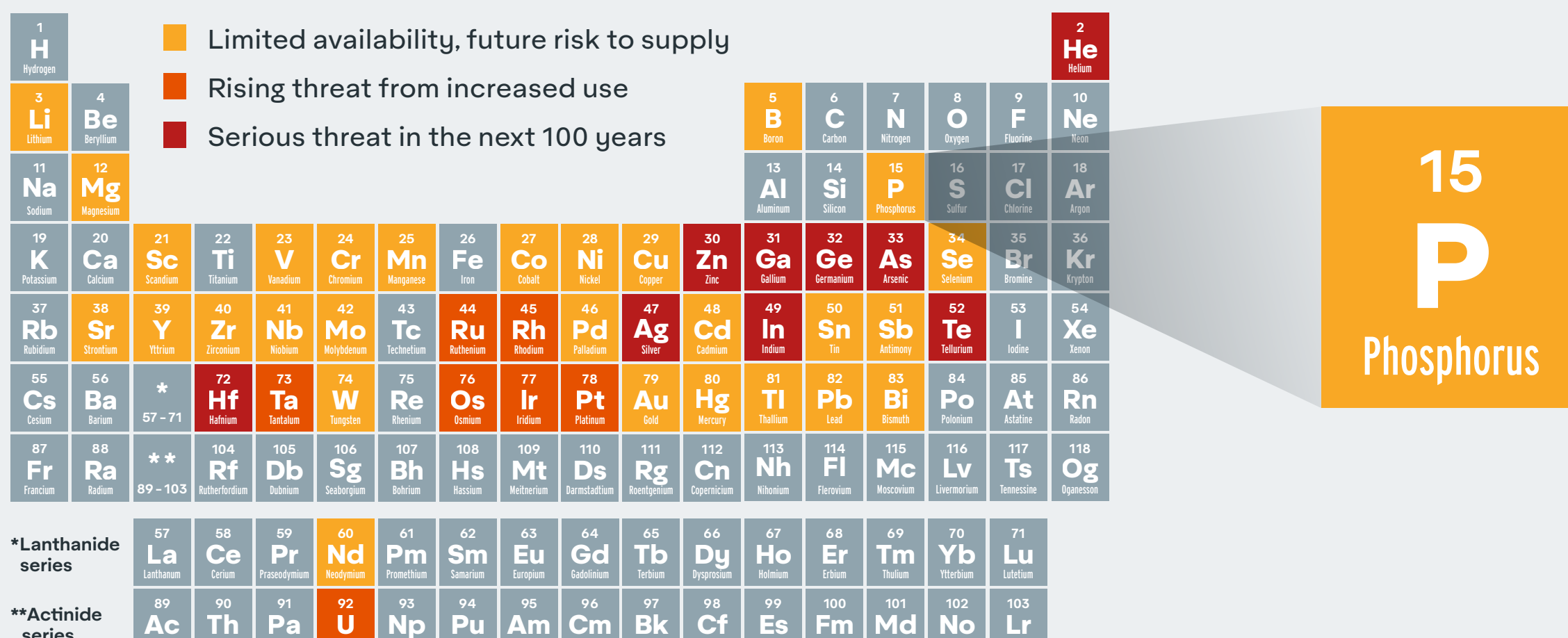


Phosphorus

An Element Critical for Life

THE PERIODIC TABLE'S ENDANGERED ELEMENTS



Phosphorus

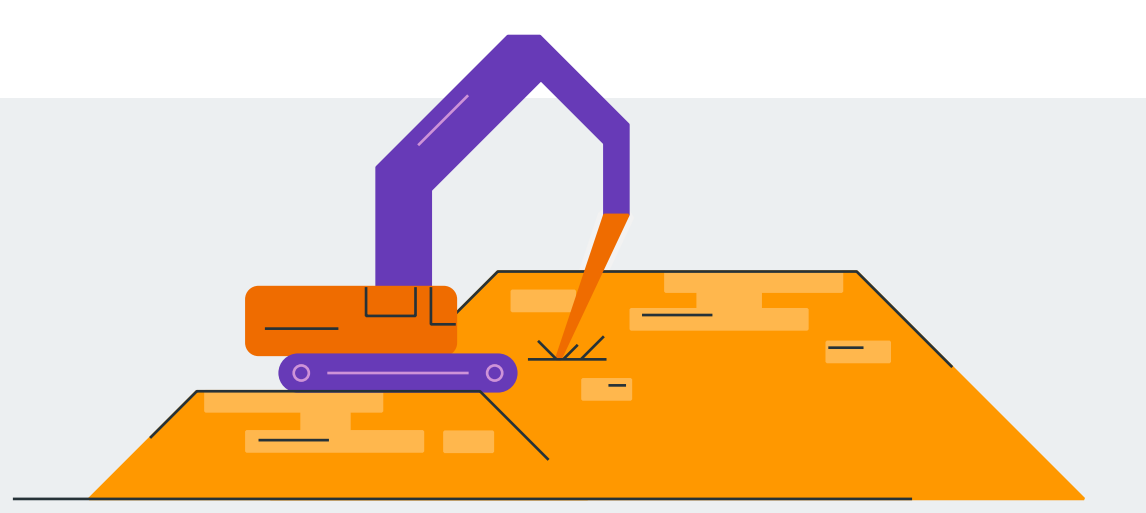


Phosphorus is essential for life and has no substitute. Phosphate rock is a finite resource that was formed from the mineralization of dead sea creatures over tens of millions of years and then lifted to the land via tectonic uplift. It is one of the three key ingredients in fertilizer.

Solving the phosphorus problem is critical to meeting U.N. Sustainable Development Goal #2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

Where is it from?

Phosphorus is present in soils, to different degrees, depending on the bedrock. However, most applied phosphorus comes from phosphate rock mining.



PHOSPHATE ROCK MINING



71% of the world's phosphate rock reserves are in Morocco, some of which comes from the contested region of Western Sahara.⁵

Phosphorus in the soil is distributed unequally around the globe. For example, the soils in sub-Saharan Africa have very little phosphorus in them naturally. Where phosphorus is lacking, fertilization is necessary for agricultural productivity.

How is it used?

90% of phosphate rock is used for food production.¹

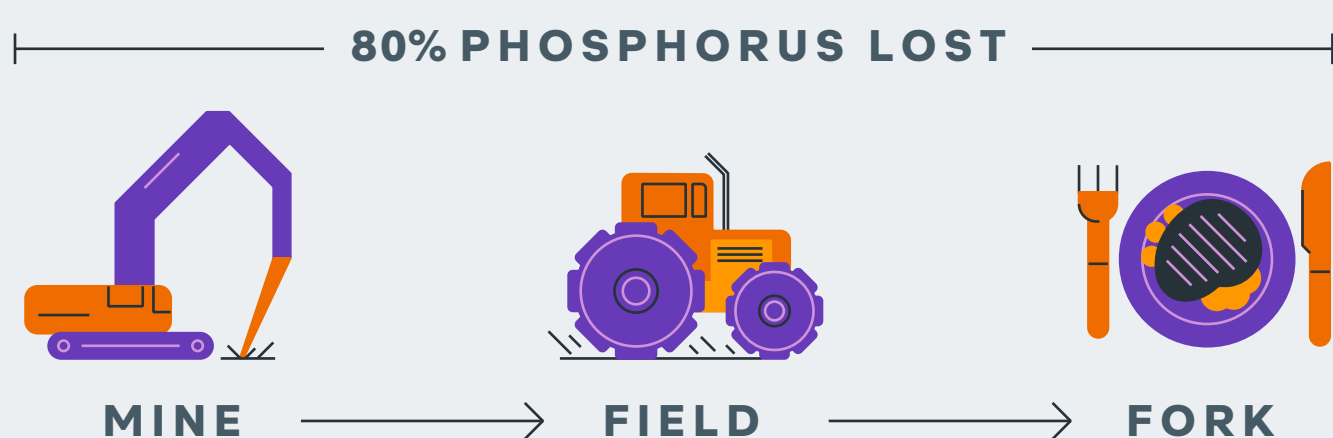


Phosphate is used in detergents to make them more efficient, but has been largely banned in the U.S., Europe and elsewhere due to its environmentally damaging role in eutrophication. However, in some parts of the U.S., it is still used in dishwashing and industrial detergents.

Why is it a critical element?

SUPPLY CHAIN LOSS

80% of phosphorus is lost or wasted in the supply chain from mine to field to fork.²



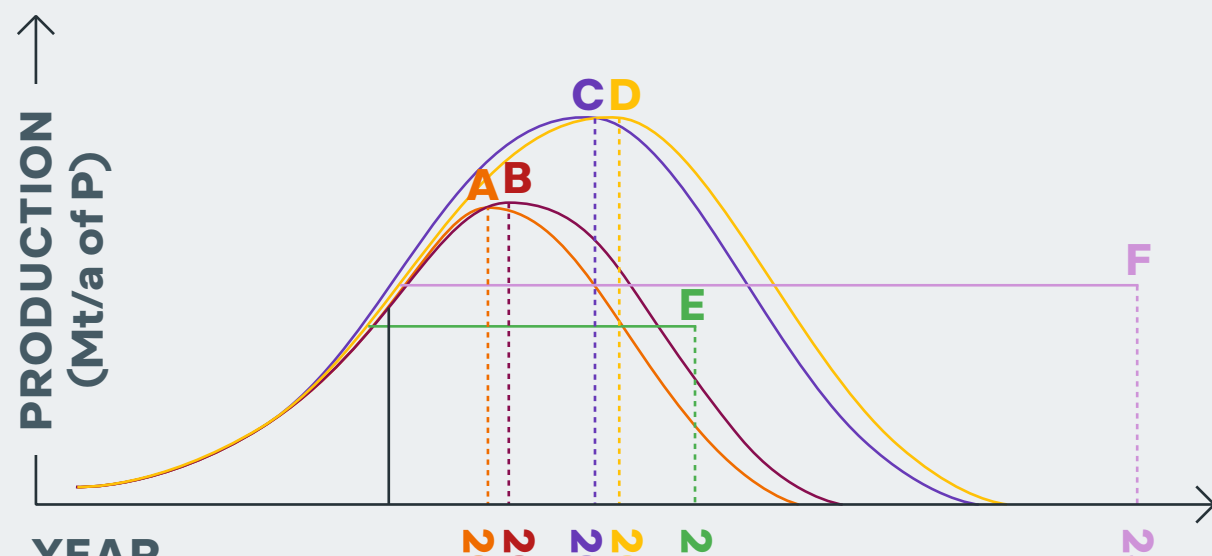
Most phosphorus is ultimately lost to water bodies via agricultural runoff and waste water.



Excess phosphorus in water causes algal blooms and eutrophication. It's estimated that eutrophication costs the United States \$2.2 billion annually.³

SUPPLY / DEMAND

Peak phosphorus is estimated between 2025 and 2084, after which high-quality sources of phosphorus will diminish and become harder and more expensive to extract.¹

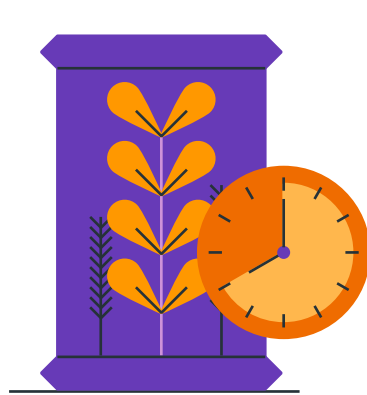


- A Mohr & Evans (2013)
- B Cordell et al. (2009), Cordell & White (2011)
- C GPRI (2010), Cordell et al. (2011)
- D Walan (2013)
- E Fixen (2009)
- F Van Kauwenbergh (2010)

At the same time, phosphorus demand is rising with most demand coming from developing countries.

There are no substitutes for phosphorus in agriculture.

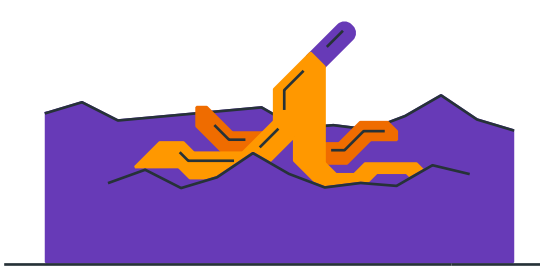
What can we do about it?



CHEMISTS

Innovation for More Efficient Phosphorus Use

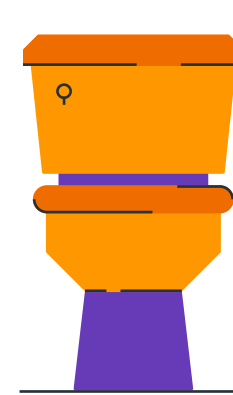
- Improving soil fertility monitoring and fertilizer application.
- Making innovations in time-release fertilizer.



INDIVIDUALS

Choices to Decrease Phosphorus Demand

- Wasting less food decreases the demand for phosphorus, and composting kitchen scraps keeps phosphorus in the soil.⁴
- Eating a diet with less meat and dairy reduces phosphorus-heavy livestock rearing.⁴



INSTITUTIONS

Programs to Recover and Recycle Phosphorus

- Recovering from waste treatment plants the three million tons of phosphorus we pass through in our urine and feces globally each year.²
- Recycling industrial phosphorus waste, such as phosphine oxides.

Find out more about Critical and Endangered Elements: acs.org/endangered-elements

SOURCES

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- 2 Cordell, D.; White, S. Sustainable Phosphorus Measures: Strategies and technologies for achieving phosphorus security. *Agronomy*, 2013, 3(1), 86-116. <https://doi.org/10.3390/agronomy3010086>
- 3 Dodds, W. K.; Bouska, W. W.; Eitzmann, J. L.; Pilger, T. J.; Pitts, K. L.; Riley, A. J.; Schloesser, J. T.; Thornbrugh, D. J. Eutrophication of U.S. freshwaters: Analysis of potential economic damages. *Environ. Sci. Technol.* 2009, 43(1), 12-19.
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- 5 U.S. Geological Survey, Mineral commodity summaries 2019, pp 200, <https://doi.org/10.3133/70202434>