NUTRIENT CYCLING

Opportunity to improve Global phosphorus governance

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Nutrient recycling is key for the circularity and sustainability of food systems. Understanding the movement of phosphorus through trade enables better geo-spatial planning and highlights opportunities for more effective phosphorus governance.

Phosphorus is a critically important element, underpinning our biological existence as part of DNA, and a key driver of our food systems [1]. Since the last century, humans have altered the Global phosphorus cycle, mining rock phosphate and distributing it around the World, mostly for use as fertiliser for crops and in animal feed, driving high-yielding food production. Unfortunately, it also leaks from productive systems and is not discriminating in driving productivity where it is unwanted, becoming acutely damaging to biodiversity and potentially, the long-term stability of the wider Earth system [2 3].

Bai et al. [4] provide us with a timely assessment of the movement of phosphorus embedded in agricultural products, using global trade matrices, a study that provides new and helpful insight into the scale and potential significance of human-led interference in the Global phosphorus cycle. Their work reveals the output per unit of phosphorus input for crop and livestock products for much of the World's trading nations since the early 1960s, not long after the start of the rise in use of Global phosphorus fertiliser. Bai et al. claim that trade in agricultural phosphorus products has saved the need to use large amounts of phosphorus in fertilizers and in animal feed, which on the face has been a great benefit. Their analysis reveals a fourfold increase in the phosphorus embedded in total exported agricultural products from 1992 to 2019 and a change in Global geographic patterns: Much of the imported feed phosphorus was dominated by Western Europe in the 1990s, with a shift towards a more evenly distributed pattern in 2019.

Bai and co-authors offer several important recommendations based on their findings; adoption of advanced phosphorus recycling technology; optimisation of fertiliser use and use of high yield breeding; spatial planning of crop-livestock production and improvement of the trade structure. Their most concerning finding is that since the 1990s, the total imported food and feed phosphorus that was recycled to agriculture appears to have decreased, in the new analysis. Adoption of advanced phosphorus recycling technology has been the primary call from the sustainable phosphorus community for well over two decades [5,6] and this seems to remain a priority recommendation from Bai et al.'s work, and is a 'wake up' to the Global community. So, a key question arising, is why is recycling seeming to diminish and what can we do as a Global community to address this?

Calls for the optimisation of fertiliser use, and high yield breeds are also welcomed as challenges for the World community. It has long been well-known that uptake of soil phosphorus presents many challenges to soil scientists as crop uptake is tremendously inefficient, with many opportunities for innovation improvements remaining at the plant soil interface [7]. Bai et al., reveal how the challenges are region specific: Ghana, Kazakhstan and Guyana are net exporting countries with large yield gaps, but geopolitical conditions and economic power impede development in this area. On the

other hand, net importing countries (Western European nations) already achieve high yields and relatively efficient phosphorus utilization. In such systems market economies and consumer dynamics are driving excess phosphorus, and a lack of investment in waste recycling. Moreover, and notwithstanding this new analysis, it is essential to stress the urgency of getting new phosphorus fertiliser supplies to some parts of the world, such as much of the continent of Africa that are still deplete of adequate phosphorus for food production [8,9].

Bai et al., suggest that geo-spatial planning could promote phosphorus circularity. Whilst this is a noble and irrefutable aspiration, there may be some challenges in achieving this. In practice crop and animal production tend to be naturally spatially separate for sound historic and geographic reasons, arising from physical differences in land used for grassland and arable agricultures. Grassland livestock production is best suited to higher rainfall areas often close to maritime coasts or in hill country, whereas cereal production favors flatter drier locations, often in continental interiors such as, for example, the Mid-Western USA. The supporting farming infrastructures are also deeply embedded in these regions. Therefore, relocating phosphorus in manure from the animal farming regions to the cropping regions of the World presents some challenges that require innovative solutions. So, land-use is also often driven by socio-cultural histories and socio-economic viability and so any solutions to Global phosphorus sustainability need to be spatially, physically and culturally relevant.

Our Planet is ca. 4.5-billion-year-old, yet it is less than a century since we started mining rock phosphate. Trade of agricultural products underpins most of the phosphorus movement around the Globe, and by broadening the conversation perhaps Bai et al. can help us broaden the solutions? Their article highlights to the economist the immediate monetary waste evident in the current trade system, while we should also be reminded of the additional costs if we continue to damage the environment [10]. Bai et al's analysis clearly highlights the interconnected and Global nature of the phosphorus problem, that it is not a burden or liability that can be exported to another geopolitical region, or stakeholder, it is on everyone's doorstep, and solutions will come from a variety of actors and measures, across a range of scales. We are also reminded that whilst such Global scale models produce interesting macro global analysis, the challenge is in linking these to local solutions [10]. It highlights that phosphorus is a Global story and that smart fiscal responses could play a key role. The challenge is to find an adequate way to interfere here, otherwise analysing patterns in Global trade may be likened to rearranging the deckchairs on the Titanic; whichever way you look at it we need to become more sustainable with our use of phosphorus.

Such studies act to provoke the international community to generate opportunities for change and manage the phosphorus cycle. Ultimately, to enact on the necessary changes, it seems that there is an opportunity for more effective phosphorus governance across scales, from Global to local. We need a mobilisation of many disciplines to navigate this global system and invest in evidenced-based, appropriate, and fit-for-purpose solutions. To achieve this, we must find a way to nurture new leadership, and merge this thinking with other major nutrient cycles (carbon being the obvious one). In 2023 we are at a true fork in the road for Global phosphorus, and this insight from Bai et al's work provides a new opportunity to improve Global phosphorus governance.

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Competing interests

There are no competing interests