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COMMENTS

Comments on "Innovations of phosphorus sustainability: implications for the whole food chain" in special issue of "Sustainable Phosphorus Use in Agri-Food System"

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Phosphorus (P) is an essential nutrient for crops, animals and humans, however, the quantity and spatial distribution of mineral P reserves are limited and uneven. There is some uncertainty about the total quantity of economically-extractable P reserves. Most recent evidence suggests the total global reserves could last for several hundred years or more, but most of these reserves are in northern Africa, so access to this supply could be disrupted. Disruption of access to mineral P resources could threaten global food security[1]. Juxtaposed against this supply limitation is the fact that environmental impacts, especially water quality or eutrophication, have arisen from excessive and improper use of P fertilizers and other P resources[2,3]. Therefore, it is extremely important to manage P inputs for sustainable food production and environmental protection[4]. Addressing this situation within this special issue on sustainable P use in agriculture, Shen et al.[5] proposed a new framework for innovations of P sustainability with implications for the whole food chain .

By extensively reviewing the literature, Shen et al.[5] systematically summarized the problems and challenges of P in the entire food chain, from producers, processors, transporters and consumers, including P utilization in soil-crop systems (i.e., P in soil, rhizosphere/mycorrhizophere and plant) to livestock production systems, from P behavior in catchments to P recycling, as well as sustainable solutions for P management (e.g., new technologies, policy support, actions and changes).

As highlighted by Shen et al.[5], P is a non-renewable and geographically restricted resource, but agricultural P requirements will continue to increase with increasing global population and living standards. This conflict between supply and demand creates a huge challenge for managing P resources sustainably. Despite this, in intensively managed agricultural areas, accumulated P additions have led to a high content of soil mobile P, with negative effects for environmental quality and water pollution and/or eutrophication. A study by Ma et al.[6] also confirmed a rapid increase in P inputs and surplus in China's arable soils and potential environmental risks for the period from 1980 to 2012. The remediation of already polluted soil and water, and recovery of P for reuse are also key problems. The authors, therefore, propose a holistic solution for sustainable P management in different sectors (e.g., fertilizer industry, crop and animal production and food industry) of agriculture from mining to dining (see Fig. 1 in Shen et al.[5]). Shen et al.[5] highlighted innovations of sustainable P management for the whole P supply chain from extraction to application in cropland. The key points are activation of insoluble P in soil, rhizosphere and mycorrhizosphere, and recycling of various P resources. This framework will motivate research and policy development to balance the requirements of both food security and environmental safety globally, through improving P use efficiency and lowering P losses to the environment through technological innovation (e.g., innovative P fertilizers and precise fertilization application), recycling of P in organic manure, crop residues and other resources with policy support and some national actions and changes. We believe that

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a particular challenge to this approach will be for animal production systems, both in China and elsewhere. Manure and the P it contains are concentrated where animals are fed on transported feed, and this manure is often treated as a waste to be discarded rather than a resource to be recycled. The approach of Shen et al.[5] can be practiced smoothly, and if the challenges posed by animal systems can be addressed, we predict that sustainable P use in agriculture will be achieved not only in China but also globally.

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