

Phosphorus Fact or Fiction!

Overview

Phosphorus Fact or Fiction introduces information about phosphorus and examines the impact of overuse of this element. Scientists are currently researching the over-mining of phosphorus and strategies to make phosphorus more sustainable. Phosphorus sustainability will rely on new materials, technologies, and strategies that can control, recover, reuse, and manage phosphorus in novel and sustainable ways. In this activity, you can test your knowledge about phosphorus, the phosphorus cycle, and the issues surrounding global sustainability.

Background

The element phosphorus is present all around us and even *in* us. The core of our very being, DNA, consists of phosphorus. We need phosphorus to live a healthy life but in large quantities it can be detrimental to our environment. Phosphorus is an essential element to life, supporting critical biological processes and driving the productivity and sustainability of global food systems. This element is present in soils, both naturally, and as a result of human activities such as faulty septic tanks or the use of fertilizers. Even minute increases of phosphorus usage can have detrimental effects on water quality, resulting in algae blooms and death of aquatic life. As stormwater runoff occurs, pollutants, including phosphorus, enter sources of water (lakes, rivers, groundwater, etc). The increase of phosphorus in our soils and waterways can be traced back to the Green Revolution of the 1950s and 60s, rock mining, and the use of fast growing plants to keep up with the world's growing population and the need for a large food supply. Naturally occurring phosphorus in rocks has decreased while the amount located in our soils and waterways have exponentially increased. The phosphorus cycle that we learned about in school has a gap! Scientists are trying to find a way to close the cycle by investigating best practices for reducing and recycling phosphorus.

Objectives

Students will be able to:

demonstrate knowledge about phosphorus

summarize the effects from overuse of phosphorus

describe the main issues of global sustainability of phosphorus

Process Skills:

Compare and contrast
Analyze

Duration:
30 minutes

Materials

[Fact or Fiction cards](#)

[List of statements and answer key](#)

[Fact or Fiction powerpoint](#)

** This activity can be utilized with a large group of students or as a table demo card sort.*

Engage

Share this cartoon with the group and have them write down what they observe and their thoughts about it. Ask for volunteers to share what they think this cartoon is trying to convey.



Explore

Fact or Fiction Game

The game can be done as A (group activity) or B (table demonstration).

Distribute one set of fact/fiction cards to each person in the group. Students will share their response to the statements on cards that feature the phosphorus cycle.

Card Sorting Activity for a table demonstration. Place the “headings” of Fact or Fiction on your table. Provide the phosphorus statements to visitors at the table for them to sort based on their knowledge of the cycle.

Explain

These statements were derived and adapted from the book, *Phosphorus: Past and Future*, by Elser and Haygarth, 2020.

1. There are .11Kg (.25 pounds) of phosphorus (P) in your body right now. *Fiction!*
 - In the average human body, there is .62kg or 1.35 pounds of phosphorus (P).
2. During an average lifetime, a person will consume 34kg (75 pounds) of phosphorus. *Fact!*
 - Foods that have a large amount of phosphorus include all types of meat and fish, dairy products, whole grains, sunflower seeds, and nuts.
3. Phosphorus is universally the least abundant of the major chemical elements that make up the “stuff” of living biomass. *Fact!*
 - The major chemical elements in biomass include hydrogen, carbon, oxygen, nitrogen, and sulfur. We need to be aware of the phosphorus cycle and its role in the biological, ecological, and sociopolitical effects of a possible future scarcity of the element, phosphorus.
4. Vitamin D is involved in regulating calcium and phosphorus in the human body. *Fact!*
 - Phosphorus deficiency in humans leads to bone disorders such as rickets (children) and

osteomalacia (adults). These conditions stem from the body's inability to produce Vitamin D which is needed for regulating calcium and phosphorus. Getting enough phosphorus means getting enough sun and having your body make Vitamin D.

5. The green revolution (1950s) accelerated agricultural production on Earth by utilizing the geological stores of phosphorus. *Fact!*
 - Earth had been recycling its own phosphorus for billions of years until the mid-twentieth century and the Green Revolution.
6. Most phosphate deposits on Earth are from igneous rock sources. *Fiction!*
 - Phosphorus deposits were formed when remains of plankton settled as organic rich materials on the bottom of the oceans. These deposits were compressed into sedimentary rocks called phosphorites. Only 5 % of mined phosphorus comes from igneous rocks.
7. Plant-available phosphorus in agriculture soil is usually about 90% of the total amount present at any one time. *Fiction!*
 - Unfortunately, plant-available phosphorus is actually only 10% or less of the total phosphorus present at any one time. 90% is unused despite long-term additions. When soil exists in a “challenging” form to access, as in organic phosphate molecules, plants can release enzymes from their roots to assist. These biological processes have decreased in the domestication of crops, perhaps because these plants have adapted to being supplied with abundant fertilizer phosphorus.
8. A nationwide voluntary ban on phosphorus-based laundry detergent was implemented in the United States in 1994. *Fact!*
 - In the United States, Maine, Florida, and Indiana were actually the first states to ban phosphorus in laundry detergent in the 1970s. Seventeen states also banned its use in automatic dishwasher detergents in 2010.
9. Phosphorus pollution is confined to inland surface freshwater lakes and rivers. *Fiction!*
 - Up until the last decade, it was widely thought that phosphorus pollution was confined to inland surface freshwater lakes and rivers, with nitrogen being central to impacts on water quality of coastal oceans and estuaries. Currently, the impacts of phosphorus do not seem to stop at freshwater boundaries. Anthropogenic phosphorus, such as poultry farming, seems to be affecting marine environments.
10. The term *peak phosphorus*, describes the point when agricultural soil can no longer adsorb or regulate phosphorus flow. *Fiction!*
 - Due to price spikes in 2008, peak phosphorus described the point in time at which global phosphate rock extraction would max out and begin to decline. This peak has been estimated to occur any time between 30 to 300 years. This upcoming critical decline is dire due to the anticipated 10 billion people that will need to be fed without fertilizer.
11. Only a small amount of the phosphorus input to agricultural systems reaches the food we eat, especially in meat production. *Fact!*
 - There is relatively low efficiency with which phosphorus is used in producing meat and dairy products. It requires much more phosphorus to produce a meat-rich diet than it does to rely on plant products.
12. One company in China has constructed the world's largest pig farm, CAFO. On this farm, a single facility can house up to 15,000 pigs. *Fiction!*
 - NO! This Chinese company, Guangxi Yangxiang, built a pig farm that can house up to 30,000 pigs in one facility! Concentrated animal feeding operations (CAFOs) can generate significant amounts of manure. The concentrated amount of manure all in one place can easily lead to overapplication and nutrient losses to aquatic systems. CAFOs require round the clock maintenance, emit large amounts of greenhouse gasses, and are in danger of failures in the wake of flooding from natural disasters such as hurricanes.
13. Two million metric tons (MT) of phosphorus passes through human digestive tracks each year resulting in equal amounts of human wastes. *Fact!*

- Historically, wastes were recycled and used for fertilizer. With the knowledge of disease exposure, this method has declined and/or disappeared. Advanced wastewater treatment plants are becoming more efficient at removing nitrogen and phosphorus but at the cost of another problem. Struvite is the mineral deposit that builds up from this removal process.

14. Globally, about 12% of all food is wasted, spoiled, or thrown away for some reason or another. *Fiction!*

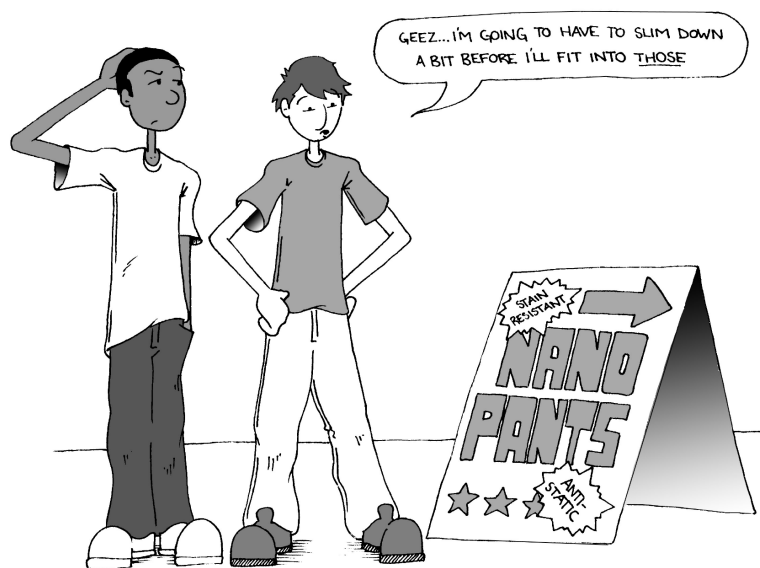
- Actually, 33% of all food is wasted, spoiled, or thrown away across the globe. In the United States, it can be as high as 40%. Surprisingly, the rate of food waste is similar in developing countries as well as industrialized ones. The waste occurs differently in various areas within the farm-to-plate process.

15. The International Plant Nutrition Institute (IPNI) is an international organization that has proposed a 4R program that has been adopted in North America to advance sustainable management of plant nutrition. *Fact!*

- Yes. The Rs include: 1. Right Source (correct type of fertilizer for particular soils), 2. Right Rate (application of fertilizer for plants), 3. Right Time (application of fertilizer with the plant needs it), and 4. Right Place (effective application in or on the soil).

Extend

Who doesn't like to laugh or get a good chuckle? People tend to like reading cartoons. There are many different types of humor but sometimes it is not what you see but what you *think*. Those types of cartoons use inferential humor. Take this one from the NanoScale Science book (Jones, et al.2007) for example...



From: Jones, M. G., Taylor, A., Broadwell, B., & Falvo, M. (2007). *Nanoscale Science*. Arlington,

VA: National Science Teachers Association Press.

Why is this funny? It's comedy with inferential humor. One student thinks you have to be nano sized to wear nano pants. One can infer that the pants are really tiny instead of just having a stain-resistant nanotechnology property.

These cartoons may remind us of the recently popular meme shared via social media. Here is one example of a science meme...a picture with few words.

A meme is a unit of cultural information, as a concept or belief that spreads from person to person (word origin, short for mimeme coined by Richard Dawkins).

Once the group has a better idea of the the following:

- importance of the phosphorus element
- phosphorus cycle
- issues surrounding the overuse of phosphorus
- need for the reduction and recycling of phosphorus

then you can have them work in small groups to create their own cartoon or meme to further describe one of those topics by either drawing a poster or creating a meme using a free version of a meme generator such as

<https://imgflip.com/memegenerator>



Evaluate

Have groups share their cartoons or memes and allow the whole group to try to explain the science concepts and/or issues relating to the phosphorus cycle.

References

Elser, J. & Haygarth, P. (2020). *Phosphorus: Past and Future*. Oxford University Press.

Truesdale Lake. (2010, April 28). *No Phosphorus Fertilizer*. Truesdalelake.
<https://truesdalelake.com/2010/04/no-phosphorus-fertilizer/>