



## The Phosphorus Problem

**For Prelims:** Phosphorus, Synthetic Fertilizers, Apatite, Cadmium Contamination, [Precision agriculture](#), [PM-PRANAM](#).

**For Mains:** Contemporary Challenges Surrounding Phosphorus, Potential Strategies for Managing Phosphorus Usage.

[Source: TH](#)

### Why in News?

The **global phosphorus problem** is gaining attention. With limited **phosphorus reserves**, **contamination issues**, and **disruptions in the fertilizer market**, finding sustainable solutions has become a critical priority.

### What are the Major Facts Related to Phosphorus?

- **About:**
  - **Phosphorus is a chemical element with the symbol "P" and atomic number 15.** It is an essential element for life and has various important properties and applications.
- **Chemical Properties:**
  - Phosphorus readily forms compounds with other elements, especially oxygen, forming various phosphates.
  - It is highly reactive and can spontaneously combust in air, producing a white smoke.
  - **Phosphorus compounds are crucial in biology**, as they are a fundamental component of **DNA, RNA, and ATP (adenosine triphosphate)**.
- **Natural Occurrence:**
  - Phosphorus is commonly found in the Earth's crust in the form of various **phosphate minerals, such as apatite**.
- **Industrial Uses:**
  - Phosphorus compounds are used in the production of fertilizers, as they are necessary for plant growth.
  - It is also **used in detergents**, where phosphate compounds help break down and remove stains.
  - Phosphorus is utilized in the **production of steel and other metallurgical processes**.
- **Phosphorus in India:**
  - India is **deficient in Apatite** (group of phosphate minerals) & **Rock Phosphate availability**.
  - According to **Indian Minerals Yearbook 2018**, in case of apatite, the country is fully dependent upon imports, while the Rock Phosphate production is only from two states namely, **Rajasthan and Madhya Pradesh**.
    - India is the world's **largest importer of phosphorus**, primarily **sourcing it from West African deposits contaminated with cadmium**.
    - **Paddy**, a staple crop in India, is particularly prone to **cadmium uptake**, and

Indian farmers extensively use fertilizers on paddy fields.

## What is the Historical Evolution of Fertilization and Contemporary Challenges Surrounding Phosphorus?

### ▪ Historical Evolution:

- The issue of fertilizing land has **plagued agriculture since its inception**. Early agricultural societies recognized that **repeated cultivation and harvest cycles depleted essential nutrients** from the soil, diminishing crop yields.
  - Indigenous communities devised various fertilization methods, **including using fish remnants and bird droppings (guano)**.
- However, significant advancements in chemistry during the **19<sup>th</sup> century** led to the creation of **synthetic fertilizers** and the identification of vital elements like **nitrogen, phosphorus, and potassium**.
  - These elements laid the **foundation for modern chemical fertilizers** and played a pivotal role in boosting agricultural productivity during the **Green Revolution of the mid-20<sup>th</sup> century**.
  - In the present scenario, **there exists a multifaceted challenge involving phosphorus**, a crucial component of fertilizers.

### ▪ Challenges Associated with Phosphorus:

- **Limited Reserves and Cadmium Contamination:**
  - Phosphorus is **scarce and primarily found in specific geological formations**. This is a major geopolitical concern.
  - **Morocco and the Western Sahara region possess the world's largest phosphorus reserves**, but these reserves contain **cadmium**, a **harmful heavy metal** that can accumulate in the kidneys of animals and humans when consumed.
  - The extraction and removal of cadmium from phosphorus resources are costly processes.
    - Cadmium-laden fertilizers can **contaminate crops, leading to potential health risks, such as heart disease**.

## Note

**Failing to eliminate cadmium** from phosphorus sources carries the potential for a public health crisis. Conversely, the **removal of cadmium could result in higher fertilizer expenses, introducing a complex trade-off between safeguarding public health and maintaining agricultural affordability**.

- The **European Union** has introduced **legislation to regulate cadmium levels in fertilizers**.
- **Market Disruptions and Associated Concerns:**
  - Out of all the countries, only **six have significant reserves of cadmium-free phosphorus**.
    - Among them, **China imposed export restrictions in 2020**, and several EU nations stopped purchasing from Russia.
      - Consequently, there has been a surge in demand for safe phosphorus.
  - This is **one of the factors behind Sri Lanka's decision to ban synthetic fertilizer imports in 2021** and shift to organic farming.
    - However, **this transition led to a sudden decline in crop yields**, triggering a political and economic crisis in the country.
- **Phosphorus Overuse:** Excessive fertilizer application leads to phosphorus runoff into water bodies. Excessive phosphorus **promotes algal blooms, depleting oxygen in water bodies** and causing fish deaths.
  - Algal blooms can also be **toxic to humans, leading to respiratory issues and other health problems**.

- **Energy Intensive Mining:** Extracting and processing phosphate rock is energy-intensive, contributing to [greenhouse gas emissions](#) and **environmental degradation**.

## What can be Potential Strategies for Managing Phosphorus Usage?

- **Smart Agriculture and Precision Fertilization:** Implement [precision agriculture techniques](#) that utilize sensor networks, [AI, and data analytics](#) to optimize phosphorus use on farms. This ensures that crops **receive the exact amount of phosphorus they need**, reducing excess runoff into water bodies.
  - **Union Budget 2023-24** launched the [PM-PRANAM](#) scheme to promote the **balanced use of chemical and alternative fertilizers**, generating awareness of **regenerative agriculture (RA)**.
- **Phosphorus Recovery from Sewage and Waste:** There is a need to develop **advanced technologies for efficient phosphorus recovery from sewage and various waste streams**.
  - This could include using **innovative filtration, precipitation, and ion-exchange processes** to extract and recycle phosphorus for use in fertilizers or other applications.
  - **Example:** Companies like **EasyMining** are **retrofitting [sewage treatment](#) plants** to recover high-quality phosphorus products.
- **Circular Phosphorus Economy:** There is a need to **establish a [circular economy](#) for phosphorus**, where products containing phosphorus are designed for **easy recovery and recycling**, reducing the need for mining and reducing environmental impact.
- **Global Phosphorus Management Framework:** There is a need to **develop an international framework for phosphorus management**, similar to global climate agreements. This would **promote collaboration and coordinated efforts to address phosphorus concerns** on a global scale.

## UPSC Civil Services Examination, Previous Year Question

**Q. With reference to chemical fertilizers in India, consider the following statements: (2020)**

1. At present, the retail price of chemical fertilizers is market-driven and not administered by the Government.
2. Ammonia, which is an input of urea, is produced from natural gas.
3. Sulphur, which is a raw material for phosphoric acid fertilizer, is a by-product of oil refineries.

**Which of the statements given above is/are correct?**

- (a) 1 only
- (b) 2 and 3 only
- (c) 2 only
- (d) 1, 2 and 3

**Ans: B**

**Exp:**

- The Government of India subsidizes fertilizers to ensure that fertilizers are easily available to farmers and the country remains self-sufficient in agriculture production. The same has been achieved largely by controlling the price of fertilizer and the amount of production. **Hence, statement 1 is not correct.**
- Ammonia (NH<sub>3</sub>) has been synthesized from natural gas. In this process, natural gas molecules are reduced to carbon and hydrogen. The hydrogen is then purified and reacted with nitrogen to produce ammonia. This synthetic ammonia is used as fertilizer, either directly as ammonia or indirectly after synthesis as urea, ammonium nitrate, and monoammonium or diammonium phosphates. **Hence, statement 2 is correct.**
- Sulfur is a major by-product of oil refining and gas processing. Most crude oil grades contain some sulfur, most of which must be removed during the refining process to meet strict sulfur content limits in refined products. This is done through hydrotreating and results in production of H<sub>2</sub>S gas, which is converted into elemental sulfur. Sulfur can also be mined from underground, naturally-

occurring deposits, but this is more costly than sourcing from oil and gas and has largely been discontinued. Sulfuric acid is used in the production of both Monoammonium Phosphate (MAP) and Diammonium Phosphate (DAP). **Hence, statement 3 is correct.**

- **Therefore, option B is the correct answer.**

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