Exploring Phosphorus Sustainability

Overview

Phosphorus is an essential element that is needed by living things in order to function. Like many elements and resources, phosphorus moves through ecosystems as it is used. As natural phosphorus reservoirs are being depleted, it is important to consider the dynamics at play in the phosphorus cycle, including where it is found and how it is stored. In this activity, explore how phosphorus moves through aquatic and terrestrial ecosystems by considering the ways that it is transferred and stored.

Objectives

Students will be able to:

- Describe the importance of phosphorus in the environment and its role in sustainable agriculture.
- Explore the challenges of phosphorus sustainability and suggest potential solutions.

Duration:
2 class periods (60 minutes each)

Background

Living organisms need phosphorus to survive. It is present in the backbone of DNA and RNA, and it plays an important role in energy transfer within plants and animals. While there are various places where phosphorus can be found within an ecosystem, it only enters plants through the soil, water, and fertilizers. Animals obtain their phosphorus from eating plants and from drinking water that may be contaminated with runoff. In other locations on Earth where phosphorus exists, it can persist for thousands of years. Rocks are one way that phosphorus is stored. As a result of weathering and runoff, it can naturally enter the phosphorus cycle through soil and water. As phosphorus cycles through an ecosystem, it is continuously recycled and reservoirs become replenished. Humans also mine phosphorus from rocks, where it can be used in developing fertilizers to help plants grow. When large amounts of phosphorus are mined, as in the case of the Green Revolution in the mid-twentieth century, it creates a disruption of this otherwise natural cycle. The phosphorus cycle is a slow process, and it takes time to restore reservoirs once they are depleted.

Materials

Whiteboard and markers
Projector or computer for multimedia presentation
Phosphorus Life Cycle Worksheet
Phosphorus Life Cycle:Teacher Answer Key
Phosphorus Life Cycle Image
Is our phosphorus use sustainable? Article
What are stakeholder views and needs for achieving phosphorus sustainability? Article

Engage **(15 minutes)**

- Begin with a brief discussion about the importance of nutrients for plant growth. Ask students what they know about essential nutrients for plants.
- Introduce phosphorus and its significance in agriculture and the environment. Explain that phosphorus is a crucial element for plant growth and development.

- Show a short video (Crash Course: https://www.youtube.com/watch?v=leHy-Y_8nRs : includes nitrogen and phosphorus; duration: 9:21) or use visual aids to illustrate the role of phosphorus in plant growth. (Key ideas: DNA/ RNA, ATP, phospholipid bilayer all require phosphorus)

Explore The Phosphorus Cycle (30 minutes)

Activity 1: Explain the phosphorus cycle using visual aids and diagrams (see attachments for the Phosphorus cycle image, student worksheet, and teacher answer key). Emphasize how phosphorus moves through different parts of the environment. Students should define key terms of the phosphorus cycle process.

- Watch a short video on the phosphorus cycle: https://www.youtube.com/watch?v=izgqpfPZyRQ (duration: 2:41)
- Distribute handouts with information for students to read or have students research on reputable websites about the phosphorus cycle and discuss in pairs or small groups. (Example: https://swroc.cfans.umn.edu/research/soil-water/phosphorus-cycle)
- After students have completed the worksheet by defining the key terms, assign students to 4 groups. Assign each group one term: decomposition, runoff, uptake, and extraction. Tell them not to share their word and come up with a way to act out their word without using words. Other groups have to guess the term.
- After researching and sharing their terms, have a class discussion about the phosphorus cycle, focusing on key points and any questions the students may have. Utilize a whiteboard, jamboard, or large sheet of paper to write down ideas from each group.

Explain Phosphorus Sustainability Challenges (15 minutes)

Activity 2: Discuss the challenges associated with phosphorus sustainability, including overuse of phosphorus fertilizers, pollution of water bodies, and the finite nature of phosphorus resources. Consider and discuss where each of these problems are particularly impactful in your state, in the country, and around the world. Utilize who, what, when, where, why, and how questions for students to develop their discussion about each problem.

- Engage students in a brainstorming session to generate ideas on how to address these challenges (leads into the next activity). Utilize a whiteboard, jamboard, or large sheet of paper to write down ideas from each group.

Extend

Activity 3: Solutions for Phosphorus Sustainability (20 minutes)

- Introduce potential solutions to address phosphorus sustainability, such as recycling phosphorus from organic waste, using more efficient fertilizer application techniques, and promoting sustainable farming practices.
- Show examples of successful phosphorus sustainability initiatives and their positive impacts on the environment (https://steps-center.org/).
- Discuss how individuals and communities can contribute to phosphorus sustainability. Ask students how they can be part of the solution (Refer to the articles, "Is our phosphorus use

sustainable? Most stakeholders doubt it and What are stakeholder views and needs for achieving phosphorus sustainability?)

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- Identify the stakeholders in the process of phosphorus sustainability:
  - Farmers
  - Industries (mining)
  - Homeowners (and pet owners)
  - Environmental groups
  - Wastewater treatment plants
  - Recreational facilities such as golf courses
  - Others?

Evaluate

Summarize the main points of each of the three activities.
Complete an exit slip:

- What are the main components of the phosphorus cycle?
- What are 2 issues with the sustainability of phosphorus?
- What are 2 solutions to help with phosphorus sustainability?
- Name one stakeholder in the phosphorus situation.

References

Phosphorus Life Cycle Image: Phosphorus Cycle iStock-1185421100
Crash Course video: https://www.youtube.com/watch?v=leHy-Y_8nRs
Phosphorus Cycle Video: https://www.youtube.com/watch?v=izgqpfPZyRQ
"Is our phosphorus use sustainable? Most stakeholders doubt it." NC State News, July 2023
Grieger, K, Merck, A., Deviney, A., & Marshall, A., "What are stakeholder views and needs for achieving phosphorus sustainability?" May 26, *Environment Systems and Decisions.*