The real impact of a limit to cadmium in European fertilizers – a constructive approach

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The reason behind this paper

In recent years, the words "phosphate" and "cadmium" have jointly come under the spotlight even in non-specialised press articles, and on more than one occasion have depicted scary, almost "doomsday" scenarios that may come as a consequence of regulatory changes by the European Commission.

Given the large amount of sometimes misleading and exaggerated claims that have been made, we felt that, as long-serving, independent market analysts, we can assist in the debate by providing some context on the issue by drawing on our specialised knowledge of the market, and by providing a general framework that will enable a properly informed policy decision.

The intention of this paper is ***not*** to take a position on the issue at stake, but rather to present a general analysis of the actual proposal and its potential effects.

What is cadmium, what is phosphorus, and why the two are connected

Cadmium is a heavy metal which some studies have suggested could have a negative impact on human health if consumed in food in sufficiently high quantities. Cadmium accumulates in the human body, mainly in the kidneys, and if sufficient quantities are ingested can lead to kidney failure.[1] The debate on the actual threshold for human cadmium consumption to be considered dangerous is still ongoing.

Phosphorus is a chemical element, widely used in agriculture as it is one of the three "macro-nutrients" (alongside nitrogen and potash) essential for plant life. Phosphorus is essential for the development of the root system of plants. It is most available to plants in its oxidised form of di-phosphorus pentoxide (P_2O_5). Fertilizer manufacture is not the only use of phosphorus, but it is nonetheless the largest one in terms of overall consumption.

The raw material for the production of fertilizer phosphorus is phosphate rock, a general term referring to ores that contain a sufficiently high concentration of phosphorus to be commercially viable to exploit. Apatite is the most common form of phosphorus mineralisation – this term is commonly used in reference to high-grade concentrate of igneous origin (as opposed to concentrate of sedimentary origin), however we opted here for the geologically correct terminology.

Phosphate rock can be then processed via various routes into different phosphate products, including various types of phosphate fertilizers (see below). Recycling of phosphate (for example from sewage ash) is currently being trialled in some regions such as Europe or the United States. However, recycled volumes are currently minimal and the output is not fully comparable to phosphate rock in terms of potential industrial application.

Mined phosphate rock is beneficiated to increase its concentration. Phosphate rock is mined commercially in 30 countries worldwide, and all concentrated rock produced varies in terms of: concentration of phosphate (from below 26% P_2O_5 to 40% P_2O_5); impurities in the rock (e.g. heavy metals such as cadmium); and the ratios of contained phosphate to other elemental oxides such as calcium oxide (CaO) or iron, magnesium and aluminium oxides, all of which will influence the processing of the rock into phosphoric acid or other products. The various parameters will determine the value of each phosphate concentrate, with prices varying according to the concentrate's quality and on the downstream processes used by the buyers.

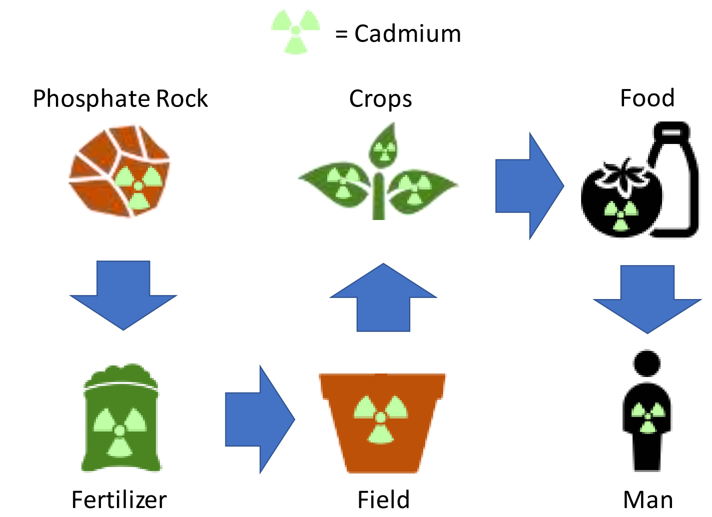
Rock is priced in terms of the crude concentrate provided. Whilst the absolute price is indicative of value, it is not definitive, as rock prices are ***not*** equalised to provide a uniform value of contained phosphate. A phosphate concentrate product with a higher price per tonne is not necessarily "more expensive" than a different phosphate concentrate with a lower unit price: normalized by quality, it is possible that a "more expensive" variety is actually a more economical source compared to "cheaper" ones. As testament to this claim, many producers are currently based on what would appear to be much more costly phosphate concentrate: if they truly had a cheaper, viable alternative, we are confident they would have explored this already. It is however also true that rock providers will also try to obtain a premium for atypical features of the rock which provide processors with perceived benefits, for example low levels of contaminants.

Many phosphate rock deposits have high concentrations of cadmium, as suggested in various scientific reviews – and indeed it is suggested that phosphate fertilizers have been the single largest source responsible for a progressive increase of the cadmium

[1] www.cadmium.org/Introduction

levels in topsoil, and consequently in food produced from agricultural products grown on such soil. The extent to which fertilizer application contributes to cadmium levels in soil is still debated, however this has been chosen as a target for further regulation by the EU –this paper aims only at discussing potential effects of policy changes, leaving a final answer on the point to scientific researchers.

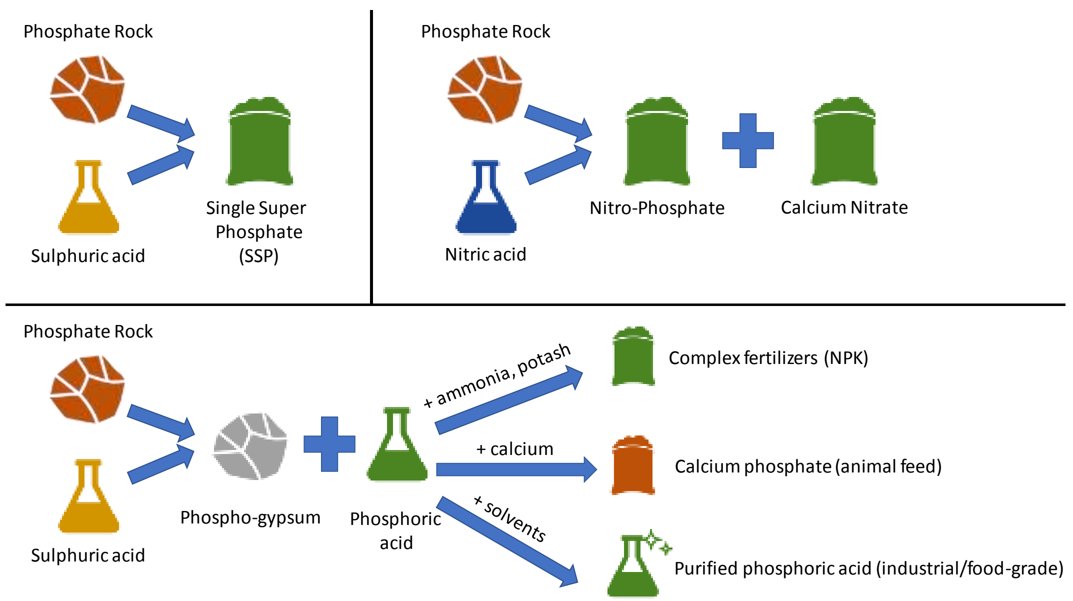
CADMIUM: FROM PHOSPHATE ROCK TO HUMAN CONSUMPTION



A quick introduction to the phosphate value chain

Production processes using phosphate rock vary according to the type of product manufactured. The following diagram provides a simplified value chain for fertilizers, which shows the most widely used process flows.

SIMPLIFIED VALUE CHAIN FOR SELECTED COMMON PHOSPHATE PRODUCTS



Suggested regulations at the EC level

If phosphate fertilizers are indeed responsible for an increase in the concentration of a noxious element in human food, imposing regulations on their application would be a sensible action.

The European Parliament, as part of its “Circular Economy Package”, has outlined a policy which aims to set a maximum level of cadmium in fertilizers, measured in terms of “parts-per-million cadmium per kilogram of di-phosphorus pentoxide” – in short, ppm Cd/kg P_2O_5 – when the P_2O_5 content itself is higher than a (low) threshold. The latest version of the policy has a long period of transition (12-16 years) to a long-term goal of 20ppm Cd/kg P_2O_5.

As the limit is imposed “per unit P_2O_5”, it won’t be viable simply to reduce the amount of phosphorus applied as fertilizer, but one would need to find sources of P_2O_5 that in themselves have sufficiently low levels of cadmium.

Notably, the limit would only apply to CE-branded fertilizers, which according to the rules of the European Economic Area (EEA) would allow free trade across national borders within the trade bloc. Individual member countries can produce fertilizers which do not comply with CE standards as long as they are compliant with the national standards in the member country, and are not traded to other member states, unless bi-lateral agreements allow trade to occur.

Another notable aspect that deserves some attention is the way in which the European Parliament has suggested to tackle the issue of cadmium. In Canada, policymakers have opted for a limit based on cadmium actually applied to the soil, with thresholds indicated as ppm Cd applied/ha. Another alternative approach is that of New Zealand, which sets a limit on cadmium levels in the soil after the application of fertilizers, checking the effect of application with regular soil samplings.

The European Parliament has instead opted for a policy targeting fertilizers directly on their raw material component, suggesting that the goal is not only to reduce cadmium in food, but with additional longer-term strategic goals. It is important to remember that this imposition will be part of a package labelled “Circular Economy”: a clear sign that incentives for phosphate recycling are also part of the policy design.

The issues at stake: potential consequences of the policy

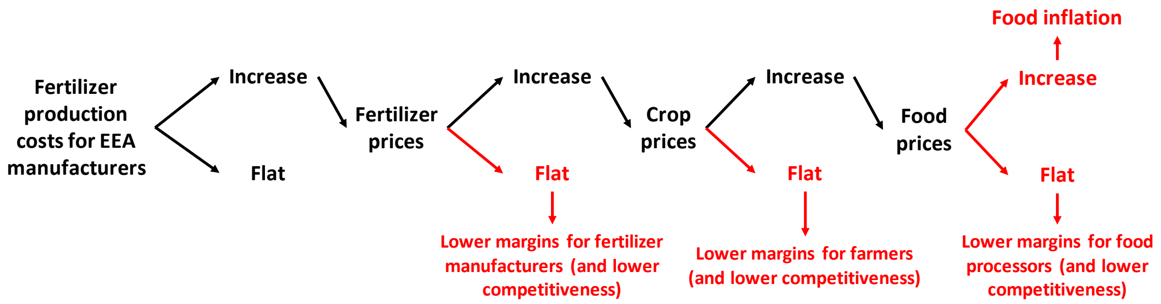
The imposition of a ceiling to cadmium content in fertilizers clearly represents a restriction to viable phosphate supply, both in terms of raw materials and fertilizers: for any set threshold, there will clearly be sources/producers that meet the requirement, and sources that don’t.

Textbook microeconomics suggest that a reduction in supply causes an increase in equilibrium prices, or at best no change – depending on the shape of the supply curve. Still holding our textbook in our hands, we are reminded that the key determinant of the overall performance of the market will be the fate of producers that are “marginal” on the supply curve, as it will be these producers that will set a “floor” to the market.

These considerations would apply to various levels of the value chain: from phosphate raw materials (rock or phosphoric acid), to fertilizers, and possibly also to crops and processed foods.

The following diagram provides a map to the potential impact of this policy change at various stages of the food supply chain, highlighting in red outcomes that would represent a cost to EEA-based market players. “Increase” and “Flat” should be interpreted as “relative to a no-policy scenario”.

POSSIBLE IMPACTS OF TIGHTER CADMIUM LIMITS: AN APPROACH BASED ON THE FOOD VALUE CHAIN



There are of course benefits to a policy aiming at reducing contaminants in fertilizers, chiefly in terms of improved health for EEA citizens. However, the main message of the chart is that this could come at a cost: should the policy cause an increase in fertilizer production costs for EEA producers, this will need to be borne at some stage throughout the value chain.

This could be in terms of lower margins for fertilizer manufacturers themselves, farmers, or food processors; citizens could also be eventually charged with higher prices for food.

In all likelihood, the actual consequence would be a mixture of all of these, with each step in the value chain absorbing part of the impact. There are therefore two essential questions:

- Under what conditions would EEA production costs increase?
- How would this impact the various stages of the EEA food value chain?

This is why we are here to help. Such analysis is precisely the business focus of Informa Agribusiness Intelligence, from raw materials to food: what is needed, and what we can provide is the bigger picture.

In this paper we will focus on issues directly affecting the fertilizer industry – however readers interested in a more holistic approach are invited to get in touch (contact details are provided at the bottom of this piece).

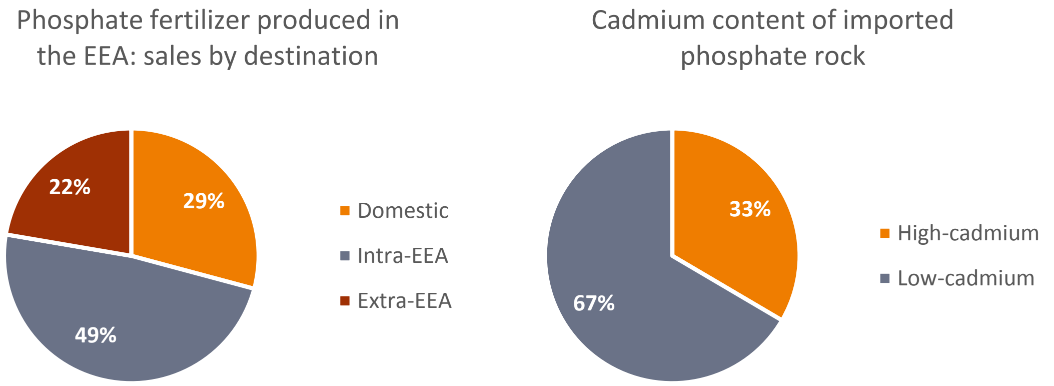
The size of the issue, demand-side: the European phosphate fertilizer market

A first necessary step is to identify the boundaries of the potential impact on the European fertilizer industry. Tighter cadmium regulations will only impact phosphate-bearing material that:

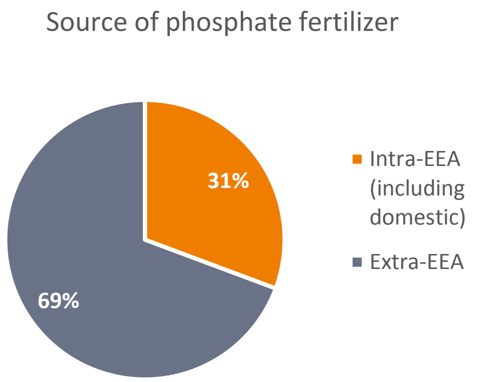
- Is currently produced using raw materials with cadmium levels against any given threshold, and
- Are destined to sales within the EEA market, unless the CE mark is not required, which could happen:
    - If domestic regulations in the country allow for higher cadmium levels, or
    - If individual member States sign bilateral agreements allowing free trade of products not bearing the CE mark.

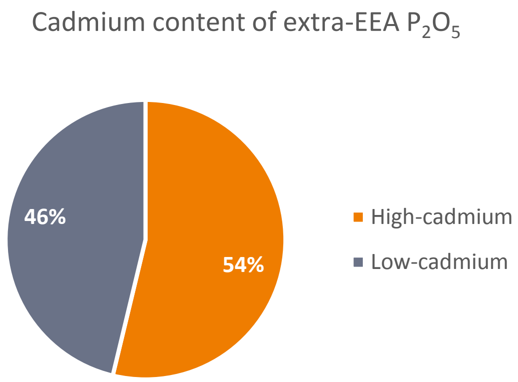
It is therefore relatively straightforward to quantify how big this might be. The following charts highlight a couple of these aspects (data refers to the 2017 calendar year).

THE EUROPEAN PHOSPHATE FERTILIZER INDUSTRY – HIGH-LEVEL SUPPLY-SIDE DATA



The chart on the left shows, at a European level, the exposure of the region to domestic sales, sales within the EEA, and exports to countries outside the EEA – as shown, about 78% (29% + 49%) of overall fertilizer production (expressed here as P_2O_5) is sold within the trade bloc. The chart on the right shows how much of the production is based on low-cadmium phosphate rock compared to high-cadmium phosphate rock – about two-thirds of production (67%) is already based on low-cadmium minerals.





When looking at European demand, regional production only accounts for about 31% of total requirement, with the remaining 69% sourced outside the EEA. Of this, slightly more than half is sourced from suppliers that would struggle to meet – in their current setup – cadmium limits below 40ppm Cd/kg P_2O_5.

Significant country-specific differences exist: individual producers will have different exposure to intra/extra EEA sales, and will purchase phosphate rock from different sources – meaning that output from some producers is entirely based on high-cadmium raw materials, while others would already be entirely based on low-cadmium raw materials.

However, these pie charts show that the size of potential impact can be measured as follows at an overall European level:

- On the supply side, strict cadmium regulations will impact about 33% (share of production based on high-cadmium raw materials) of domestic and intra-EEA sales (78% of total sales) – i.e. about **26% of total European output as P_2O_5**.
  - This translates to phosphate rock containing around 840,000t P_2O_5 (or less than this if one allows for blending of rock from different sources– as discussed in the next sections)
- On the demand side, the regulation could impact:
  - around 54% (share of imports from high-cadmium suppliers) of imports coming from outside the EEA (69%)
    - 54%*69%=37%
  - local production (31%) dedicated to domestic and intra-EEA sales (78%) and based on high-cadmium rock (33%)
    - 31%*78%*33%=8%
  - In total, this equates to 37%+8%=**45% of EEA-wide demand, or about 1.8 million tonnes P_2O_5 equivalent**

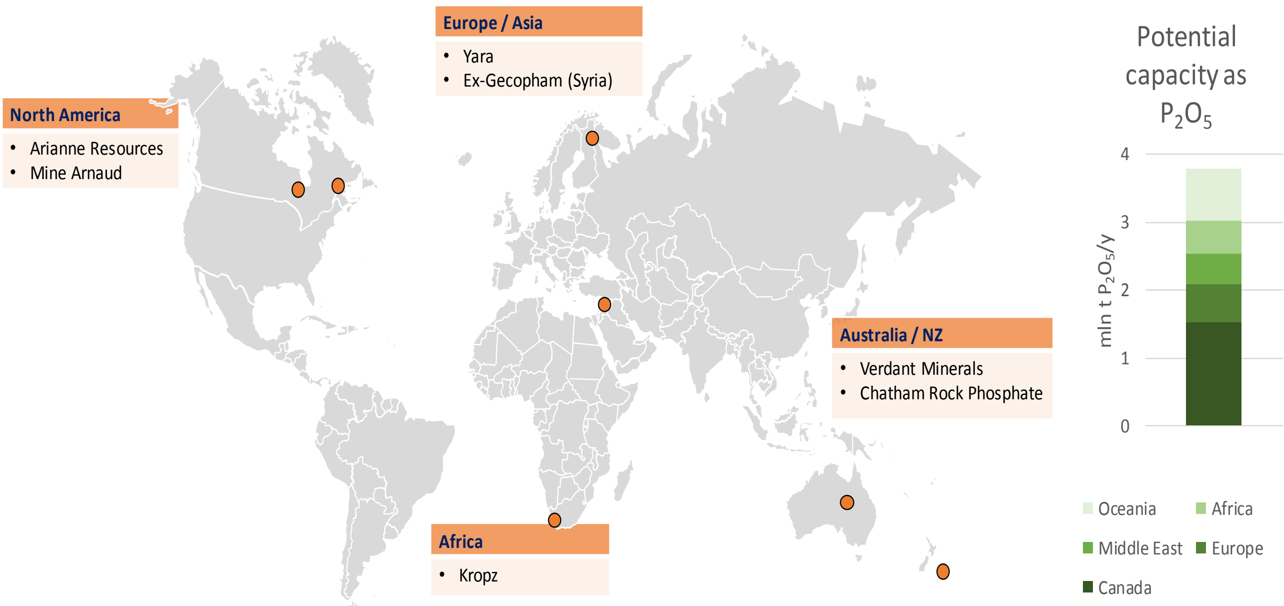
The size of the issue, supply-side: low-cadmium phosphate rock reserves

As stated above, in terms of phosphate rock the potential impact of tighter cadmium limits can be measured at around 840,000 tonnes P_2O_5 equivalent. It is therefore natural to ask whether there are currently sufficiently large resources that could meet this requirement?

First, it is important to note that this figure is likely an over-statement: phosphate rock from producers based on igneous deposits (currently Russia, South Africa in terms of export supply) have a cadmium content of around 4ppm Cd/kg P_2O_5; assuming other sources average about 60ppm Cd/kg P_2O_5, by blending igneous rock with higher cadmium rock one would only need to re-purpose about 600,000 t P_2O_5 to achieve a final average grade of 20ppm Cd/kg P_2O_5, or 300,000 t P_2O_5 to achieve an average of 40ppm Cd/kg P_2O_5.

Even if this is not considered – and therefore focussing on a full target of 840,000 t P_2O_5 – it is fair to say that there are currently a number of mining projects that would be able to cover this requirement, as shown in the diagram below. Clearly not all projects will necessarily succeed, nor would they all be able to economically serve the EEA market (e.g. due to significant freight costs from Oceania), however it would appear that availability of low-cadmium phosphate, in terms of known reserves, is not a major hurdle.

SELECTED LOW-CADMIUM PHOSPHATE ROCK PROJECTS (IRRESPECTIVE OF DEVELOPMENT STAGE)



Adapting to a policy change

As stated above, the policy would only affect CE-branded fertilizers. This is important, as it allows each individual national parliament to pass new laws allowing for higher cadmium limits, or again signing bilateral trade agreements with key partners currently within the EEA to allow the export of fertilizers not meeting the standards required to receive the CE-brand.

This could well be the fastest option, however politicians might be wary of passing laws that imply a relaxation of Europe-wide environmental standards, or at least potentially appearing to be not taking the issue seriously, particularly in those economies where environmental movements play a significant part in the electorate. Notably, this solution would not be in the direct control of fertilizer companies themselves.

What these companies will instead be able to control is their inflow and processing of raw materials, which can be managed to allow sufficiently low levels of cadmium in the final product (fertilizers). Options include the following:

a) **Using phosphate rock naturally low in cadmium**
   - This does not necessarily relate to individual sources (see the previous section), but could also be achieved by blending more than one source until the average cadmium level is compatible with prevailing limits;

b) **Reducing the content of cadmium in phosphate rock**
   - The only process which is currently proven and technologically viable at commercial scale consists of the thermal treatment of high-cadmium rock, bringing it to around 1,200°C (requiring significant additional energy costs);
   - Other novel processes (e.g. JDC Phosphate's IHP process, or EcoPhos's process based on hydrochloric acid, but not limited to these) claim to be able to use high-cadmium phosphate rock while yielding low-cadmium downstream products, however these are still not fully proven at a commercial scale.

c) **Removing cadmium at intermediate processing stages**
   - This can happen primarily at the liquid phosphoric acid stage – the technology requires the addition of dedicated chemicals that allow the removal of cadmium and is already used in countries such as Israel or Lebanon.
   - As this technology operates at the phosphoric acid stage, it is not a viable option for production processes which do not pass through this phase, for example the manufacture of SSP or the rock used in TSP (the two product account for 640,000 t P_2O_5, or 16% of European fertilizer phosphate demand).

Both options b) and c) could be implemented by suppliers of phosphate raw materials (rock and acid) instead of their buyers, paid for by a combination of higher pricing and/or margin sacrifice.

Risks and uncertainties

When thinking about the future one has to consider the many risks and uncertainties that affect even the most accurate and scientific of forecasts.

We have mentioned various potential options, each of which has associated risks:

- **New mining projects** to replace current high-cadmium suppliers
    - Such projects might not be properly managed or fail to be commissioned in time, or again experience production issues during their life
    - Changing the source of phosphate in chemical plants can be tricky, and the suitability of each new source is yet to be verified
- **New technologies**, e.g for cadmium removal from rock or acid
    - Risks: Processes demonstrated at pilot plant level might not prove viable at a commercial scale
- **Governments to allow domestic exemptions to EEA-wide cadmium limits**, possibly including bilateral trade agreements
    - As per all policy decisions, these would be subject to a strong degree of political pressure, and in any case (as stated) these are not truly "industry" responses)

Most importantly, both new technology and new mines will require investment, which in turn needs to be paid for.

As solutions based on current sources of igneous rock are available (albeit possibly not to the level needed to bridge the current volumes of high-cadmium products), any new investment will need to compete with the costs associated with those current sources of rock. Depending on the scale of the investment, it might not be possible to raise the financing from conventional sources without subsidies or EU-guarantees.

Lastly, considerable risk lies with the consequences of the regulation on the farming sector. The imposition of stricter limits will undoubtedly restrict the number of potential suppliers of phosphate raw materials and fertilizers, meaning that prices for both will at best be in line with a "no policy change" scenario, and concerns about higher prices in the future are also justified.

It is important to stress that the regulation relates to inputs, and not outputs. If, because of the stricter controls required, fertilizer prices increase, there is the risk that farmer in-put costs increase, and margins decline. Soft commodity prices for the main grain and oilseed staple crops are global. Increased costs and reduced margins for Europe's wheat farmers will not be afforded any protection from lower cost imports, even if produced using higher cadmium-containing fertilizer, because the cadmium content of the wheat is not measured. There is a risk therefore that any increase in fertilizer costs in order to meet the regulation disproportionately impacts on European farmers in the supply of globally traded soft commodities to the market.

Conclusions

Fertecon – and the whole of the Informa Agribusiness Intelligence team – hope that this paper helped position some of the key arguments in the broad "cadmium debate", for example:

- Phosphate concentrate comes in a large variety of qualities, therefore higher prices per tonne concentrate do not mean this concentrate is "higher-cost" from the point of view of the buyer.
- There are various ways in which the industry can meet tighter limits on cadmium in fertilizers – some of which are already proven, and some of which still need to be tested on a large scale. Most of these, however, will require investment.
- The policy in its current design focusses on cadmium in fertilizers rather than cadmium in the soil, suggesting an implicit strategic nature (e.g. incentivising the development of phosphate recovery or cadmium removal technologies).

Overall, we believe this policy will indeed have an impact, but not necessarily as draconian as some articles available in the public domain would suggest. A full assessment of the impact, however, requires a sophisticated approach, as various countries will be more or less exposed to the potential changes in the market triggered by this policy, and at various stages of the food value chain.

Which countries will experience the heaviest burden of the policy, and which industries will suffer the most?

Is phosphate-bearing fertilizer manufacturing be at risk of being displaced by extra-EEA competitors? How can fertilizer manufacturers adapt to tighter cadmium limits?

Should fertilizer prices increase, will European farmers be competitive against international suppliers, or will European food manufacturers switch to imported crops?

What side interventions could the European Commission implement to minimize the costs of this policy change?

These are just a few of the questions the Fertecon Phosphate Team are here to answer. For any enquiry, please contact the author Alberto Persona at alberto.persona@fertecon.com.

Fertecon is a company which has been active for 40 years in the independent analysis of fertilizer markets. The company is now part of the London-based Informa group, under its "Agribusiness Intelligence" division – a leading global supplier of services to the agriculture and food industry.