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EU Policy on Natural Resources

POLINARES is a project designed to help identify the main global challenges relating to competition for access to resources, and to propose new approaches to collaborative solutions

POLINARES working paper n. 22
March 2012

Secondary phosphate

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EUROPEAN COMMISSION
European Research Area
SEVENTH FRAMEWORK PROGRAMME
Funded under Socio-economic Sciences & Humanities

The project is funded under Socio-economic Sciences & Humanities grant agreement no. 224516 and is led by the Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP) at the University of Dundee and includes the following partners: University of Dundee, Clingendael International Energy Programme, Bundesanstalt fur Geowissenschaften und Rohstoffe, Centre National de la Recherche Scientifique, ENERDATA, Raw Materials Group, University of Westminster, Fondazione Eni Enrico Mattei, Gulf Research Centre Foundation, The Hague Centre for Strategic Studies, Fraunhofer Institute for Systems and Innovation Research, Osrodek Studiow Wschodnich.

10 Secondary phosphate

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Used as fertilizer phosphate is an essential raw material for the food production. Up to 90% of the consumed phosphorus is used in agriculture, mainly as fertilizer. None of the P recovery processes is economical yet. But while the price of primary phosphate is expected to increase, the costs of producing secondary phosphorus are expected to decline and could reach the break even around 2020.

10.1 Motivation for use of secondary phosphate

The apparent consumption of phosphate in Europe has followed a decreasing trend over the past decade. The values have decreased from approximately 3.5 million tonnes at the turn of the century to slightly over 2.5 million tonnes in 2008 and less than 1.5 million tonnes in the crisis-year 2009 (see Figure 1).

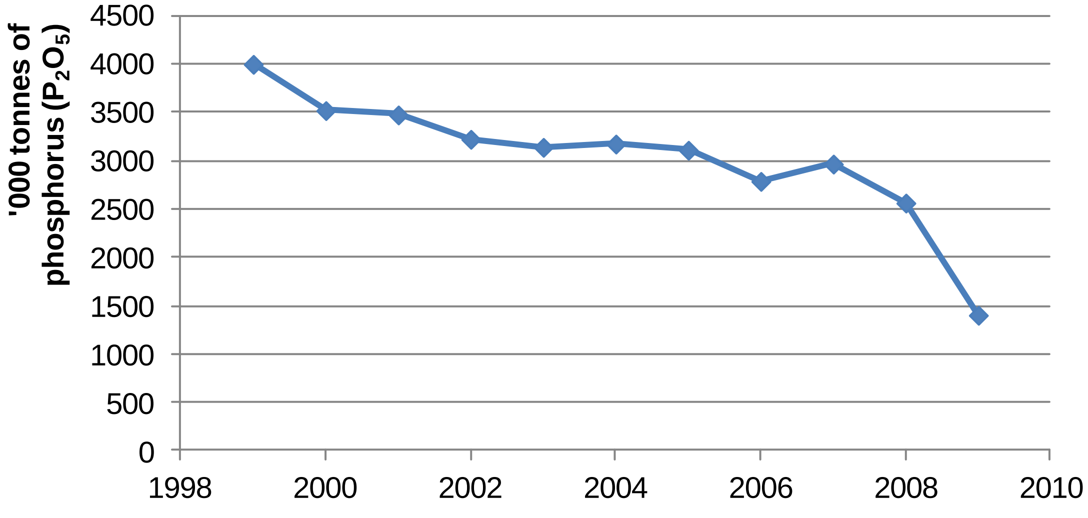

Figure 1: Apparent consumption (in 1000 t P2O5) of phosphorus in Europe (EU 27). Apparent consumption of phosphate basically comprises production + import – export of rock phosphate. Since the figures are meant to reflect the complete basis of phosphorus consumed in the EU, the difference of import and export of phosphoric acid is included. Data: IFA (2011)

Up to 90% of the consumed phosphorus (P) is used in agriculture, mainly as fertilizer. As shown in Figure 2 for the case of Germany, a substantial share of the crop production is used as feed in animal farming. However, the main part of the corresponding flow of P is contained in manure and other animal excrements and reused as farm fertilizer for crop production. Therefore, there is substantial recycling of P at this point.

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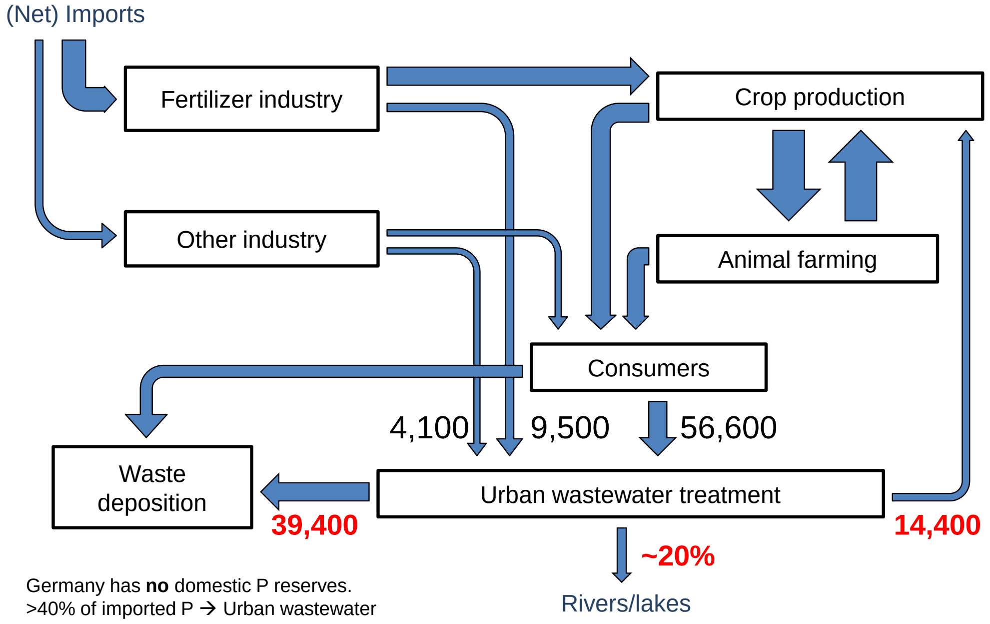

Figure 2: Basic flows of P in Germany with special emphasis on agriculture, wastewater treatment and waste deposition (Source: Gethke 2011, own calculations)

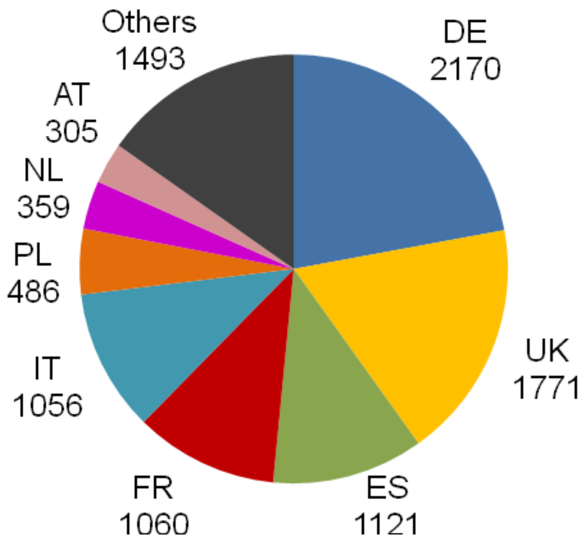

Figure 3: Sewage sludge generation in urban wastewater treatment plants in EU-27 in 2005 (in 1000 tonnes). Source: Eurostat 2010. DE: Germany, UK: United Kingdom, ES: Spain, FR: France, IT: Italy, PL: Poland, NL: Netherlands, AT: Austria.

Basically the same argument would apply for human food production, if also human excrements were used as fertilizers in agriculture. This was in fact the case in pre-industrial times and rural environments or when urine and faeces were collected and treated in wastewater treatment plants (WWTPs; including P elimination) and the yielded sewage sludge spread on the fields subsequently. The amount of sludge generated in European WWTPs is shown in Figure 3. It should be noted that sludge generation is not proportional to

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the population of a country because the extent of wastewater treatment varies from country to country. However, due to current regulation, these differences will increasingly disappear in the near future.

Unfortunately, the re-use of P contained in human excrements is increasingly compromised in all industrial and emerging countries by the contamination of sludge with heavy metals and toxic organic substances. As a consequence, the share of P returned to agriculture after wastewater treatment differs very much from country to country. The combustion of sewage sludge, which excludes its use in agriculture, already represents a major alternative in some countries (e.g. the Netherlands, Germany and Austria) and the relevance of this route is increasing. An overview of uses for WWTP sludge for selected European countries is shown in Figure 4.

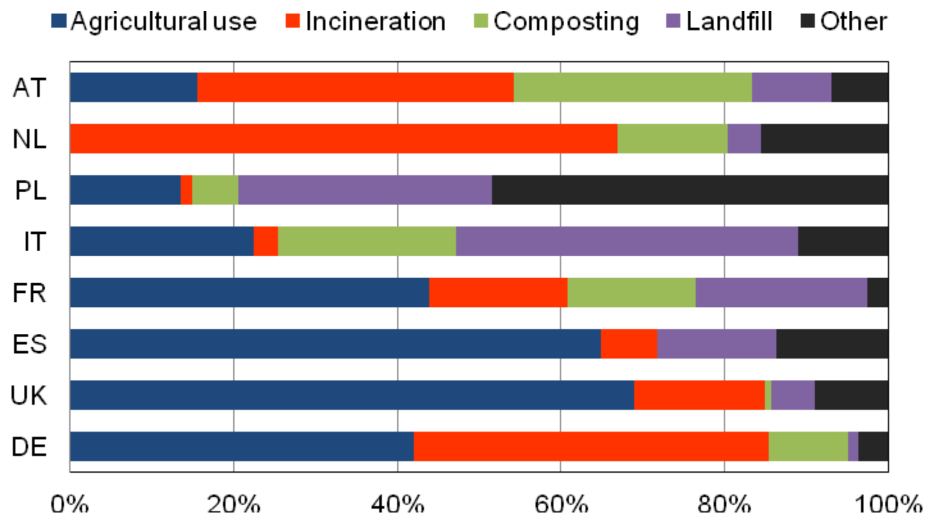

Figure 4: Shares of different routes for the deposition of sewage sludge in selected EU countries in 2005 (Source: Eurostat 2010)

As a rough estimation, approximately 0.7 kg P per person and year arrive in WWTPs. Assuming that 80% of this needs to be eliminated in order to prevent eutrophication in the receiving waters, and scaling by the population of the EU 27 (~500 million people), the total quantity of P that, for the reasons given above, may soon not be available anymore for re-use in agriculture amounts to 280,000 tonnes. This amounts to approximately ¼ of the quantity consumed in 2008[1].

10.2 Promising approaches and their potential

Basic approaches for the recovery of P during wastewater treatment can be distinguished according to the P flow they tap on in the WWTP and subsequent sludge treatment (see Figure 5). Of the approaches shown there, the following are most promising regarding their effectiveness and costs:

(1) Precipitation/adsorption of P from sludge liquor after anaerobic digestion of the sludge, and
(2) Treatment of the sludge ash to remove toxic heavy metals.

[1] Note that 1 tonne P ≈ 2.3 tonnes P_2O_5.

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What share of the available P can actually be recovered depends on the specific circumstances, i.e. on the extent and type of processes used for wastewater treatment in different countries. For Germany, a national implementation strategy designed for the time period from 2012 to 2030 shows that 46 percent of the P entering WWTPs could be recovered in the medium term. This corresponds to e.g. 12% of all P consumed for agricultural purposes in 2007.

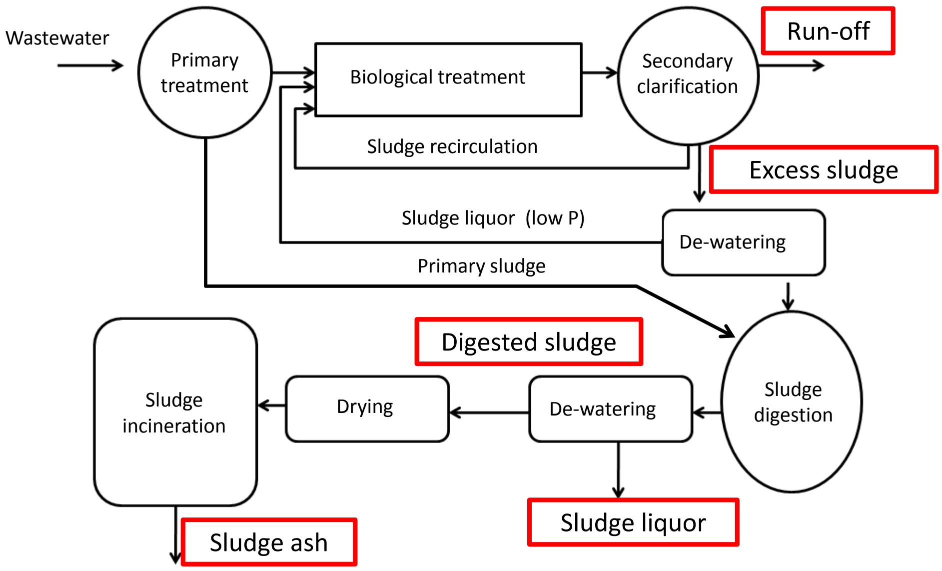

Figure 5: Basic approaches to tapping on the phosphorus flows in a wastewater treatment plant. Source: Horn et al. 2010

Approach (1) uses precipitation/adsorption of P from sludge liquor during or after anaerobic digestion of sludge; approach (2) is a treatment of the sludge ash to remove toxic heavy metals. Both approaches draw on P flows shown in the lower right and lower left part of Figure 5 respectively. While FIX-PHOS (representing approach 1) delivers high quality phosphate, ASH DEC (approach 2) yields less well specified decontaminated ash. However, ASH DEC recovers 90 percent of the P while FIX-PHOS recovers only around 40 percent. PASCH, the third process shown in Figure 5 combines the advantages of high yield and a good specification, but is more expensive. Achievement of a recovery rate of 46% (see above) involves a combination of the processes FIX-PHOS on the one hand and ASH DEC and/or PASCH on the other.

10.3 Cost and commercial availability

None of the P recovery processes is economical yet. As is evident from Figure 6, the most inexpensive processes as of early 2011 supply secondary P at a (cost) price of around 2 € per kg P, while the actual price of P (as phosphoric acid) from rock phosphate is at 1.35 € per kg P. But while the costs of producing secondary P are expected to decline, the price of primary P is expected to increase. According to our calculations (see Figure 6), the break even point is expected to be reached around 2020 and toward the end of the 2020s for the FIX-PHOS and ASH DEC processes, respectively.

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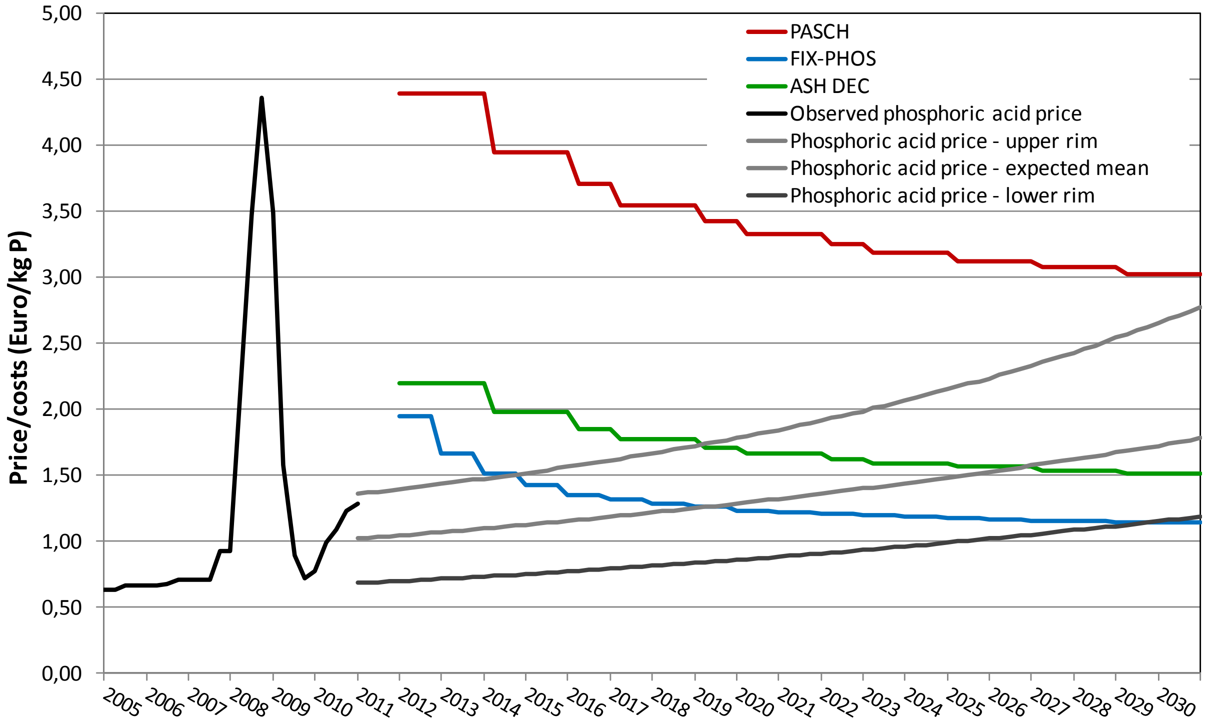

Figure 6: Convergence of the cost of P recovery using the processes ASH DEC, FIX-PHOS and PASCH and the expected average price of rock phosphate. Source: Sartorius (2011).

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