the phosphorus they contain is used by the animals in bones, teeth, shells, and other tissues.

Humans can introduce phosphorus into the system from several sources: human wastes, animal wastes, industrial wastes, and human disturbance of the land and its vegetation. Sewage effluent should not contain more than 1 mg/l phosphorus according to the U.S. Environmental Protection Agency, but outdated wastewater treatment plants often fail to meet this standard. Sometimes storm sewers contain illegal connections to sanitation sewers. Sewage from these connections can be carried into waterways by rainfall and in some areas, melting snow. Phosphorus-containing animal wastes sometimes find their way into rivers and lakes in the runoff from feedlots and barnyards. Fertilizers used for crops and lawns release nutrients like phosphorus that remain dormant and accumulate over a period of years. Furthermore, wetlands that have been drained no longer function as filters of silt and phosphorus, allowing more runoff, and phosphorus, to enter waterways.

Problems arise when too much of a particular nutrient, such as phosphorus, is present. Phosphorus is understood to be a “limiting factor” because plants will use up all the available phosphorus they can find. When the phosphorus is used up, the plants slow their growth. Extra phosphorus entering an aquatic ecosystem can upset the natural balance and cause changes in aquatic plant growth, which can lead to oxygen depletion and death of aquatic organisms. If we pay attention to the news, we may hear about algae blooms and fish kills, especially in the summer. Algae blooms are often caused by putting too many nutrients into an aquatic ecosystem.

Eutrophication occurs where the water contains high levels of nutrients and aquatic plant life (including algae) and low levels of oxygen. It is not a healthy situation, especially in an area where people make a living from the water.

The growth of algae in fresh water is actually limited by the absence of phosphorus. Thus, phosphorus is a “limiting factor.” The items that any organism needs to obtain from their environment can be called **limiting factors**, because their presence or absence or quantity limits the environments in which that organism can live. Algae use up phosphorus rapidly and stop growing when it is depleted. If there is excess phosphorus, an algae bloom is often triggered.

Algal blooms can lead to a decrease in the dissolved oxygen level in a lake or other water body. This decrease in oxygen occurs when algae reproduce so much that they form a thick mat. This results in a decrease in the amount of sunlight that reaches the photosynthetic organisms under the mat during the day. This decreases the amount of photosynthesis and subsequently the amount of oxygen produced by photosynthesis. Benthic photosynthetic organisms may die if too little sunlight reaches them. Dead organic matter becomes a food source for decomposers; this increases the amount of cellular respiration. Cellular respiration requires oxygen and this reduces the dissolved oxygen in the body of water. Therefore, the amount of dissolved oxygen is decreased two ways. The first is due to the decrease in photosynthesis and the second is due to the increase in cellular respiration.

Both phosphorus and nitrogen, along with potassium, are components found in fertilizers. Fertilizers are a substance that adds essential nutrients to the soil. Farmers and gardeners use fertilizers to replay nutrients removed from soil by crops are harvested. All fertilizers have a series of three numbers listed on the label. These three numbers represents the percentage of available nitrogen (N), phosphorus (P) and potassium (K) that is provided by the fertilizer. This series of numbers is called the NPK rating. The nitrogen in the fertilizer promotes overall plant growth. The phosphorus promotes root growth and flowering. Potassium regulates opening and closing of the stomata (little pores in the leaf).

Procedure

1. We are going to play a game called Musical Nutrients. This activity will teach us about a nutrient called phosphorus, which is essential to life and often controls how well plants grow. Too much phosphorus, however, can sometimes cause problems. *Pass out the “P” signs to the students (these represent phosphorus).*
2. Musical Nutrients is like the game Musical Chairs. You are organisms who need enough nutrients to grow. *Have students place all of their chairs back to back in a double row. They need to tape a blue*

- “P” square on each chair. Hand out the organism tags to each student have them tape the tag to their clothing. Each of you now represents an organism in our ecosystem.*
- I will play music while you move around the line of chairs. When the music stops, you must claim a chair and sit on it. Let’s do a practice round. The “P” on the chair is the phosphorus you need to grow. *Turn on the music for about a minute. Students should move around the chairs to the music. When you turn off the music, each student should find and sit in a chair. Everyone should get a chair this time.*
 - Stick a brown soil particle on one “P” sign on a chair. No one may sit on the chair with this soil particle on it. The phosphorus is attached to the soil and unavailable as a nutrient. Turn on the music. When the music is turned off, the student who does not get a chair this time is “out”.*
 - Stick a yellow organic matter particle on one “P” sign on a chair. This yellow tag represents phosphorus contained in decaying matter. Only shrimp can get phosphorus from decaying matter, so only a shrimp may sit in this chair. Turn on the music. When the music is turned off, the student who does not get a chair this time is “out”. Continue playing the game, each time adding one or two soil particles and organic matter tags.*
 - Speaking to those “out” of the game: Why are you out of the game? Because phosphorus was not available to them. Not enough phosphorus means some organisms don’t make it and they die. We’ll change things a little here and free up that phosphorus trapped in soil and organic matter. When I take off the soil and organic matter tags, anyone can claim the phosphorus again. Remove the soil particles and organic matter tags from the chairs.*
 - Those of you left in the game, stay in your seats. Now all the algae left in the game, pick someone who is out to join you as a new algae. This will double our algae population. Next time I stop the music we must let the algae have a seat first, because they need the phosphorus and, in real life, algae would take up phosphorus very quickly. So let the algae sit. Then, if you are not an algae, see if there is a seat left for you. It may not sound fair, but we are simulating nature, and in nature some organisms have an advantage over others from some things.
 - What do we now have the most of? *Algae*. This is what is meant by an “algae” bloom. Algae populations quickly grow very large as they take in the available nutrients in the water. What caused the algae to bloom? There was plenty of phosphorus for them and they were given an advantage for getting it.
 - After the game is over, review the ideas in the game. Discuss how, when insufficient nutrients were available in the game, some organisms did not survive (they were out of the game). When more nutrients were added to the game, the algae were the ones to benefit the most and they multiplied rapidly, causing an algae bloom. Algae are very efficient at absorbing phosphorus and using it up fast. If there is plenty of phosphorus, there will be plenty of algae. If there’s little phosphorus, there will be little algae.

Blackline Master

1. The Phosphate Cycle

Assessment

- none

Resources

BTNEP Resources:

Portrait of an Estuary, publication by LSU AG and BTNEP

Websites:

The Environmental Literacy Council, July 10, 2005, **Phosphorus Cycle**, accessed January 9, 2006, at <http://www.enviroliteracy.org/article.php/480.html>.

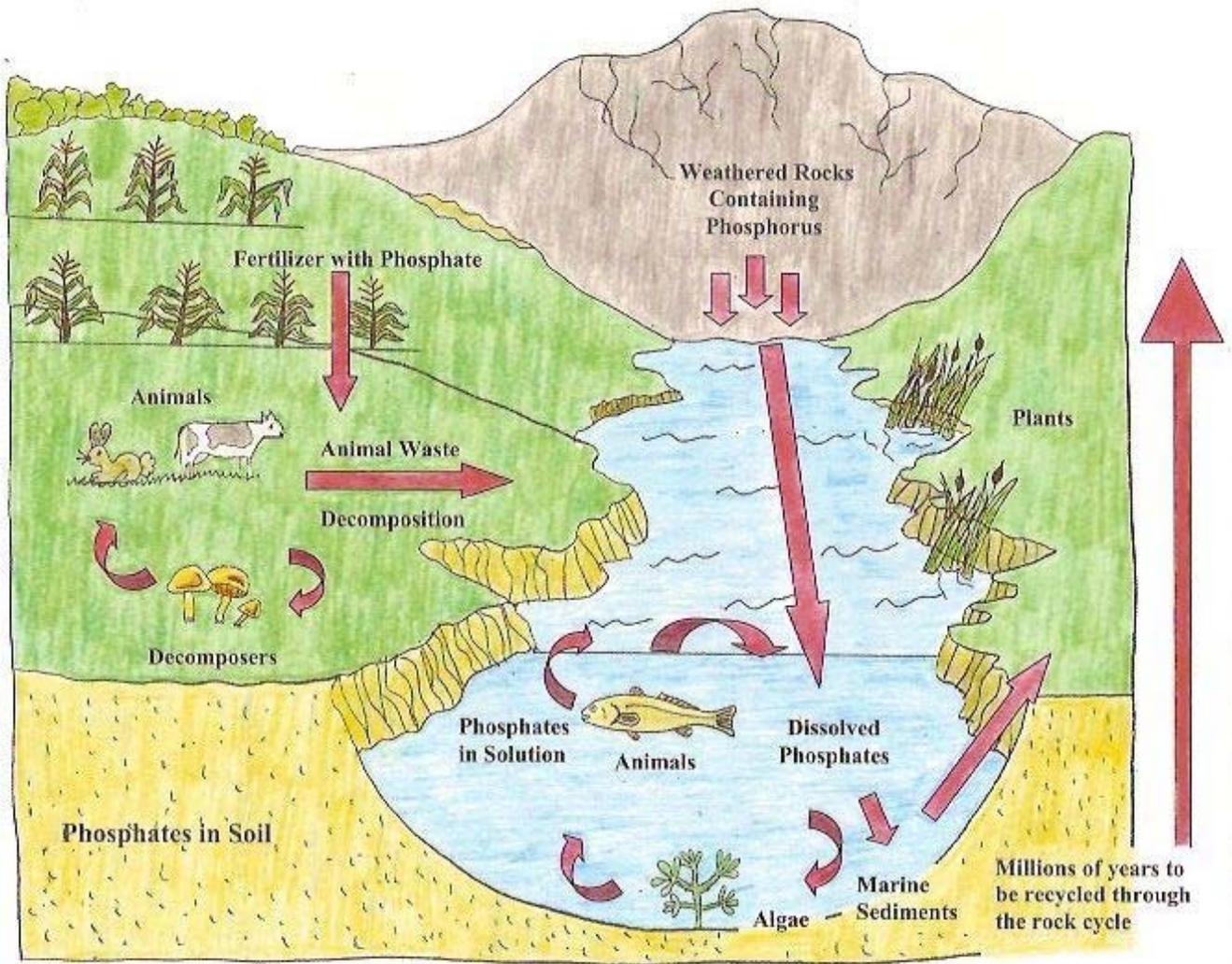
Clear explanation of the phosphorus cycle along with teacher materials including diagrams and additional information on phosphorus.

References:

DeBusk, William F., n.d. Phosphorus Cycling in Wetlands, accessed January 9, 2006, at <http://edis.ifas.ufl.edu/SS302>.

The Phosphorus Cycle

Drawing by: Lainey Pitre



Description of the Phosphorus Cycle.

Phosphate erodes from rocks and minerals. Plants are able to incorporate phosphate found in the soil into their tissues. This phosphate is then passed on to the next trophic level when consumers eat the producers (plants). Consumers assimilate this phosphate into teeth, bones, shells, etc. As these organisms die, their phosphates, once again, become available for plants to repeat the cycle.

The recycling of phosphorus (as phosphate) is slow because no biologically important form of phosphorus is gaseous. Phosphates that become part of marine sediments may take millions of years to solidify into rock, uplift as mountains, and erode to again become available to organisms. This part of the phosphorus cycle is extremely slow.

Humans introduce phosphorus through a number of sources: human wastes, animal wastes, industrial wastes, and human disturbance of the land and its vegetation. When this additional phosphorus enters the system, plants respond by excessive plant growth. In aquatic environments, this can have large effects. Aquatic algae use up phosphorus rapidly and only stop growing when it is depleted. This excessive growth of algae is often called an **algae bloom**.

Algal blooms can lead to a decrease in the dissolved oxygen level in a lake or water body. This decrease in oxygen can occur two ways. Sometimes the algae reproduce so much that they form a thick mat, which can block or seriously reduce in the amount of sunlight that reaches the photosynthetic organisms under the mat during the day. Without sunlight, these photosynthetic plants and animals can produce little oxygen. Bottom-dwelling photosynthetic organisms may die if too little sunlight reaches them. The second way that dissolved oxygen is reduced in the water occurs when dead organic matter becomes a food source for decomposers. In the decay process, the level of cellular respiration increases. Cellular respiration requires oxygen and this reduces the dissolved oxygen in the body of water. Therefore, the amount of dissolved oxygen is decreased two ways. The first is due to the decrease in photosynthesis and the second is due to the increase in cellular respiration.

Eutrophication occurs where the water contains high levels of nutrients and aquatic plant life (including algae) and low levels of oxygen. Eutrophic waters appear to be vivid green in color, indicating large numbers of algae in the water.