

Phosphorus Cycle

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.

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 only obtain their phosphorus from eating plants and drinking water. 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 soils 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

Game Sheets

10 six-sided dice

Journey worksheets (table and map versions)

Optional:

10 different colors of pony beads (one color to represent each part of the phosphorus game)

Pipe cleaners or yarn to make bracelets

Engage

Share this picture with the group and ask them to identify a part of the landscape where they could find phosphorus. Ask for volunteers to share where they could find phosphorus in our environment and why they think it would be there.

Objectives

Students will be able to:

Describe the movement of phosphorus within the phosphorus cycle

Conceptualize the ways that the various biotic and abiotic components play a part in this cycle

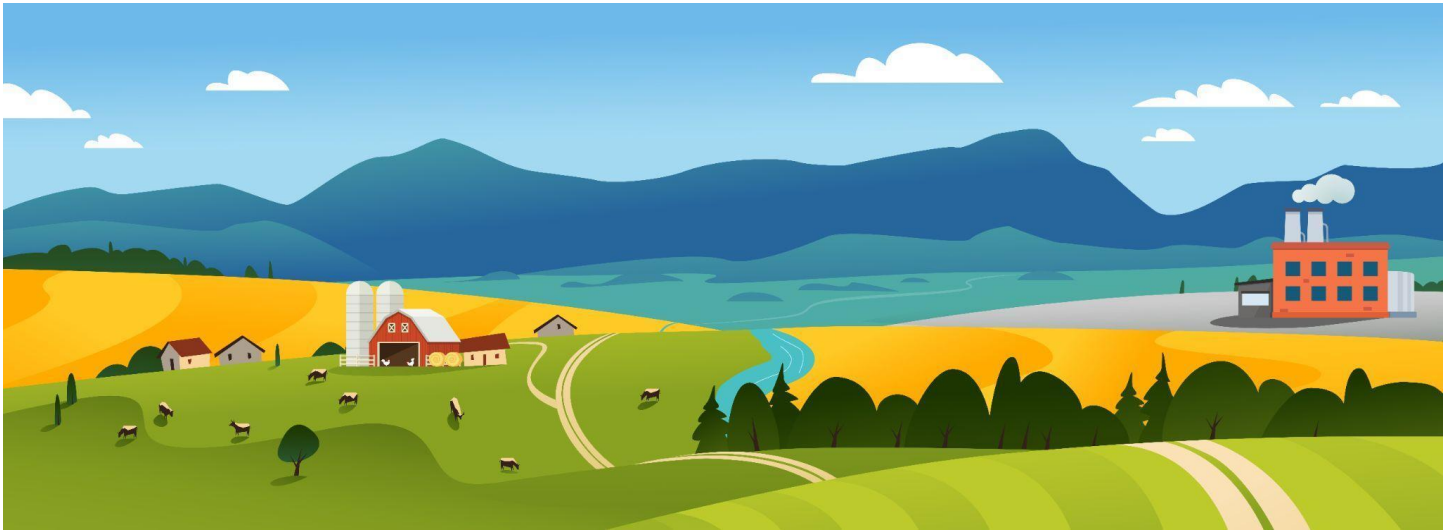
Process Skills:

Modeling

Analyzing

Duration:

60 minutes



Note: Phosphorus is not found in the atmosphere or clouds in significant amounts.

Explore

Phosphorus Cycle Game

This game can be played in a classroom, outdoors, or even adapted for a demo table version.

Set Up & Getting Started:

Set up the 10 phosphorus cycle stations around the room (or outside). Each station should have a game sheet with the corresponding die. Have a visible sign for each station so that participants can easily move through the game/cycle. Before starting the game, point out the location of each of the 10 stations.

Give each participant a Journey Worksheet (or Journey Map) and have them line up. Divide the group by assigning them to a particular station. Note: Avoid starting everyone at the same station.

Playing the Game:

At their assigned starting station, each participant should record where they begin on their map or table. Then, each participant should roll the die at their assigned station and use the game sheet to record where they move next in the phosphorus cycle. Each time they roll the die, they should record their turn on the Journey Worksheet or Journey Map. They will record their movement throughout the phosphorus cycle using their paper. Participants should complete about 20 turns by the time the game ends.

Optional:

For a visual representation of the phosphorus cycle, you may choose to have one particular color pony bead for each station. Participants will collect beads representing each part of the cycle they visit (stations). The beads could be collected on a pipe cleaner or yarn to create a bracelet representing their journey through the phosphorus cycle.

Explain

Have participants share their journey through the phosphorus cycle that they recorded on their data table or journey map. What patterns do they notice in how phosphorus moves through the environment? Did they stay in one station longer than others?

After discussing the journeys of various participants, further explain the phosphorus cycle. The diagram below can be used as a visual representation of the cycle and the components throughout.

Compared to other biogeochemical cycles such as carbon and nitrogen, the phosphorus cycle is relatively slow. Be sure to discuss the various components of this cycle:

- Weathering
- Transfer via soil and water
- Decomposition
- Human impact
- Absorption by plants and animals

Extend

How long can the phosphorus cycle last?

Using the time periods below, participants can calculate how long their phosphorus cycle journey lasted. Depending on where they spent most of their time, their journey will vary in length. For example, participants who spent most time in plants and animals would have a quicker journey than those who spent most of their time in rocks.

Soil: 16-18 years; residence time referred to as “**Land**” (soil <60 cm deep): 425-2,311

Sediments: residence time referred to as “**crustal rocks and soil >60 cm deep and marine sediments**”: 42,000,000 to 201,000,000 years

Rocks: falls under Ruttenger’s definition of sediments above

Oceans: 20,000 to 100,000 years

Surface Water: residence time of “**surface ocean**”: ~2.5-4.5 years

Ground Water: residence time of “**deep sea**”: 1502 years

Animal Waste:

Live Animals: residence time of “**land biota**”: 13-48 years; residence time of “**oceanic biota**”: 16-78 days

Live Plants: residence time of “**land biota**”: 13-48 years; residence time of “**oceanic biota**”: 16-78 days

Dead Organisms:

Minable phosphorus/fertilizer:

Estimated times were derived from research from Ruttenger, 2003 and Sharpley, et. al, 2019.

Evaluate

Have participants share the length of their journey in the phosphorus cycle, explaining the differences that contributed to their specific journey.

Student Data Sheets

- [Game Sheets](#)
- [Journey Worksheet](#)
- [Journey Map](#)

References

Adapted from Water Cycle Game (APA reference)

Goulburn Valley Water. (n.d.). Retrieved September 12, 2022, from <https://www.gvwater.vic.gov.au/community/education/resources#118499-water-cycle>

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Ruttenberg, K.C. (2003). "The Global Phosphorus Cycle" in *Treatise on Geochemistry* (1st ed, pp. 585-643). Elsevier Science.

Sharpley, et. al, 2020. *Can soil phosphorus sorption saturation estimate future potential legacy phosphorus sources?* Agrosyst Geosci Environ.