The Future of Phosphorous

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1. Introduction

The interlinked issues of farming and nutrients now regularly makes news headlines in New Zealand and around the world. In NZ, the main concern currently is mostly nitrogen, particularly in relation to dairy farming. However, phosphorous is not far behind, firstly because it is the other main cause of waterway pollution, and secondly, and much more importantly, because the supply of phosphorous is finite, and we may ‘run out’ relatively soon. An indication of the growing political importance of this issue is a recent report from the European Commission (the executive body of the European Union) “Science for Environment Policy, in-depth report: Sustainable phosphorus use”(Science Communication Unit University of the West of England Bristol, 2013) http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR7.pdf which makes for rather sobering reading. This article looks at the main issues raised by the report and puts them in a New Zealand context.

2. Infinite nitrogen vs. scarce phosphorous fertilisers

As the name implies all essential plant nutrients are essential, and if their availability is sub-optimal pant growth and yield suffers and if they are deficient, plants struggle to grow at all. However, across the planet it is N and P that are the crop nutrients that most commonly limit crop growth, i.e., that are at sub-optimal levels, and they are also the nutrients that are required in the largest amounts for crop growth and therefore need to be applied in the largest amounts. While there are many problems with synthetic N fertilisers, from the fossil energy used in their manufacture through water pollution and multiple contributions to climate change, there will never be an absolute shortage of nitrogen fertiliser, as N makes up about 80% of the atmosphere, and practically all the N on the planet is in the sky: you could say bag nitrogen is dug out of the sky. Farming will therefore never face an absolute shortage of N, just difficulty in finding enough energy to fix it and avoid the downstream problems it creates. Phosphorous, and all the rest of the essential nutrients / fertilisers, such as magnesium, potassium, etc., are completely different to N, they don’t have atmospheric forms, they can’t be dug out of the sky, instead they are dug out of the ground.

While there is some 1,600,000,000,000,000,000 tonnes of P in the earth’s crust, most of it is very dilute, e.g., a fraction of a percent of most rocks so it is unusable as fertiliser. Concentrated forms that are sufficiently easy to extract and turn into fertilisers are very few and far between. These deposits were created by geological processes, mostly from the evaporation of shallow seas, tens to hundreds of millions of years ago (in the days of the dinosaurs). Phosphorous fertiliser is therefore akin to fossil fuels, in that it was created in the distant geological past, and is now being dug out of the ground infinitely faster than new deposits are being created. Once we have exhausted these concentrated forms, then agriculture is faced with a very acute shortage of phosphorous fertiliser.

So just as there will be, or has been, peak oil, there will also be a peak of fossil P fertilisers. And, also like peak oil, there are endless arguments about when it will happen, because much of the knowledge about current reserves are sensitive commercial secrets, and as prices start to rise due to demand outstripping supply, the economic optimums for mining may shift and the profitability of currently underused or difficult to access P sources will improve, and so bring them on line, therefore shifting the goal posts. Despite this uncertainty, the estimates for peak phosphorous start in around 50 years, which is not very long.

3. Peak phosphorous

This situation is not new. The world faced a serious P shortage back in the mid 1800’s which resulted in "guano imperialism" where the USA annexed a large number of oceanic islands rich in guano (Foster & Magdoff, 1998). Yet another crisis loomed with the depletion of the guano, which was solved by the current practice of using mined rock phosphate. The problem is that the fundamentals have not changed in any of these systems: a clearly finite source of phosphorous is being used to supply agriculture with P, which is then lost to waterways either directly or via produce eaten by consumers, passed into the sewerage systems and then finally flushed out to sea. However, unlike the past where new sources of P were available to replace the previous one as it ran out, this time, there are no new sources. Science now fully understands where all the phosphorous is on the planet, and there are no new sources.

4. Solutions

The solution, as the EU report points out, is that society as a whole, including agriculture, needs to turn the current phosphorous stream, back into a cycle, as happens in natural systems. The main strategy the report suggests is two fold:

1) maximise the effective use of P, by for example, only applying sufficient P to meet crop needs, which minimises nutrient runoff, i.e., waste, and reducing the amount going into the food system, through things such as reducing food wastage (both at home and in the supply chains) and moving to a plant dominated diet, i.e., less meat, as meat is higher in P than plants and producing it also uses more P per unit of food.

2) Capture and recycle the P moving through the sewerage and other biological waste streams, e.g., green ‘waste’ going to landfill, and return it to the farmland from where it originated.

While easy to say, the practicalities of these requirements are immense. They effectively require a major redesign of the way economies and societies work and the engagement of both citizens and political leaders. Interestingly, and possibly fortunately, many of these solutions are similar to those proposed to deal with other global issues such as climate change and food security, i.e., changing the food production and supply business and the way people prepare food and what they eat.

5. The implications for NZ

The implications for NZ are therefore profound. With about half of our economy based on agriculture, and agriculture entirely dependent on phosphorous, for which there is no substitute (regardless of what some economists may think!), reducing availability of P fertilisers can only push up input costs and/or threaten product ivy. This is why Chatham Rock Phosphate Limited are so serious about the difficult task of mining phosphorous from the sea floor, and why there has been a recent rush in the financial sector to invest in phosphorous mines as they believe they will be major cash cows.

If the world does move to reduce its consumption of meat and other animal products (clearly against current opposite trends, due to increasing affluence) that will impact our animal dominated agriculture. At the same time, people still have to eat, and applying some very basic economics, e.g., that iPads are not edible, a growing world population is going to need (as in have to have) more food, so growing markets should cause prices to rise, potentially balancing out increased P prices.

Finally there is the issue of getting ‘our’ phosphorous back from our customers. The EU report, was clearly EU focused, and as the EU is a net importer of food, and therefore P, if it can effectively recycle all its P from its sewerage and other waste streams, then, it will have more P than it needs for its own farmland. However, with NZ producing enough food to feed 40, million people, 36 million of whom live overseas, the P in exported products will have to be shipped back again. This is if those overseas customers are willing to return the P in the first place rather than use it for their own agricultural systems.

Clearly there are large number of known unknowns in this mix, many with complex interactions that make predictions difficult, and all of which may be further muddied by Donald Rumsfeld's infamous unknown, unknowns. Finally the P issues is only one of the other major societal changes required to address major global issues such climate change - some of which work with and some against the need to recycle P. The future of phosphorous is therefore a key component of what has been described as the perfect storm of issues heading civilisations way (Beddington, 2009).

Over in the silver lining department, there are some positives that come out of a move to the use of recycled P. Current fossil phosphorous sources all contain a significant amount of the toxic heavy metal cadmium (Cd) that accumulates in soil and enters the food chain. In NZ, due to our extensive use of P fertilisers, Cd levels are now reaching 'hazardous' levels in some soils and NZ sheep offal has Cd levels higher than recommended for human consumption. It is very hard, and therefore expensive, to remove the Cd and other unwanted elements from mined phosphate, so there is currently no grand plan on how to deal with this issue. However, recycled phosphorous generally has low levels of such contaminants and future recycling systems can be designed to further minimise such unwanted materials. Ironically, the need to move to recycled P could be the solution to NZ's cadmium issue.

To conclude, the future of phosphorous is no longer some abstract academic argument that is far in the future. The issue is already moving up the political agenda, as evidenced by the EU report, and the investment rush into phosphorous mines show that the financial sector believes that prices will go up, along with profits. The future of phosphorous has therefore already started. It is therefore increasingly important that NZ as a national and particularly farmers and growers start to understand and grapple with this vital issue.

6. References

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