Better Phosphorus Use Can Ensure its Stocks Last More than 500 Years and Boost Global Food Production

The world has enough stocks of phosphorus to boost global food production for over 500 years – but only if countries are less wasteful with how they use this finite supply.


Phosphate mine in Morrocco / photo by Rich McDowell

More efficient use of phosphorus could see limited stocks of the important fertiliser last more than 500 years and boost global food production to feed growing populations.

But these benefits will only happen if countries are less wasteful with how they use phosphorus, a study published today in Nature Food shows.

Around 30-40 percent of farm soils have over-applications of phosphorus, with European and North American countries over-applying the most.

The global population is due to hit nearly 10 billion by 2050 and it is estimated that to feed this increased population a further 500 million hectares of arable land will be needed – unless phosphorus can be more efficiently used to boost and maintain crop yields.

Listed as a critical raw material by the European Union, and recently a topic of discussion by the United Nations Environment Assembly, globally 20,500 kilotons of phosphorus are applied to agricultural soils each year as fertiliser.

Concerns have been raised about its limited supply and loss to freshwater where it can degrade water quality. Phosphorus predominantly comes from mining phosphate rock sources, of which there are only a relatively small number of sources located in countries like Morocco and Russia.

Previous estimates of how much phosphorus we have left globally have varied greatly from between 30 to over 300 years. These prior estimates were based on current wasteful practices continuing and contained a lot of uncertainty.

This latest research, looking at global phosphorus use and soil concentrations, by scientists at Lancaster University in the UK as well as AgResearch and Lincoln University in New Zealand, examined concentrations of phosphorus in farm soils across the globe for optimum growth of 28 major food crops from wheat and maize to rice and apples. The research revealed soils that did not contain enough phosphorus, and soils that contain concentrations higher than plants need for optimal growth.

Their findings shed new light on the amounts of phosphorus available in soils and needed as fertilisers and reveal that phosphorus reserves could last for up to 531 years if we use it more efficiently and equitably – that's 77 years longer than if we stick with current practices.

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Professor Phil Haygarth of Lancaster University and co-author of the paper said: "Phosphorus is an essential fertiliser that drives food production on farms around the world. It's the 'energy' of agriculture that drives our food systems, but we need to manage our supplies carefully.

"We need to seek ways to be more efficient and sustainable with its use and our study shows that there's considerable potential to improve the efficiency of how we use phosphorus fertilisers. We show it's possible to optimise global food production without accelerating the depletion of precious and finite global phosphorus fertiliser reserves.

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The research team calculated 10,556 kt of phosphorus is wasted each year through over-application with much of that dominated by wheat and grassland in Europe and maize and rice in Asia.

Professor Richard McDowell of Lincoln University and AgResearch New Zealand and lead author of the study said: "Many farmers over-apply phosphorus to bank it in the soil. However, only a fraction of soil phosphorus can be used by plants. Adjusting applications to sustain the levels that plans need to produce optimal yields negates the need for phosphorus being wasted. If there are excessive levels in soil that plants can't use, phosphorus can potentially be lost to water, which risks causing water quality problems like eutrophication."

But it is not all about reductions. The scientists, using data for farmland globally, also calculated that around the world nearly three quarters of farmed soils are in phosphorus deficit – with phosphorus deficits being most acute in Asian countries such as India. As a result, the researchers calculate that globally there needs to be an application of almost 57,000 kt of phosphorus to alleviate those soils in deficit to boost crop yields.

They then calculated that 17,500 kt of phosphorus is needed each year to maintain optimum soil phosphorus concentrations. This would result in a global reduction in the demand for phosphorus by around 3,000 kt annually.

Professor McDowell said: "The science is clear, but to use phosphorus efficiently and extend supplies, governments need to collaborate to make policy that promote phosphorus use only where needed. That will involve balancing distributions of phosphorus for optimal crop growth and reducing subsidies that sustain overuse of phosphorus and likely cause water quality problems."

The findings are outlined in the paper 'Phosphorus applications adjusted to optimal crop yields can help sustain global phosphorus reserves' published by Nature Food.

The paper's authors are Professor Richard McDowell and Peter Pletnyakov of Lincoln University and AgResearch, and Professor Phil Haygarth of Lancaster University. Professor McDowell was funded by New Zealand's Our Land and Water National Science Challenge.

Additional information:

Separately to this international Nature Food article, Our Land and Water simultaneously released a New Zealand-focused report, The viability, feasibility, and environmental effects from using New Zealand sourced phosphate. The key findings are:

- New Zealand has accessible, on-shore sources of phosphate.
- There are known phosphate deposits in Clarendon, Otago (containing at least 1.6Mt of phosphate ore) and in North Canterbury and Kaikoura (containing a combined 10-20 Mt). There are also likely deposits in South Canterbury and Waitaki.
- The carbon footprint for domestically sourced phosphorus would be approximately half that of imported material.
- The quarrying process for phosphate rock has similar environmental effects to that of limestone.

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