Phosphorus use inefficiency in China's agriculture – Implications for global phosphorus security

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Background

Phosphorus (P) is an essential nutrient for plant growth; this makes it a key ingredient in fertilizers necessary to sustain high crop yields worldwide (Cordell et al., 2011; Ulrich & Schnug, 2013). In fact, agriculture is by far the greatest consumer of P resources with 90% of total societal P use associated with food production (Van Kauwenbergh, 2010; Wang et al., 2011). Most of the world's P is derived from mined phosphate rock; a non-renewable and increasingly scarce natural resource (Cordell et al., 2009; Cordell & White, 2011). Thus, managing P use efficiency in agriculture is an urgent, global challenge.

Today, China is one of the largest producers and consumers of P fertilizer in the world. The country is also the holder of the second-largest phosphate rock reserves after Morocco. However, the supply is dwindling (Wang et al., 2011).[1] Furthermore, there is now clear evidence that agricultural P inputs are often used inefficiently, leading to losses and associated environmental pollution (Ma et al., 2013; Sims et al., 2013; Wang et al., 2011). Considering China's economic power, size and large population base, how the country will meet food security challenges while improving P resource-use efficiency and environmental sustainability is of both national and international concern (Ma et al., 2013; Sims et al., 2013; Zhang et al., 2008).

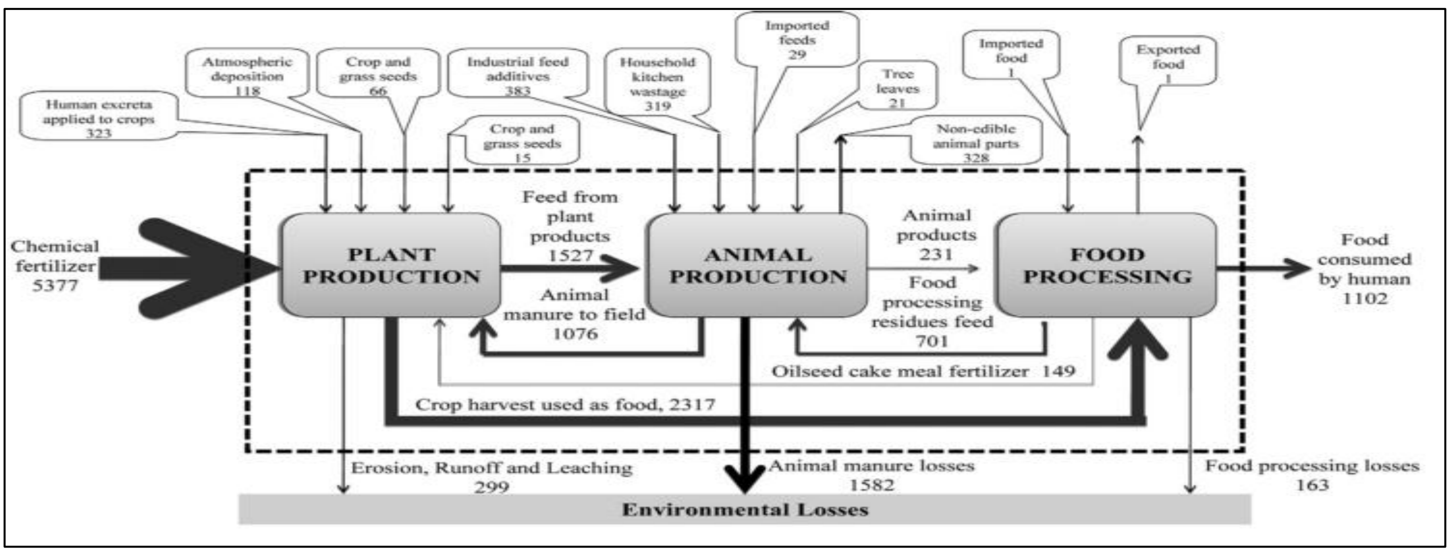

Figure 1. P flows into, within, and out of the major sectors of the food chain in China (in Gigagrams - Gg): Overall the food chain had 6652 Gg of external P inputs and 1102 Gg P as food output for human consumption with an overall P use efficiency of only 18 % (all data for the year 2006; figure adapted from Wang *et al*., 2011).

Scientific Debate

In 2008, a short-term 800% price spike in P fertilizer commodities, due to increased demand, sparked interest in long-term P security. There is no substitute for phosphate rock and the natural reserves that are unevenly distributed around the globe are steadily being depleted (Cordell et al., 2009; Cordell & White, 2011). Whilst the critical nature of P in agriculture as highlighted in the introduction is not in doubt, there is much debate over the 'timeline' of remaining phosphate rock reserves; estimates range from 100-1000 years (Cordell et al., 2009; Koppelaar & Weikard, 2013; Van Kauwenbergh, 2010).

Some of the uncertainty is due to lack of accurate data and research, while other sources of contention are due to misunderstanding and oversimplification of the situation and the fundamental principles and

[1] While China is one of the largest annual producers of P, it recently imposed a 135% export tariff on phosphate, effectively banning any exports in order to secure domestic supply (Cordell & White, 2011).

assumptions around which the arguments concerning P availability are based (Cordell & White, 2011). What is clear, though, is that the supply of high grade phosphate rock is likely to be constrained in the future while demand and prices are expected to rise (Cordell & White, 2011). As a result, collaborative research and literature concerning phosphate rock depletion have proliferated and the issue of global P scarcity has been taken up by a number of recently founded international platforms such as the Global Phosphate Forum, Global Phosphorus Research Initiative, Global Phosphorus Network and the European Phosphorus Platform (Ulrich & Schnug, 2013).

Despite this burst of interest in P, research and debate has mostly centred on Western Europe and North America and relatively little has been said about emerging economies. China has experienced rapid socio-economic development and is the most populous country in the world with forecasts indicating a population of 1.5 billion by 2030 (Ma et al., 2010). Notwithstanding, China grows enough food to feed 20% of the world's population with only 9% of global arable land (Li et al., 2013). To achieve these impressive crop yields, farmers have intensified their production, aided by massive fertilizer subsidy programmes that ensure the availability of sufficient fertilizers at affordable prices (Li et al., 2013). However, combined with a high rate of urbanisation- 50% in 2010- and changing dietary preferences towards a greater inclusion of animal products, these trends pose serious challenges to the sustainability of agriculture and the management of P flows (Ma et al., 2010).[2]

P use efficiency in China is lower than the global average, and this is partly due to over-application and mismanagement of fertilizers (Ma et al., 2013; Li et al., 2013). As can be seen in Figure 1, the main source of total P entering the food chain is as chemical fertilizer; comprising 75% of the total plant production sector inputs. Excess P on crop fields results in losses via erosion and runoff causing pollution of water bodies (Chen et al., 2008; Li et al., 2013). The largest component of P output is from the animal production sector in the form of excreta – 2658 Gg. Of this, 1582 Gg of manure or 60% is not recycled into agricultural land but lost to the environment. In fact, the animal production sector is by far the greatest source of P losses to surface waters (Ma et al. 2010; for an in-depth assessment of the environmental impacts of Chinese livestock policies, see Zheng, 2013). Eventually, only 18 % of P entering the Chinese food chain is captured in food for human consumption (Wang et al., 2011). Understanding these flows is crucial to developing innovations and policies that maximise the efficiency of P use and thus relieve the pressure on global P reserves.

Further issues for consideration

The following issues are suggested for consideration by policy makers:

- Introduction of a collaborative national nutrient monitoring- and advisory system (Li *et al*., 2013; Sims *et al*., 2013)
- Implementation of measures to improve P efficiency in the food chain through: improving animal husbandry infrastructure and waste management, preventing erosion and improving fertilizer recommendation and application methods (Schröder *et al*., 2011).
- Research on the feasibility of new technologies and low cost options for P recycling and recovery (Koppelaar & Weikard, 2013)

[2] Research shows regional variation in P use efficiency- the expanding cities situated along China's eastern shoreline exhibit the highest rates of P losses due to concentrated, industrialized food production practices (Hou *et al*., 2013)

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