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COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Consultative Communication on the Sustainable Use of Phosphorus

(Text with EEA relevance)

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1. INTRODUCTION

Phosphorus is an essential building block of life. It is an irreplaceable part of modern agriculture, as there is no substitute for its use in animal feed and fertiliser. The current situation, involving waste and losses at every step of the phosphorus life cycle, contributes to concerns about future supplies and water and soil pollution, both in the EU and worldwide. With efficient production and use, as well as recycling and minimisation of waste, major strides could be made towards the sustainable use of phosphorus, thereby setting the world on a path towards resource efficiency and ensuring that reserves are still available for the generations to come.

The purpose of this Consultative Communication is to draw attention to the sustainability of phosphorus use and to initiate a debate on the state of play and the actions that should be considered. It is not designed with specific legislation on phosphorus in mind. This action was announced in the Roadmap to a Resource Efficient Europe[1] and should be seen as part of the overall drive to improve resource efficiency in the EU and worldwide.

Phosphorus resources are relatively abundant globally and reserves are significant. However, there are several factors that together mean that for the EU, the issues affecting the security of supply should be monitored. Firstly, within the EU, there are only small reserves of phosphate bearing rock. Secondly, there has been recent price volatility - in 2008, prices of phosphorus rock rose by 700% in a little over a year, contributing to increases in fertiliser prices. Thirdly, there is little scope to switch from less important uses of phosphorus, as the essential use of feed and fertiliser already consumes around 90% of the total mined resource. Improving the use of recycled phosphorus in the EU and worldwide would help safeguard the supply of this fundamental raw material and encourage a more even distribution of phosphorus at both regional and global level. Economically, diversifying the supply of phosphate to the EU businesses that depend on it would improve their resilience faced with any future price instability and other trends that might aggravate their import dependency.

In addition, the environmental and resource use benefits of increasing efficiency and reducing losses would be significant. The current use of phosphorus is inefficient at many stages of the life cycle, causing problematic water pollution and the waste of a wide range of associated resources. Contaminants such as cadmium and uranium in the raw material may also cause health and environmental problems. Independently of the total volume of mined phosphate available and the security of supply aspects, these benefits alone would justify action being taken to use and recycle phosphorus more efficiently. The actions taken to improve the

[1] COM/2011/0571 final.

efficiency of phosphorus use and recycling would have a wide range of other advantages – better soil management would have climate and biodiversity benefits, for example.

Addressing these issues is not straightforward. Regions in the EU with arable crop production tend towards a stabilisation in soil phosphorus levels, but continue to depend on the application of mineral phosphate fertilisers. Intensive animal production is concentrated in specific areas close to ports, major population centres and available labour and expertise. This concentration has led to an oversupply of manure into these regions, with a gradual build-up of the phosphate content of soils and increased risks of water pollution. Likewise, the growth of major cities means that phosphorus containing sewage and food waste is increasingly distant from the arable farms where it might be used following appropriate treatment.

Despite this there is a great deal of scope for improving the situation. Major routes for losses of usable phosphorus include soil erosion and leaching, as well as inefficient use of manure, biodegradable waste and waste water. Flow analyses from France, for example, show that 50% of the total phosphorus used there is lost – around 20% in wastewater, the same through erosion and leaching and 10% in the form of food waste and other biowaste[2]. The sustainable use of phosphorus has now become the subject of considerable research. In the UK, work undertaken for the Department of Environment Food and Rural Affairs identified phosphorus as a future resource risk that was significant for agriculture, and one where the Member State alone could do little to address the risk[3]. Numerous scientific publications have set out the dangers and costs of our current approach.

Measures have already been taken at national, EU and international level, mainly to address water pollution problems from phosphorus and to reduce the waste of materials such as food or other biodegradable waste that also contain phosphorus. However, these actions were devised with the prevention of water pollution in mind or for other policy objectives, rather than for the purposes of recycling and saving phosphorus. Initiatives that are directly focused on phosphorus efficiency and recovery remain scattered, and are rarely considered in policy development. An exception is Sweden, where a national interim target was established: "By 2015, at least 60% of phosphorus compounds present in wastewater will be recovered for use on productive land. At least half of this amount should be returned to arable land". The Netherlands has put in place a phosphate value chain agreement, in which a range of stakeholders have committed themselves to targets such as using a set percentage of recycled phosphorus in their manufacturing process[4]. Germany is working on legislation planned to reduce the waste of phosphorus. Following the first European Conference on Sustainable Phosphorus, a European Phosphorus Platform has been set up by stakeholders in order to create a European recycled phosphorus market and to achieve a more sustainable use of phosphorus[5].

The complete replacement of phosphate mined in the EU by recycled phosphorus is neither feasible nor necessary in the foreseeable future. However, greater recycling and use of organic phosphorus where it is needed could stabilise the amounts of mined phosphate required and mitigate the soil contamination and water pollution issues. This will then put us on track to

2 http://www.bordeaux-aquitaine.inra.fr/tcem_eng/seminaires_et_colloques/colloques/designing_phosphorus_cycle_at_country_scale

3 Review of the future resource risks faced by UK Business and an assessment of future viability, AEA, 2010

4 http://www.nutrientplatform.org/?p=306

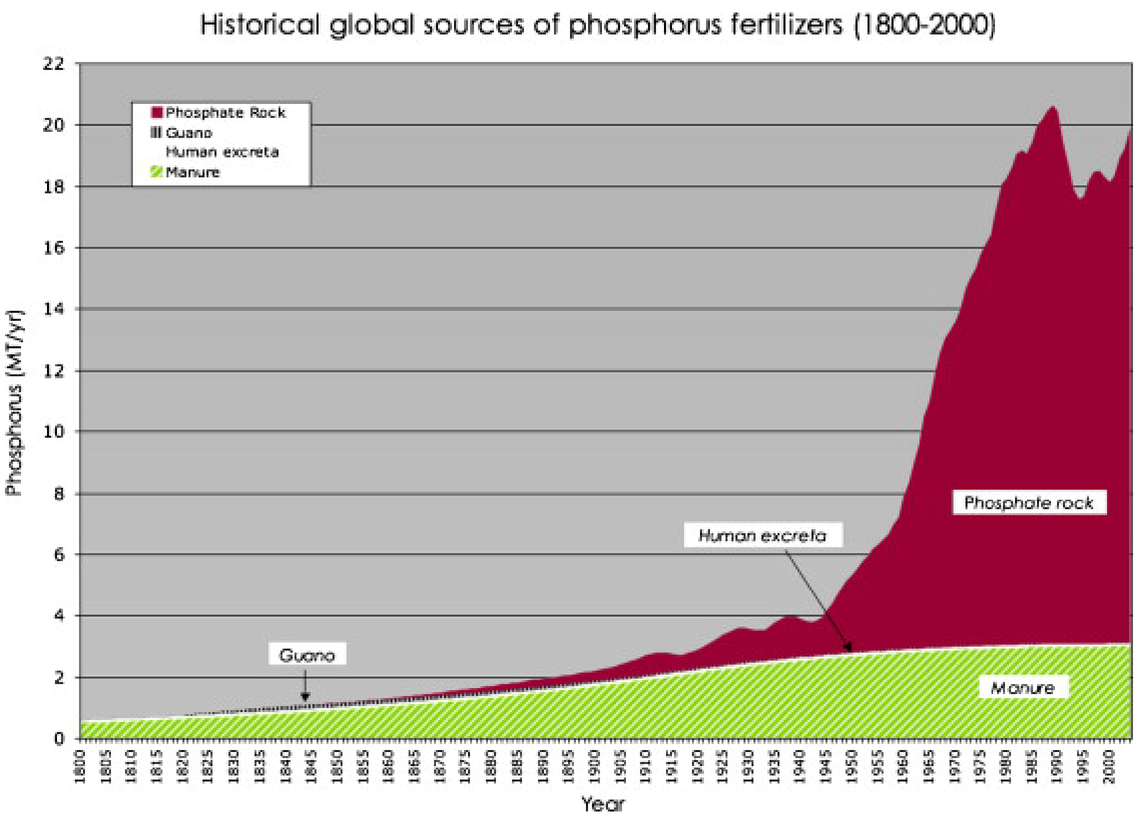
5 http://www.phosphorusplatform.org/

close the phosphorus cycle in the long term, when the physical limitations of the resource will become increasingly important.

2. THE SUPPLY AND DEMAND PICTURE TO 2050 AND BEYOND

Historically, the first phosphorus fertilisers came from organic sources – mainly manure through mixed farming systems and then from bone meal and guano, the first major tradable fertiliser commodities. Efficient techniques for mining and manufacturing fertiliser from phosphate rock were then developed, and this was one of the conditions for the 'green revolution' in agricultural productivity from the 1940s onwards. Although animal manure remains an essential part of phosphorus supply in fertiliser (in the EU, it is a key source - 4.7 million tonnes of manure are applied as fertilisers annually[6]), mineral phosphate fertiliser has become the main source of phosphorus to crop production globally, as well as the original source of all new phosphorus in the cycle.

Fig 1: Historical global sources of phosphorus fertilisers[7]



[6] Phosphorous imports, exports, fluxes and sinks in Europe, Richards and Dawson 2008
[7] The Story of phosphorus: Global food security and food for thought, Cordell et al, 2009

Historical global sources of phosphorus fertilizers (1800-2000)

- Phosphate rock
- Guano
- Human excreta
- Manure

Year

Phosphorus (MT/yr)

2.1. The supply of phosphorus

Current production of phosphate rock is concentrated in a limited number of countries. None are in the EU, with the exception of Finland where there is a small amount of production. In 2011, the EU's import dependency rate was around 92%[8]. Two thirds of the current phosphate rock reserves identified in the most recent research from the International Fertilizer Development Center (IFDC)[9] on the subject come from Morocco/Western Sahara, China and the US, although there are many countries that have smaller reserves. In this report, the large new reserves identified in Morocco/Western Sahara are noted as being subject to caution.

Consequently, it is difficult to forecast precisely the extent of supplies of phosphate rock and the ability of these supplies to meet demand in the long term. However, the best available evidence indicates that there are sufficient supplies for several generations, and that new reserves are regularly being identified, with a clear trend towards a broadening of the geographical area of future production. There will be a point at some stage in the future when supplies will begin to diminish, but it is not immediate.

Some statistical information on fertiliser use worldwide is collated by the FAO, but this does not cover phosphate rock resources and reserves. Company phosphate rock reserves are widely covered for commercial purposes by the Australian JORC[10] code or equivalent, which is an industry standard for classification and harmonisation of reserve descriptions, but this is not designed as a basis for the compilation of national or international reserves. The reference source for such information has always been the United States Geological Survey (USGS), but between 1990 and 2010 the USGS statistics were not fully updated with information from non-governmental sources. As noted above, in 2010 the International Fertilizer Development Center (IFDC) reported new, significantly higher estimates of reserves based on industry information, and in 2011 the USGS updated its resource estimates accordingly[11]. These figures, and the definitions of resource and reserve from the USGS, have been used wherever possible in this paper. Figure 2 shows the change in the estimates of reserves.

Fig 2: <u>Impact of revision of phosphate rock reserves – expressed as billion tonnes P205</u>[12]

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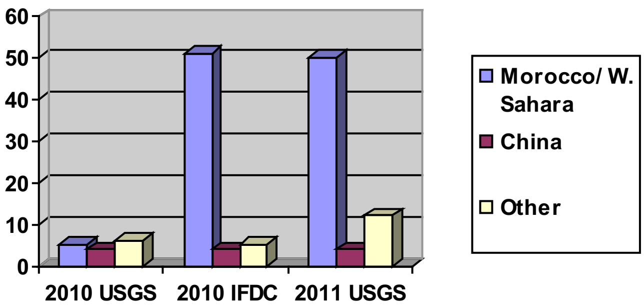
8 Import dependence is calculated as "net imports / (net imports + production in EU) – methodology from COM(2011) 25 'Tackling the challenges in commodity markets and on raw materials'

9 World Phosphate rock reserves and resources, IFDC, 2010

10 Joint Ore Reserves Committee - more information available at www.jorc.org

11 http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/mcs-2011-phosp.pdf

12 Adapted from a presentation by Blanco, 2011



Morocco/W. Sahara
China
Other
USGS (United States Geological Survey)
IFDC (International Fertilizer Development Center)

The question of whether it is necessary to set up an official reporting system and statistical follow up has been posed in several academic publications. This would need to allow information to be collated in a way that respects commercial confidentiality, but at the same time gives public bodies and other stakeholders confidence that they have accurate information. Integration of existing national geological survey organisations would be crucial.

Organic sources of phosphorus are often heavy and voluminous materials such as manure or sewage sludge that cannot easily be transported over long distances. However, supplies could be better distributed at the regional level, and availability of the material could be improved both quantitatively and qualitatively. This issue is further explored in section 4.

2.2. Increasing demand for fertiliser to feed the world

FAO forecasts of the global demand for fertiliser suggest that world use of fertilisers will continue to expand. They indicate projected increases for phosphate as a fertiliser nutrient of up to 43.8 million tonnes per annum in 2015 and to 52.9 million tonnes in 2030[13]. These figures are based on the assumption that the undesirable situation of very low fertiliser use in some developing countries, especially in Sub-Saharan Africa, is maintained. As far as phosphorus is concerned, current world consumption is around 20 million tonnes per annum. Demand for phosphorus in feed is also predicted to rise, driven by large increases in animal production[14].

In the longer term, a number of factors indicate that demand is likely to continue to grow. The world population is predicted to rise to more than nine billion people by 2050. This, combined with changes in dietary habits, has led the FAO to predict a demand for 70%[15] more food by that date, if the current unsustainable trends persist. In turn, this is likely to mean more land in agricultural production, and/or greater intensification on existing farm land. This will then drive demand for fertiliser.

13 Forecasting Long-term Global Fertiliser Demand, FAO, 2008.
14 Rosegrant et al, 2009 for predictions in growth of animal numbers
15 New assessments may indicate values closer to 60% - see NPK foresight study by the JRC, 2012

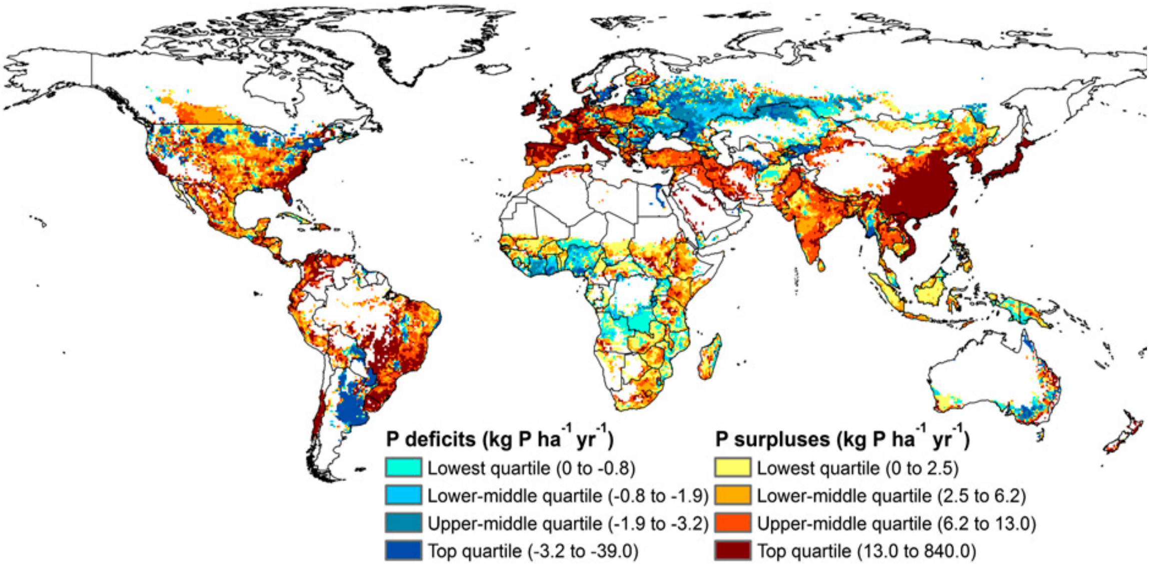
The increase in demand for fertilizer will also be driven by the increase in global production of biofuels. [16]. In 2007/8 fertilizer use associated with the production of biofuels was already estimated at 870,000 tonnes of phosphate per annum.[17].

[16] The Impact of First-Generation Biofuels on the Depletion of the Global Phosphorus Reserve, Hein and Leemans, 2012

[17] Medium Term Outlook for Global Fertilizer Demand, Supply and Trade 2008-2012 Heffer and Prud'homme, 2008

2.2.1. *Global imbalances in phosphorus use*

Fig 3: Global map of agronomic P imbalances for the year 2000[18]



P deficits (kg P ha^{-1} yr^{-1})

- Lowest quartile (0 to -0.8)
- Lower-middle quartile (-0.8 to -1.9)
- Upper-middle quartile (-1.9 to -3.2)
- Top quartile (-3.2 to -39.0)

P surpluses (kg P ha^{-1} yr^{-1})

- Lowest quartile (0 to 2.5)
- Lower-middle quartile (2.5 to 6.2)
- Upper-middle quartile (6.2 to 13.0)
- Top quartile (13.0 to 840.0)

Figure 3 is the result of a study that seeks to calculate phosphorus balances worldwide. It shows that there are many developing countries where there are significant phosphorus deficits[19]. These levels are below what would be necessary to maintain the long-term productivity of soils and to allow the improved crop yields that will be necessary. Some of this additional requirement could come from better use of local organic sources, but it is likely that much of this demand will have to be supplied by phosphate rock. As the growth in the human population is forecast to be in the developing world, the greatest need for increased phosphate fertiliser will be in those areas which currently have the lowest soil phosphate levels.

Increases in demand at world level will be partially slowed by decreases in phosphorus use around areas of intensive animal production, where soils now contain more available phosphorus than is required for crop production, as a result of excess manure spreading (parts of the EU, US, China). Such decreases may be due to economic factors, since extra phosphorus on saturated land brings no benefit for the crop, or to environmental regulations

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[18] Agronomic P imbalances across the world's croplands, Macdonald et al, 2011

[19] See also http://www.africafertilizer.org/

aimed at tackling water pollution. However, it should be noted that, if animal production in these areas is not reduced, the phosphorus demand via animal feed will remain the same.

2.3. The balance between supply and demand

Since industrial fertiliser production began, the constant increases in demand for fertiliser have been consistently matched by the increasing volumes of phosphate rock being mined. There have been occasional blips due to wider geopolitical events, notably when the collapse of the Soviet Union in the 1990s led to a temporary fall in the global demand for fertiliser, but otherwise the rise has been continual.

2.3.1. The 2008 price spike

From 2007-8 the price of phosphate rock went up by over 700% in a fourteen-month period. In 2008, China imposed an export duty of 110-120% on phosphate rock, which was then reduced in several stages to the level of 35%, which is still applied today. Global operating capacity for phosphoric acid peaked at close to the maximum possible. This high price attracted considerable interest from the press and stakeholders. The spike was followed by a collapse during the global recession, although prices have been rising again since the start of 2011. Price rises for phosphate rock are essentially a function of supply and demand, with increased demand from biofuel crops being one factor. They also mirror food prices and may also be a minor contributing factor to rises in food prices, although they are much less significant than oil prices in that regard.

2.3.2. The discussion around 'peak phosphorus' and security of supply

Based on the USGS statistics, which were the only publicly available source at that time, a number of academic and other commentators predicted that "peak phosphorus", i.e. the point in time when global production of phosphate rock would reach its peak and would start to decline, might happen in the medium term[20], or may even have passed[21]. Since then, the USGS has updated its reserve estimates and these calculations are no longer relevant. In addition, a number of academic commentators have argued that examining reserves using a Hubbert curve[22] is essentially inappropriate for phosphorus, particularly due to the fact that phosphorus can be recycled. They also argue that as the price goes up, other resources will be found, even if some of these sources are more complex to mine or contain more impurities.

Whilst peak phosphorus due to phosphate rock depletion seems unlikely to be an issue for the coming generations, the security of supply issues that were raised by that discussion remain relevant. Although new mines and new technologies – notably seabed resources – are being developed and new reserves are being reported, other sources are diminishing. Under current technological and environmental conditions, mines in the US may not have a lifetime much beyond fifty years or so. The lifetime of China's internal production is not clear, but given the huge internal needs there seems little likelihood of this source being available for export in significant quantities in the future.

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[20] A rock and a hard place – peak phosphorus and the threat to our food security, Soil Association, 2010

[21] 'Peak P' what it means for farmers, Déry and Anderson, 2007

[22] A **Hubbert curve** is an approximation of the production rate of a resource over time, first used to predict peak oil, and since applied to estimate depletion of other resources (definition from Wikipedia).

2.3.3. Raw materials Initiative

In 2010 a European Commission Working Group assessed 41 raw materials with the aim of identifying which materials are of critical importance for the EU. After the WG evaluated the economic importance, supply risk and environmental impact of each and every material, the Commission adopted a list of 14 raw materials that it deemed as critical. This assessment will take place again in 2013 and will include an evaluation of phosphate rock.

2.3.4. Quality of the phosphate rock reserve

More than the size and location of reserves, it is the heavy metal content of the remaining deposits that is a potential cause for concern. Rock phosphate is generally contaminated to some degree by cadmium, which is a toxic element. The phosphate rocks which are mined in Finland, Russia and South Africa are igneous and have very low cadmium contents (sometimes below 10 mg cadmium/kg P_2O_5). In contrast, those found in North and West Africa and in the Middle East are sedimentary and generally have much higher cadmium levels, above 60 mg cadmium/kg P_2O_5 in the worst cases. The need to control the contamination of soil with cadmium from fertilisers (section 3.3) means that, if cleaner sources are depleted, the cost of producing fertiliser that meets soil protection standards is likely to rise, or higher standards in the EU will lead to material with higher cadmium content being sold elsewhere. Inefficient use of clean reserves will bring us more rapidly to this point, unless decadmiation[23] technologies become economically viable.

Q1 – Do you consider that the security of supply issues for the EU in relation to the distribution of phosphate rock are a matter of concern? If so, what should be done to engage with producing countries in order to tackle these issues?

Q2 – Is the supply and demand picture presented here accurate? What could the EU do to encourage the mitigation of supply risks through i.e. the promotion of sustainable mining or the use of new mining technologies?

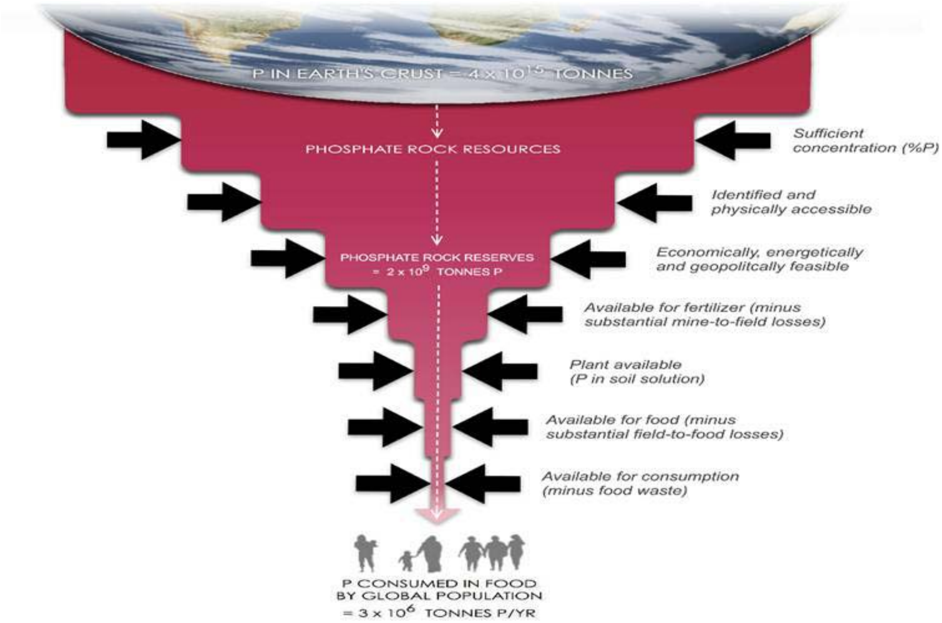
Q3 – Do you consider that the information on the worldwide supply and demand of phosphate rock and fertiliser is sufficiently available, transparent and reliable? If not, what would be the best way to obtain more transparent and reliable information at EU and global level?

3. ENVIRONMENTAL IMPACTS THROUGHOUT THE PHOSPHORUS CYCLE

Sustainable use of phosphorus goes wider than the issues around that one element. When phosphorus is wasted, the energy, water and other resources contributing to its production cycle are wasted along with it. In addition, phosphorus ending up in water bodies causes its own environmental problems, notably in the shape of eutrophication. Figure 4 shows the scale of inefficiency along the chain.

[23] Removal of cadmium from the processed product

Fig 4: Losses along the phosphorus chain [24]



P in earth crust = $4x10^{15}$ tonnes
Phosphate rock resources
Phosphate rock reserves = $2x10^{9}$ tonnes P

Sufficient concentration (%P)
Identified and physically accessible
Economically, energetically and geopolitically feasible
Available for fertilizer (minus substantial mine-to-field losses)
Plant available (P in soil solution)
Available for food (minus substantial field-to-food losses)
Available for consumption (minus food waste)

3.1. Mining, processing and transformation into fertiliser or feed

Modern phosphate mining is mostly carried out in open cast mines. This type of mining requires large areas of **land**[25]. As well as the land that is mined, land is also needed for spoil heaps and for clay settling ponds. The quantities of total solid **waste** produced can be high, but they vary significantly between plants – one study reports findings where, for one tonne of phosphoric acid produced, 9.5 tonnes of phosphate ore are required and 21.8 tonnes of diverse wastes and 6.5 tonnes of tailings are produced[26].

Phosphoric acid plants also produce large quantities of a **by-product** called phosphogypsum. In some countries phosphogypsum is stored in large stacks due to regulation of radioactivity levels or because the alternatives (natural gypsum and flue gas gypsum) are more competitive.

24 Sustainable use of phosphorus, Cordell et al, 2010 – figures from date of publication
25 Florida phosphate mining disturbs about 5,000 – 6,000 acres annually, at 9,000 tonnes US per acre of land mined
26 Global **phosphorus** flows in the industrial economy from a production perspective, Villalba et al, 2008

In a few countries such as Brazil and China, however, it is increasingly being used in construction and in agriculture[27].

The mining and processing of phosphate rock also uses a great deal of **water**. Although modern mines can reuse as much as 95% of the water taken, this level of efficiency is by no means universal. In addition, there can be a risk of spills or seepage of highly acidic process water, notably from pools on the phosphogypsum stacks, and this can contaminate aquatic ecosystems. As phosphate rock deposits are often located in water deficient regions, water supply can be a significant limiting factor in the development of phosphate mining.

The mining process is also **energy** intensive. The only comprehensive surveys of energy use across the industry are now quite dated, but they give figures of 2.4 GJ of primary energy required per tonne of final product – this amount would be double if transport to Europe were taken into account[28]. Recent efficiency gains in phosphate mines are likely to have improved this situation, which in any case varies from mine to mine. Each year, millions of tonnes of rock and fertilisers are transported worldwide, with the environmental transport costs that this entails.

3.2. Water pollution from agriculture and waste water

Excess phosphorus, mainly from intensive agriculture and horticulture is a major cause of eutrophication of lakes and rivers. Uncontrolled or poorly controlled waste water from human excreta and other household uses, as well as industrial pollution, also contributes significantly to these problems. Mineral fertiliser is less often the cause of the regional imbalances that are symptomatic of these problems, but can be a contributing factor in some regions.

Soil erosion can carry significant amounts of soil-bound phosphorus into surface **water.** A recent model of **soil erosion** by water constructed by the JRC has estimated the surface area affected in EU-27 at 1.3 million km^2[29]. Almost 20% of this affected area is subjected to a soil loss in excess of 10 tonnes per hectare per year. Run-off from recently applied fertiliser or manure can contribute further to water pollution. Loading soils with very high levels of phosphate will generally not impair crop growth, but may affect plant biodiversity in natural ecosystems, while increased migration of phosphates to nearby bodies of water will also upset the biological balance. In addition to indirect losses, manure is still directly discharged into watercourses or into the sewage system in some parts of the world, adding to pollution from urban waste water. While soil erosion is the main pathway for phosphates to enter water in sandy soil areas or where there are slopes without vegetation, leaching into surface water can also be a significant factor in saturated areas.

According to the SOER 2010[30], agricultural emissions of phosphorus to freshwater exceed 0.1 kg of phosphorus per hectare per year across much of Europe, but reach levels in excess of 1.0 kg P/ha/year in hotspots. As a consequence, several marine and coastal waters across the EU have high or very high concentrations of phosphorus. Preliminary results of the assessment of river basin management plans[31] show that, in 82% of river basins, agriculture is causing

[27] It should be noted that natural radioactivity levels in phosphate rock can differ widely, depending on the geology of the mine

[28] Materials flow and energy required for the production of selected mineral commodities, Kippenberger, 2001 (but the energy figures themselves date from 1994)

[29] The implementation of the Soil Thematic Strategy and ongoing activities, COM(2012) 46 final

[30] The European environment - state and outlook 2010: http://www.eea.europa.eu/soer

[31] Based on 38 River Basin Management Plans

significant phosphorus pressure on watercourses. Some studies[32] have argued that we have already exceeded the planetary boundaries for freshwater pollution by phosphorus.

Losses of phosphorus and other nutrients via these routes and due to wastewater pollution can cause an increase in the growth of plants and algae. This results in **eutrophication**, which can then lead to an imbalance between the processes of plant/algal production and consumption which has adverse effects on species diversity and the suitability of water for human use. It can also cause very severe algal blooms, some of which consist of harmful species that cause the death of fish and other marine fauna and which – once decomposed – can poison humans and animals due to emissions of hydrogen sulphide. Such a situation takes years to remedy even when the source of pollution has been eliminated, because phosphorus becomes part of the sediments which are subject to frequent disturbance, triggering repeats of the eutrophication process.

3.3. Soil contamination

The contaminant present in phosphate fertilisers (unless removed by decadmiation technologies) that is currently of most concern is **cadmium**, although other heavy metals may also need monitoring. Once present in soil, cadmium cannot be easily removed, but can migrate and accumulate in plants. Certain plants (sunflowers, colza, tobacco, etc.) tend to accumulate larger amounts of cadmium.

In 2002, the Commission asked the Scientific Committee on Toxicity, Ecotoxicity and the Environment (SCTEE) for its opinion[33] on the likelihood of an accumulation of cadmium in soils resulting from the use of phosphate fertilisers. Based on risk assessment studies carried out by eight EU Member States (and Norway) and additional analysis, the SCTEE estimated that phosphate fertilisers containing 60 mg cadmium/kg P_2O_5 or more are expected to result in cadmium accumulation in most EU soils, whereas phosphate fertilisers containing 20 mg cadmium/kg P_2O_5 or less are not expected to cause long-term soil accumulation over 100 years if other cadmium inputs are not considered. Some soils naturally contain high levels of cadmium, and therefore a more cautious approach is required in those areas.

In terms of health impacts, the EU Risk Assessment Report[34] on cadmium and cadmium oxide was issued in December 2007. It found that the major risk of cadmium is kidney damage through food consumption and smoking. The Risk Reduction Strategy for cadmium and cadmium oxide recommended measures to reduce cadmium content in foodstuffs, in tobacco blends and for phosphate fertilisers, taking into account the range of different conditions throughout the EU[35]. This was confirmed by the risk assessments on cadmium in food carried out by the European Food Safety Authority (EFSA) in 2009[36] and 2011[37], as well as by the conclusions of the Joint FAO/WHO Expert Committee on Food Additives (JECFA)[38] in 2010. So far, the preparatory work for most of these measures is not finished, but risk management decisions have been taken based on the maximum residue levels in feed and food.

32 Reconsideration of the planetary boundaries for phosphorus, Carpenter and Bennett 2011
33 http://ec.europa.eu/health/ph_risk/committees/sct/documents/out162_en.pdf.
34 http://esis.jrc.ec.europa.eu/doc/risk_assessment/REPORT/cdmetalreport303.pdf
35 OJ C 149, 14.06.2008, p. 6
36 EFSA Journal (2009) 980, 1-139; http://www.efsa.europa.eu/en/efsajournal/pub/980.htm
37 EFSA Journal (2011); 9(2):1975; http://www.efsa.europa.eu/en/efsajournal/pub/1975.htm
38 WHO Food Additives Series 64, 73rd meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA), Wold Health Organisation, Geneva, 2011

Soil and groundwater contamination by **uranium** – mainly from natural background presence, but possibly exacerbated by the presence of uranium in phosphate fertilisers[39] – has been reported in areas with sandy soil in Germany, with consequences for the processing of drinking water in some cases. This contamination could result in extra precautions and costs in the areas of drinking water and agricultural production.

Q4 – How should we handle the risk of soil contamination linked to phosphorus use in the EU?

4. POTENTIAL FOR AND OBSTACLES TO A MORE EFFICIENT USE OF PHOSPHORUS

The flow analyses and research undertaken show that there are a number of key points in the phosphorus use cycle where significant quantities are currently being lost. Yet there are also techniques that can recover phosphorus or improve the efficiency of its use[40]. When prices of phosphate rock and its derived products reached a peak in 2008, a number of new alternative sources of recycled phosphorus became economically interesting. Since then, prices appear to have reached a new plateau at 200 dollars a tonne. Much of the previous analysis of the cost efficiency of phosphorus recycling dates from before the price rises in phosphate rock and is therefore now out of date. Moreover, as the technology for the processing of the most promising sources of recycled phosphorus improves and efficiencies of scale kick in, their costs come down. Aside from the price issues, the major economic advantage of using recycled phosphorus is in terms of resilience – consistent flows, sourced locally, and without the price volatility of phosphate rock.

Modelling undertaken in the context of resource efficiency suggests that the global increase in the use of phosphorus fertilisers from primary sources could be limited to 11% by 2050 against a business-as-usual scenario of 40%[41]. Economic modelling of the US situation suggests that, if prices of mineral fertilisers go up and taxation is adjusted to cover even a small part of the externalities of excess phosphorus use, the use of phosphorus from recycled sources would spread to large areas of arable land[42]. Work done on the JRC project on NPK foresight has helped contribute to the knowledge base on likely developments[43].

Figure 5 shows one analysis of the flows and losses at a global level – in some respects, the EU picture will be significantly different, particularly as regards crop and post harvest losses. Other global, national and regional analyses can still differ sharply, and some of the losses announced are contested. Academic work is in progress to try and improve this global picture.

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39 Rock phosphates and P fertilizers as sources of U contamination in agricultural soils, Kratz and Schnug, 2006

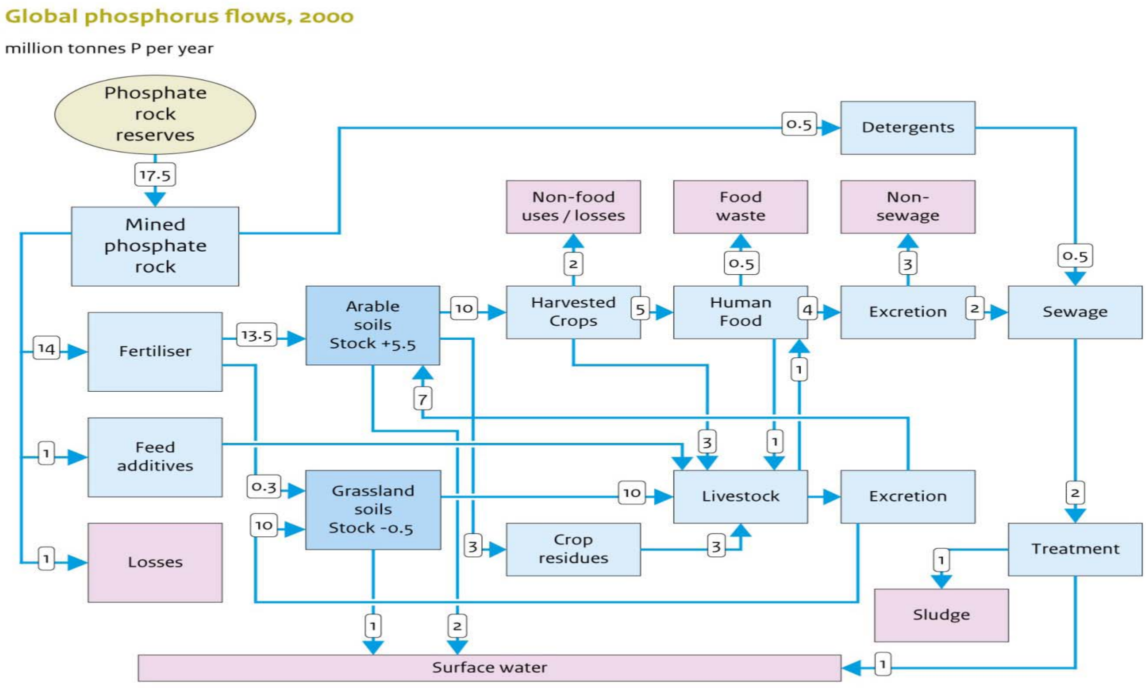
40 A number of these techniques are set out at http://www.phosphorus-recovery.tu-darmstadt.de

41 EU Resource Efficiency Perspectives in a Global Context, PBL, 2011

42 Shakhramanyan et al, Working Paper, 2012.

43 http://eusoils.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/other/EUR25327.pdf

Fig 5: Global phosphorus flows through the agricultural, food and sewage systems (figures rounded) [44]



Global phosphorus flows, 2000 Million tonnes P per year Phosphate rock reserve Mined phosphate rock Fertilizer Feed additives Losses Arable soils stock +5.5 Grassland soils stock -0.5 Detergents Non-food uses/losses Food waste Non-sewage Harvest crops Human food Excretion Sewage Crop residues Livestock Excretion Treatment Sludge Surface water

44 Global phosphorus flows through the agricultural, food and sewage systems, Van Vuuren *et al.* (2010)

Q5 - Which technologies have the greatest overall potential to improve the sustainable use of phosphorus? What are the costs and benefits?

Q6 – What should the EU promote in terms of further research and innovation into the sustainable use of phosphorus?

4.1. More efficient extraction, processing and industrial use

Previous academic analysis of the efficiency of phosphate mining has shown that up to one third of the total rock can be lost through mining, processing and beneficiation operations[45], and a further 10% through transportation and handling[46]. However, recent investments following the price rises have led to significantly improved efficiency in some mines. There are numerous technological innovations being applied or under development that avoid waste of product or by-product, produce cleaner product, or save energy, water or chemicals. Higher prices and depletion of the optimal reserves are most likely to drive these improvements, but EU consumption requirements (particularly in terms of decontamination) may also play a part. Work is also continuing on improving fertiliser safety quality and transparency of fertiliser content via labelling, notably in the context of the revision of the Fertiliser Regulation. The recently adopted revision of the Detergents Regulation restricting the use of phosphates and other phosphorus compounds in consumer laundry and automatic dishwasher detergents will also help to reduce non-essential use and to limit the discharge of phosphorus originating from detergent use.

4.2. More efficient use and conservation in agriculture

Efficient crop production means having enough plant-available phosphorus in the soil (the critical level) to meet the requirements of the plant throughout its development, but no more[47]. Within the EU, several initiatives have already led to more efficient phosphorus use and reductions in phosphorus losses in agriculture. These include the codes of practice and action programmes under the Nitrates Directive[48], and agri-environment schemes under the Rural Development policy. The increased interest in soil protection fostered by the thematic Strategy for Soil Protection, together with the soil part of the good agricultural and environmental conditions (GAEC)[49] within cross-compliance in the Common Agricultural Policy, are contributing to improved soil management and to a reduction in the decline and erosion of organic matter, both of which play a part in phosphorus loss. However, there still remains considerable scope for further improvements in phosphorus use and efficiency at farm level[50]. This includes 'precision farming' techniques, such as manure injection and incorporation of inorganic fertiliser, although testing of field levels of phosphorus and manure content is also important to ensure that the right amount of fertiliser is used in the right place and at the right time – thus raising phosphorus to the critical level. Greater efforts to reduce erosion by wind and water, as well as increased crop rotation, would help in general to reduce

45 Kippenberger 2001

46 Phosphate rock, Lauriente 2003.

47 Efficiency of soil and fertilizer phosphorus use, Syers, et al, 2008

48 Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources

49 GAEC, Good Agricultural and Environmental Conditions, is a list of standards designed to ensure that all agricultural land is maintained in good agricultural and environmental conditions and is part of the cross-compliance system.

50 Improved phosphorus use efficiency in agriculture: A key requirement for its sustainable use, Schroder et al, 2011

losses of soil and the phosphorus it contains. The use of fertilisers in horticulture can also be improved, in particular through closed systems.

Some new technologies that are either already on or coming on to the market could increase the efficiency of fertilizers, notably through enzyme-based techniques, such as innovations to improve root development and the use of microbial inoculants, all of which are designed to improve the efficiency of phosphorus uptake by the plant.

Techniques to improve phosphorus efficiency within animal production have become more widespread. The phosphorus content in diets in particular has been adapted to the needs during the different life stages of the animals ("phase feeding") and the phytase enzyme has been added to feed for mono-gastric livestock. These approaches are contributing to a lowering of the phosphorus content of animal feeds because the animals process the phosphorus more efficiently. However, these approaches are not yet being fully exploited. New phytase enzymes are steadily being authorised as feed additives in the EU.

Costs and practicality of use are the main obstacles standing in the way of a wider take-up of these technologies. While use of the phytase enzyme is already widely accepted, other technologies will require robust investigation – including dedicated field trials – if they are to become standard.

In this respect, the Research Framework Programme for 2014-2020 and forthcoming European Innovation Partnership for agricultural productivity and sustainability could play an important role in developing new solutions for a more efficient use and conservation of phosphorus in agriculture.

Q7 – Do you consider that the available information on the efficiency of phosphorus use and the use of recycled phosphorus in agriculture is adequate? If not, what further statistical information might be necessary?

Q8 – How could the European Innovation Partnership on "agricultural productivity and sustainability" help to take forward the sustainable use of phosphorus?

4.2.1. Better use of manure

During the past decade, the implementation of the Nitrates Directive has been a driver for much better manure management. There has been a surge of interest in manure processing and in transforming the phosphorus-rich solid part of processed manure into a saleable product outside its area of production, where fields are often saturated with nutrients. Although slurry manure starts off with a water content of about 95%, processing can reduce the volume of the solid fraction to about 30% of the original slurry manure, but a number of obstacles to exporting processed manure such as cost (transport, energy) – still remain. Acceptability by receiving farms is also still an issue.

For 15 out of 22 Member States[51], the main supply of phosphorus to agricultural land is already in the form of recycled phosphorus in manure. However, in the other Member States, and in many regions across the EU, the opportunities for greater processing of manure and its use in place of mineral fertilisers are not yet being fully exploited.

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[51] no data available for Cyprus, Luxembourg, Bulgaria, Romania and Malta

Q9 – What could be done to ensure better management and increased processing of manure in areas of over-supply and to encourage greater use of processed manure outside of these areas?

4.3. Potential gains related to prevention and recovery of food waste

Any reduction of food waste at the production and consumption stages would reduce the need to introduce new phosphorus into the system from the rock resource. The situation around food waste has been exhaustively studied. Every person in the EU wastes on average 180 kg of food every year[52]. How we produce and consume food, the type and quantity of food we eat and how much of it we waste has a significant influence on the sustainable use of phosphorus, which makes this an area where there is great potential for improvement. This topic will be further explored in a Communication on sustainable food, which is due to be adopted in 2013. This was announced in the Resource Efficiency Roadmap which has set a target to halve the disposal of edible food waste in the EU by 2020.

As well as preventing food waste, we could also make better use of the food waste that is generated. Currently, large quantities of food waste and biodegradable waste in general are incinerated, and often the phosphorus in the ash is not reused. In addition, significant quantities of phosphorus are also lost to landfill. The Landfill Directive[53] requires Member States, by 2016, to gradually reduce the land filling of municipal biodegradable waste to 35% of the total amount of such waste produced in 1995. The Directive has led to a very significant increase in the recycling of bio-waste to produce biogas and nutrients for soil improvement and agriculture, but does not always direct the resource to the highest value use.

Using biodegradable waste in the form of compost, digestate or ashes from green or kitchen waste would recycle significant quantities of phosphorus along with other nutrients. The take-up of this waste stream is currently hindered by highly fragmented approaches to the appropriate use and quality standards for biodegradable waste across the EU. End of Waste criteria, defining when biodegradable waste ceases to fall under the waste definition, are being developed at Community level. This will help to remove legal obstacles.. The revision of the Fertiliser Regulation due for adoption in 2013 will also be significant. An opportunity will be examined in this context to further harmonise the access to the EU market for biodegradable wastes fulfilling these End of Waste criteria as they might then be used as input materials for organic fertilisers and soil improvers which will be proposed for extension of the scope in the future Fertilisers Regulation.

In addition to this, there are a number of waste streams from agriculture and by-products from food production that could recycle significant quantities of phosphorus, if properly managed. For some of these resources, public health problems and the actions needed to tackle them have made this process less efficient in recent years. One notable example is meat and bone meal and processed animal protein, given that phosphorus is mainly concentrated in the bone structure. Although some meat and bone meal is incinerated and the ashes are used either as fertiliser, directly as a form of soil improver, or in phosphorus production[54], much of the phosphorus is simply wasted. Processed animal protein is authorised for use in feed and organic fertilisers and is available on the market in significant quantities. It may be possible to

[52] EU Preparatory Study on food waste in EU 27; BIO IS, October 2010
[53] Council Directive 1999/31/EC on the landfill of waste.
[54] Thermochemical processing of meat and bone meal, a review, Cascarosa et al, 2011

refine the legal framework[55] governing the uses of such material if other safe uses are identified.

Q10 – What could be done to improve the recovery of phosphorus from food waste and other biodegradable waste?

4.4. Waste water treatment

Waste after human consumption is inevitable, but there are a number of technologies that enable recovery of the phosphorus from waste water treatment plants. These techniques have developed significantly over recent years, with the setting up of several pilot projects and now commercial scale operations in western and northern Europe.

Although removal of phosphorus from waste water is a requirement under Article 5 of the Urban Waste Water Treatment Directive[56], this does not require extraction of the phosphorus in a useable form. One particular feature of the Directive is that it allows the flocculation of the phosphorus using iron, which produces a strongly bound compound from which the phosphorus is not easily commercially recoverable and which may not be fully available to plants.

There are alternative techniques to extract phosphorus which do not create this problem. These include removing of phosphorus waste water in the form of struvite, incinerating sewage sludge and using the ashes, and applying the sewage sludge directly onto fields after appropriate treatment. In all cases, the agronomic quality of the product is crucial to ensuring that the phosphorus is actually available and being taken up by crops. About 25% of the phosphorus contained in waste water is currently reused, the commonest method being direct application of sewage sludge on to fields. The total potential for recovery is quite high – about 300,000 tonnes of phosphorus per annum in the EU[57] – and the significant discrepancies between the different Member States in the EU in terms of how much sewage sludge is used (either directly or in the form of ash) shows potential for harmonisation around best practice.

The commercial and environmental viability of most of these approaches is dependent on the extent to which the resource has been diluted. Dewatering and moving large volumes of liquid around is an energy-intensive and expensive process. The absence of contaminants is also crucial, as it requires high standards and careful control procedures and, in the case of sewage sludge incineration, means that sewage sludge cannot be mixed with other waste during the incineration process.

Although the Sewage Sludge Directive[58] has established the conditions for safe use of sludge on agricultural land, it is now considered to be out of date, notably as regards the maximum limit values for cadmium and other contaminants are considered to be too high. Sixteen Member States have adopted more stringent standards than those set out in the Directive. Harmonisation of higher quality standards would encourage greater confidence amongst farmers and consumers on the safe use of sludge in the EU. In order to encourage more efficient resource use in the future, these issues will need to be addressed so that product standards for sewage sludge inspire confidence right across the chain of end users: namely

55 Animal by-products legislation and Transmissible Spongiform Encephalopathies (TSE) legislation.
56 Council Directive 91/271/EEC concerning urban waste water treatment
57 EUREAU position paper on the reuse of phosphorus, 2006
58 Council Directive 86/278/EEC on the protection of the environment when sewage sludge is used in agriculture

farmers, retailers and ultimately consumers. Sewage sludge can also be composted and the End of Waste criteria currently under development is examining whether this sludge compost can fulfil the stringent standards to safeguard its use by farmers once composted.

Q11 – Should some form of recovery of phosphorus from waste water treatment be made mandatory or encouraged? What could be done to make sewage sludge and biodegradable waste more available and acceptable to arable farming?

4.5. Use of organic fertilisers

One advantage of the more efficient use of phosphate from organic by-products and wastes would be that it does not increase the overall volume of cadmium present in the European ecosystem, to the extent that these by-products and wastes come from food and feedstuffs produced in Europe, which in turn contain cadmium absorbed from European soils. However, copper and zinc contamination can be an issue with some organic fertilisers.

Although many industrial technologies for the recovery of phosphorus (from manure and sewage and biodegradable waste) are already on-stream and used to varying degrees, there is no common strategy to promote the use of such renewable sources by farmers. The price of recovered fertiliser is generally higher than the price of mineral phosphate fertiliser. Much more could be done in terms of identifying markets for recycled phosphorus and barriers to its increased use, and in implementing the technologies that are already available.

5. NEXT STEPS

This Consultative Communication sets out for the first time at EU level the issues around the sustainability of phosphorus use. The intention is now to launch a debate on the state of play and the actions that should be considered.

The European Institutions and all those interested – organisations or private individuals – are invited to submit their comments on the questions set out in the Consultative Communication, as well as on any other issues that they wish to raise concerning the sustainable use of phosphorus.

All stakeholders are invited to send in their comments by 1 December 2013 at the latest, by e-mail to: env-use-of-phosphorus@ec.europa.eu .

It is important to read the specific privacy statement attached to this consultation for information on how your personal data and contribution will be dealt with. Professional organisations are invited to register in the Commission register for Interest Representatives (http://:ec.europa.eu/transparency/regrin). This register was set up as part of the European Transparency Initiative. The Commission will publish stakeholder contributions on the Internet, unless you explicitly request us not to do so.

The results of the public consultation will help shape the further work of the Commission regarding the contribution that the EU can make to the sustainable use of phosphorus.