SCOPE NEWSLETTER

NUMBER 95 July 2013

Public consultation

European Commission

Official consultation on phosphorus use

The European Commission has published an official stakeholder consultation on the sustainable use of phosphorus.

The Phosphorus Challenge

Now online

European Sustainable Phosphorus videos

A series of videos produced by the 1st European Sustainable Phosphorus Conference are now online.

Greenpeace International

Report on phosphate in agriculture

A 40-page report from Greenpeace International sets out the organisation's position on sustainable phosphorus management and implications for farming and sanitation.

Sustainable phosphorus management

Key points and actions to address the Phosphorus Challenge

Two papers assess phosphorus flow analyses and identify hotspots for phosphorus stewardship, including a 'toolbox' of sustainable phosphorus measures.

Australia

Intervention points for phosphorus security

Using an updated phosphorus SFA (substance flow analysis), key focus points for improving Australia's food system resilience are identified.

Food waste

UN and EU actions to cut food wastage

International initiatives to reduce losses in the food chain will contribute to phosphorus sustainability.

Phosphorus flows

ICIS / IFA / Ameropa

Global fertiliser trade map

Downloadable PDF map shows global fertiliser trade flows and volumes for 2011.

Nutrients in the environment

France condemned for failure to implement Nitrates Directive

The European Court has condemned France for failure to implement adequately the EU 1991 Nitrates Directive.

P recovery and recycling

Brazil

Struvite precipitation from cola drink

Struvite was precipitated from cola beverage in a lab-scale batch experiment, by adding magnesium and ammonia, showing 97% phosphorus precipitation.

Novel Electrodialysis: Selectrodialysis

Concentrating wastewater phosphate to improve P-recovery

Selective electrodialysis was tested lab-scale on food industry effluent, to concentrate phosphate and improve P-recovery by struvite precipitation.

Budenheim process

P-recovery from sewage sludge using CO_2

A patented process, tested at semi-pilot scale, enables P-recovery from sewage solids using CO_2 without high temperatures, avoiding heavy metal transfer.

Recycled phosphates quality

Struvite contaminant levels and fertiliser value

Struvite from municipal sewage sludge and potato processing wastewater was analysed for heavy metals and PCBs and tested in pot trials.

Agenda: dates 2013-2014

*The **SCOPE Newsletter** is now published by the **European Sustainable Phosphorus Platform**.*
*With thanks to the Cefic Sector Group **PAPA**, European Phosphoric Acid and Phosphates Producers Association (ex CEEP) who created this Newsletter.*
*Back-issues of the **SCOPE Newsletter** are online at **www.ceep-phosphates.org***

Public consultation

European Union

European Commission consultation on phosphorus use

The European Commission has published an official "Consultative communication on the sustainable use of phosphorus" (19 pages) setting out European issues around phosphorus use and proposing options to improve efficiency and reduce environmental impacts.

Environment Commissioner Janez Potočnik said: "*We are currently wasting this precious resource and creating a pollutant. Using phosphorus more efficiently will reduce its impact on the environment and improve security of supply. We can also create new business opportunities in the recycling sector*."

Deadline: 1st December 2013

All interested stakeholders are invited to submit comments by 1st December 2013 latest, in response to **11 questions** proposed by the European Commission or on any other related issues they wish to raise:

- 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?
- Q4 – How should we handle the **risk of soil contamination linked to phosphorus use** in the EU?
- 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?
- 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?
- 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?
- Q10 – What could be done to improve the **recovery of phosphorus from food waste and other biodegradable waste**?
- 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?

The Commission "*will analyse the contributions in the course of 2014. It will integrate the results of this work into pertinent policy areas, from agricultural policy through water and waste to work on raw materials*."

Links to other EU policies

The European Sustainable Phosphorus Platform welcomes this communication, which confirms that phosphorus stewardship is now recognised as an issue Europe needs to address. Phosphorus is essential and non-substitutable for food production and a range of industries. Europe's supply security is therefore an issue. The Commission's communication shows that phosphorus management has important links with other key EU objectives: critical raw materials and resource efficiency, agriculture, water quality, bio-resources, food wastes …

This European Commission consultation on phosphorus use comes at the right time. **Awareness of the phosphorus challenge is developing rapidly**, with Nutrient Platforms under establishment in several member states (Netherlands was the first in 2011), the Flemish in 2012, Germany only a few weeks ago. The European Sustainable Phosphorus Platform was launched in March 2013 by concerned industry players, regulators, NGOs and knowledge centres at the first European Sustainable Phosphorus Conference in Brussels. Other initiatives are underway in Japan, the USA, Canada and globally (UNEP/Global TraPs).

This official EU consultation will enable this **stakeholder and value-chain energy to generate ideas** to better integrate phosphorus stewardship into Europe's programmes, policy and green growth initiatives.

The European Sustainable Phosphorus Platform will contribute to mobilizing the debate on sustainable phosphorus use launched by the European Commission, by disseminating and inciting response to the consultation, and by facilitating exchange of ideas and information between interested stakeholders.

European Commission press release: http://europa.eu/rapid/press-release_IP-13-658_en.htm
Consultation page on the Sustainable Use of Phosphorus (until 1/12/2013)
http://ec.europa.eu/environment/consultations/phosphorus_en.htm

The Phosphorus Challenge

Now online
European Sustainable Phosphorus videos

A series of videos produced by the 1st European Sustainable Phosphorus Conference, March 2013, are now online:

ESPC conference video:
http://www.youtube.com/watch?v=2AuSj3CCqAM

ESPC Phosphorus Challenge:
http://www.youtube.com/watch?v=Y17HqUsaoj8

ESPC Phosphorus and Food Security:
http://youtu.be/YXpnr9nnmn4

Greenpeace International
Report on phosphate in agriculture

Greenpeace identifies a number of reasons for radically changing how humanity manages phosphorus in agriculture: hazardous contaminants in mined phosphate rock (radioelements, cadmium); progressive resource depletion leading to increasing costs and burden on farmers, price volatility and geopolitical issues; pollution of surface waters by agricultural phosphorus (eutrophication). Greenpeace underlines the need to reduce phosphorus overuse on arable land, to reduce industrial livestock production and reorganise so that manures can be used in local agriculture cycles, to move towards ecological farming, to implement phosphorus recycling from sewage and to develop ecological sanitation.

Greenpeace quotes Carpenter & Bennet 2011 who estimate that human-modified phosphorus cycles today **overshoot planetary boundaries** by some 3 to 20 times.

Phosphate rock contaminants

The report notes the variations in estimates quantifying world phosphate rock reserves, but that all data agrees that **reserves are concentrated in certain regions of the world, in particular Morocco and China**, with other regions (Europe, India …) being almost totally dependent on imports.

The **impacts of phosphate rock mining** are underlined: local accumulation of wastes containing radioactivity and heavy metal contamination, impacts on water systems, local contamination by dust, air pollution and radioactivity. Greenpeace is also concerned about risks posed by uranium, cadmium and fluoride in **phosphogypsum stockpiles**, resulting from processing of phosphate rock to produce phosphoric acid and fertilisers.

The organisation also considers that the **implications of radioactivity and cadmium in mineral phosphate fertilisers**, used in agriculture, need to be further evaluated, both as regards accumulation in agricultural soils and in downstream water bodies, quoting estimates that over 50% of cadmium in the environment may come from mineral fertiliser use.

Greenpeace concludes that "*both mining of phosphate rocks and application of mined phosphate fertiliser to soils imply some environmental and health risks …for mine workers, farmers, farm labourers and further a potential risk for the consumer if pollution is carried upwards in the food chain*".

Farm – food losses and overuse

Greenpeace identify the **biggest losses of phosphorus from farm to fork as being in arable agriculture and in livestock production**, because only 15-30% of fertiliser applied to farmland is actually used by harvested crops and because of improper management of livestock manures. Only about 1/10th of phosphorus used in agriculture actually reaches humans in food, and at the same time only around 1/10th of phosphorus in human sewage is recycled.

In the last 50 years, use of mineral fertilisers has been multiplied by around 3x and **phosphorus from crop production and livestock is a major contributor to the eutrophication of lakes, rivers and coastal waters**, particularly when excess fertiliser or manure is applied, and when soil erosion occurs.

Around 70% of the world's cropland has excess phosphorus, and around 30% a phosphorus deficit.

The report looks in detail at the specific situation in Europe, China, India, concluding that the situation is very variable in different regions, with surpluses often being the result of geographical concentration of livestock production, and that there is a limited understanding at the global level.

Solutions for a broken phosphorus cycle

Greenpeace propose **six measures to manage phosphorus more sustainably** in agriculture and food systems:

- **Stop overuse of phosphorus fertiliser**, by adapting fertiliser use to soil – crop needs and optimising land use
- **Avoid phosphorus losses from cropland soils**, by improving soil quality and reducing soil erosion (increasing organic matter in soil, encouraging healthy microorganism activity in soils, use of cover crops, vegetation buffers to reduce erosion, etc)
- **Maximise use of manure** (organic matter, nutrients) for soil fertility of croplands and pastures. This will mean completely redesigning concentrated, intensive livestock production systems, where animal feed is grown long distances from the livestock consuming it, and manure is produced regionally in large quantities which cannot be used on local farms. Organic sources of phosphorus are important for ecological farming.
- **Adjust livestock diets**, avoiding high phosphate diets and moving to more sustainable animal production. For example, pigs can be fed food scraps with safety precautions, but this is currently forbidden under EU regulations following mad cow disease.
- **Recover phosphorus from manures**, in synergy with energy recovery (eg. anaerobic digestion), but also with the preservation and use of the organic matter to enrich soil structure.
- **Recover and recycle phosphorus from sewage and industrial waste streams**, in the long-term by development of ecological sanitation to save water, energy and nutrients, and in existing centralised sewage systems by P-recovery and recycling processes.

"Phosphorus in agriculture: problems and solutions", R. Tirado & M. Allsopp, Greenpeace Research Laboratories Technical Report (Review) 02-2012 http://www.greenpeace.to/greenpeace/wp-content/uploads/2012/06/Tirado-and-Allsopp-2012-Phosphorus-in-Agriculture-Technical-Report-02-2012.pdf

Sustainable phosphorus management

Key points and actions to address the Phosphorus Challenge

Dana Cordell and the Institute for Sustainable Futures are amongst the leading instigators of global awareness of the Phosphorus Challenge since 2008. Two recent papers update their approach to this issue and provide an assessment of current knowledge on phosphorus flows (substance flow analyses SFAs) at different levels (local, regional, global). An overview of key actions necessary to address the Phosphorus Challenge within different sectors is established.

The first paper analyses 18 recent (post-2005) **phosphorus SFAs (substance flow analyses)** from Eurasia, China, Australia and Africa, at national, regional, catchment or city level, as well as worldwide phosphorus SFAs.

Identifying hotspots for phosphorus management

The paper looks at how SFAs at different scales can be used to identify "hotspots" for P-stewardship, that is **points in the food chain with high potential for reducing phosphorus losses and increasing phosphorus efficiency**, thereby moving towards sustainability.

The authors note that until the last decade, most nutrient SFAs tended to concentrate on losses to the environment, whereas it is now recognised that **both pollution and scarcity aspects are important**. Most available SFAs do not address P-losses in mining, phosphate rock processing and fertiliser production (because these are upstream of and outside the sectors or geographical area studied), although both these losses and potential for savings are very high. The SFAs generally recognise the **inadequacy or inaccuracy of available data** and the need to develop standardised data collection. Although, agriculture, household and wastewater are generally addressed in SFAs, the processes between these are mostly simplified into one flow (termed "industry") which includes very different sectors such as food production, food processing, distribution and retail, each of which involves significant and distinct phosphorus losses.

City-scale SFAs tend to show more detailed information, enabling identification of fate of phosphorus losses. Qiao et al. 2008 showed that the majority of phosphorus in food consumed in Beijing ends up in landfilled sewage sludge.

Several SFAs confirm the **low rate of recycling of phosphorus from wastewater and organic wastes**, and indicate that this recycling rate is decreasing as agricultural use of biosolids is reduced because by policy or because of transport costs.

The authors also note that SFAs address the quantitative potential for phosphorus stewardship, but do not take into account **qualitative dimensions such as farmer livelihood security, national dependence on P-imports, phosphorus geopolitics**. Synergies between sustainable phosphorus management and other environmental and energy policies are also important.

Identification of sustainable phosphorus actions and measures

The second paper provides a comprehensive classification of supply- and demand- side measures in agriculture and food policy to achieve long-term phosphorus security, emphasising the need to combine and link actions in an integrated strategy with a systemic approach to identifying and defining policies and actions. A framework is proposed for assessing and comparing possible measures and identifying the least cost actions in a given context.

The authors indicate that phosphorus security objectives could include:

- **Increasing agricultural P efficiency** (food production per tonne of phosphorus used)
- **Reduce dependency** on imported phosphate rock and fertilisers
- **Ensure healthy soils**, neither P deficiency nor accumulation
- **Meet farmers' needs** for fertilisers
- **Reduce losses and wastage** where possible
- Reduce loss to the environment and so **eutrophication risks**

Supply and demand measures

Supply measures deliver a phosphorus source for use as a fertiliser, including mineral fertilisers manufactured from non-renewable mined phosphate rock or renewable sources such as recovered or recycled phosphorus or biosolids.

Possible sources of phosphorus which could be better used include mine tailings, phosphogypsum, farmed or harvested algae, crop wastes, cultivated green manure crops, manures, animal wastes (such as bone ash), food processing wastes, food waste, sewage and sewage-recovered phosphates ….

Demand measures aim to **reduce phosphorus demand** for a given level of crop or food production, or to increase food production without increasing phosphorus demand.

They include a range of actions and policies such as **reducing waste and improving efficiency** both in farming and food production and processing, **improving crop biological P-efficiency**, and reducing total phosphorus demand through changes towards **diets which require less phosphorus** to produce (in particular, reversing current trends towards increasing meat and dairy product consumption worldwide).

Sector by sector analysis

The paper **assesses supply and demand measures sector by sector**, covering phosphate rock mining, fertilisers, agriculture (crop agronomy), livestock production, food production and consumption, wastewater and sanitation.

These different measures can be implemented by a **combination of policy tools** including regulatory, economic instruments and communication / education.

In order to assess the costs and different measures, a framework is proposed including:

- **Identification of objectives and drivers**, involving stakeholders
- **Define a baseline scenario** (business as usual = reference case)
- **Identify** a wide range of possible measures
- **Match policy instruments** to the measures
- **Estimate** for each measure the potential phosphorus savings or phosphorus supplied
- **Derive cost-effectiveness** of each possible measure and then construct a realistic portfolio of combined measures, taking into account other impacts and benefits

The authors underline the need to **ensure that synergies are considered**, and also that aspects such as transport, logistics, social and farmer acceptability are considered.

"The phosphorus mass balance: identifying 'hotspots' in the food system as a roadmap to phosphorus security", Current Opinion in Biotechnology, vol. 23, Iss. 6, pages 839–845, 2012.
https://www.researchgate.net/publication/224036882_The_phosphorus_mass_balance_identifying_%27hotspots%27_in_the_food_system_as_a_roadmap_to_phosphorus_security?ev=sim_pub

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“Sustainable Phosphorus Measures: Strategies and Technologies for Achieving Phosphorus Security”, Agronomy, vol. 3, pages 86-116, 2013 http://www.mdpi.com/2073-4395/3/1/86

D. Cordell, S. White, Institute for Sustainable Futures, as above.

Australia

Intervention points for phosphorus security

A phosphorus substance flow analysis (SFA) for Australia was presented in Scope Newsletter n° 77. This is updated, concluding that despite being a net food exporter, Australia is a net phosphorus importer of 80 000 tonnes of phosphorus per year (80 ktP/a). This further paper identifies key points where actions could improve Australia’s phosphorus stewardship, and so food security and resilience.

Australia is **the world’s 5th largest phosphorus using country**, although only 52nd by population. Agriculture (not including forestry) is the largest single contributing sector in Australia’s economy (GDP). The continent’s ancient soils, naturally low in phosphorus, were further depleted by European agricultural methods for over a century, before the recent period of generous application of superphosphate fertilisers.

A P-SFA (phosphorus substance flow analysis) for Australia was presented in SCOPE Newsletter n° 77, concluding that **the country is highly dependent on imported mined phosphate rock**, because of these phosphorus-depleted soils and highly phosphorus-intensive agricultural exports. This paper includes an update of this P-SFA, indicating that Australia imports 179 ktP/a net in phosphate rock and fertilisers and exports 99 ktP/a net in agricultural food products. The country thus has a total net phosphorus import of c. 80 ktP/a.

Australia also extracts some 288 ktP/a in its own phosphate rock mines. This domestic P production and the net P import accumulate in agricultural soils (c. 96 ktP/a), in pastures (c. 113 ktP/a), in non agricultural soils (c. 96 ktP/a) and is permanently lost from the country via virtual exports in food and agricultural commodities (c. 100 ktP/a).

Australia’s livestock production accounts for 63% of Australia’s phosphorus demand. That is, some 257 ktP/a net phosphorus consumption (including fertilised pastures and animal feeds) whereas crop production (other than of animal feeds) only 150 ktP/a net.

Total phosphorus in animal manures is c. 700 ktP/a, of which most accumulates in soils of pastures and grazelands (only c. 64 ktP/a is in flows identified as leaving the livestock production area).

Total phosphorus in human urine and faeces is only around 12 ktP/a (cf. Australia’s relatively low human population), although total P in sewage is somewhat higher (c. 18 ktP/a) because of industrial uses of phosphorus, food wastes, food processing waste streams …

Hotspots for intervention and policy

The authors underline that the study identifies phosphorus flows only, not stocks, and that the **data must be considered as indicative not accurate**, because most flows are estimated, many are not estimated directly but are derived by differences between other estimated flows and some smaller flows are not considered.

Nevertheless, the P-SFA enables **identification of key focus points where action or policy could significantly improve Australia’s phosphorus management**, and thus resilience of the food system, and so also economic security (because of the importance of agriculture to the nation’s GDP).

Key interventions identified are:

- **Reconsider the profile of agriculture**, including exports (that is, shifting the mix of agricultural production types to less P-intensive commodities)
- **Diversify phosphorus sources** to better use organic P: for example, the phosphorus in manure = 60x that in human foods consumed in Australia
- **Increase P reuse and recycling**, for example by producing fertilisers from recovered phosphates, investigate P-recycling from phosphogypsum
- **Reconsider diet** towards P-efficient foods: embodied phosphorus in meat products is 2-3x higher than in vegetable products
- **Increase phosphorus use efficiency** whilst maintaining productivity: in mining/P-rock processing, fertiliser efficiency in soils including on pastureland, reduce losses in crop spoilage and food wastes

The authors conclude the **importance of a national phosphorus substance flow analysis in enabling the identification of context-specific policy scenarios** to secure resilient food systems.

“Phosphorus flows through the Australian food system: Identifying intervention points as a roadmap to phosphorus security”, Environmental Science & Policy, 2013, Environmental Science & Policy, 2(9) 87–102, http://dx.doi.org/10.1016/j.envsci.2013.01.008

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Food waste

UN and EU actions to cut food wastage

UNEP, FAO, the EU and the industry association FoodDrinkEurope are leading initiatives to cut food waste losses, which are currently around 1.3 billion tonnes of food/year worldwide, containing maybe 2 million tonnes of phosphorus.

A number of international, national and industry initiatives are being launched to **cut food waste** worldwide.

Think.Eat.Save.

UNEP has launched a **global campaign**, "**Think.Eat.Save.Reduce** Your Footprint" *http://www.thinkeatsave.org/*, in support of the "SAVE FOOD" initiative run by FAO and faire trade NGOs and actions by organisations such as WRAP (the UK's Waste and Resources Action Programme).

UNEP estimates that around **one third of world food production gets lost or wasted** at some stage in the supply chain, in production, harvesting, transport or retail and consumer food waste.

Every Crumb Counts

The EU has announced objectives, in the Roadmap to a Resource-Efficient Europe, to halve food waste losses by 2020 and to end landfilling of food waste by developing digestion or composting (which potentially enable nutrient recycling).

The **European food industry association FoodDrinkEurope** has launched a food chain initiative "Every Crumb Counts" to support this objective, committing industry to the EU objective of halving edible food waste in Europe by 2020.

The European retail sector has also pledged to act to reduce food waste, see SCOPE Newsletter n°90. See also Tristram Stuart's book "Waste, uncovering the global food scandal", SCOPE Newsletter n°81.

Phosphorus in food wastes

UNEP estimates that 1.3 billion tonnes of food are lost or wasted every year, with a value of US$ 1 trillion. If an approximation of 1.5g of phosphorus per g of food is used, this means the direct loss of **c. 2 million tonnes of phosphorus**.

The European Commission estimates that the EU generates 89 millions tonnes of food waste per year in the retail and consumer sectors only (**approx. 180 000 tonnes of phosphorus loss**).

Given the losses of phosphorus upstream of food production (mining and rock processing, agricultural phosphorus losses to surface waters) the phosphorus resource consumption implications are even higher.

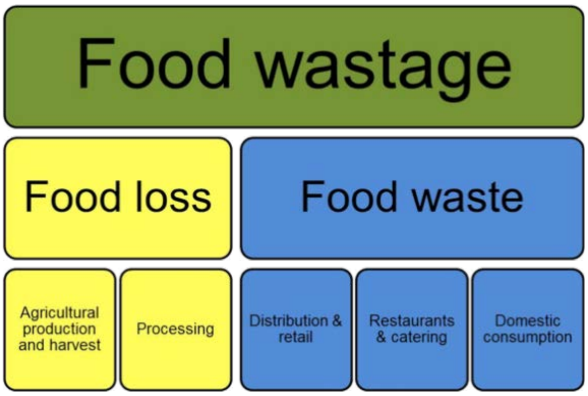
NOTE: phosphorus contents of foods vary widely, from approximately 0.9 mgP/g food in white bread to c. 1.3 – 2.5 mgP/g in most raw meat or fish and 3 – 6 mgP/g in whole-grain cereals, beans or nuts. However, a significant part of the phosphorus in the latter types of food may not be available to humans, because it is in the form of inositol phosphates (phytates) Source: G. Barril-Cuadrado et al., Rev. Nefrologia 2013 http://www.revistanefrologia.com/revistas/P1-E550/P1-E550-S4065-A11918.pdf

UNEP indicates that in **the developing world**, 95% of food losses occur in food production, harvesting, storage, cooling, transport and packaging, because of financial, managerial and technical limitations, whereas **in developed countries** large quantities of food are wasted at the processing, retain and consumer stages, due to inefficient practices, quality standards that over-emphasize appearance, confusion over date labels and consumers being quick to throw away edible food due to over-buying, inappropriate storage and preparing meals that are too large.

The **campaign website** *www.thinkeatsave.org* provides simple tips to consumers and retailers, will allow users to make food waste pledges, and provides a platform for those running campaigns to exchange ideas and create a truly global culture of sustainable consumption of food.

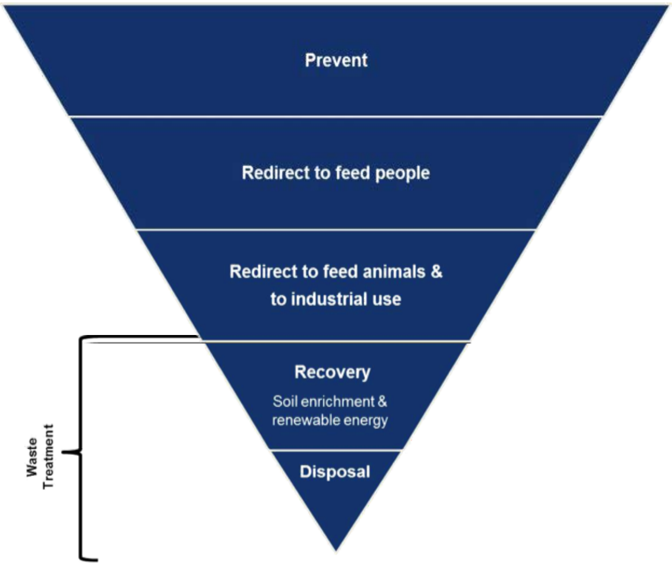
Food wastage and food waste

The European industry association FoodDrinkEurope declaration "Every crumb counts" presents the distinction between '**food wastage**' (which occurs at the production, post-harvest and processing stages) and '**food waste**' (which arises at the retail and consumption stage).



The food wastage hierarchy is emphasized, underlining that the best policy is to avoid waste (prevention), and that only if re-direction to feed people or animals is not possible should recovery be engaged (digestion, composting for renewable energy production or reuse of organic and nutrient content). Recovery is nonetheless preferable to disposal (landfill).

Click on a layer of the image below to see campaign guidance on best practices for the food industry (source FoodDrinkEurope http://fooddrinkeurope.eu/industry-in-focus/foodwaste-toolkit/food-wastage-hierarchy/ *)*



The campaign emphasises that **preservation of food safety and quality are important**, in that protecting food from damage and deterioration during storage and along the supply chain is paramount to limit losses.

UNEP "Think, Eat, Save: UNEP, FAO and Partners Launch Global Campaign to Change Culture of Food Waste": http://www.unep.org/newscentre/Default.aspx?DocumentID=2702&ArticleID=9377&l=en

FoodDrinkEurope "Every Crumb Counts" campaign declaration http://fooddrinkeurope.eu/industry-in-focus/food-wastage-declaration/ *and toolkit:* http://fooddrinkeurope.eu/industry-in-focus/foodwastagetoolkit/

The European retail sector has also pledged to act to reduce food waste, see SCOPE Newsletter n°90. See also Tristram Stuart's book "Waste, uncovering the global food scandal", SCOPE Newsletter n°81.

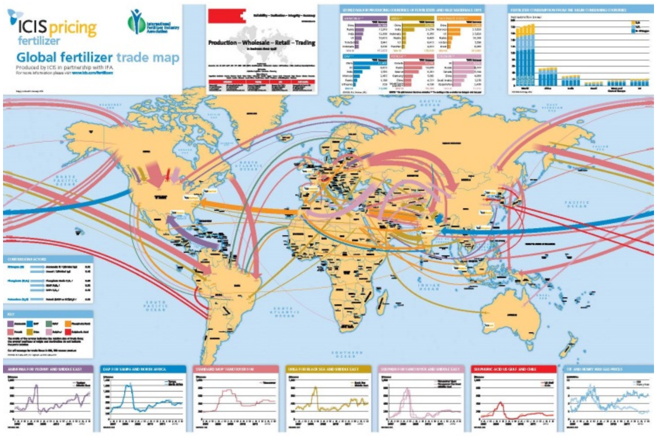
Levels of P in different foods: G. Barril-Cuadrado et al., Rev. Nefrologia 2013 http://www.revistanefrologia.com/revistas/P1-E550/P1-E550-S4065-A11918.pdf

Phosphorus flows

ICIS / IFA / Ameropa

Global fertiliser trade map

ICIS Pricing (market intelligence), Ameropa (fertiliser, grains and oilseeds) and IFA (International Fertiliser Industry Association) have published a map showing global fertiliser trade flows and volumes, between continents and main producer/user countries, of MAP (mono ammonium phosphate), DAP (di ammonium phosphate), ammonia, urea, phosphate rock, phosphoric acid, potassium and sulphur covering 2011.



In addition to the map showing trade flows of these 8 products, the document includes (data source in bracket):

- **conversion factors** for nitrogen or phosphorus content of the different products charted;
- **figures for total world production**, and production for the 6 world leading producer countries for each of six fertiliser categories in 2011 (IFA)
- **graphs** showing known and predicted production of nitrogen, phosphorus and potassium fertilisers for 2011 – 2016 (for China, India, Brazil, USA, Central-Western Europe and world total) (IFA)
- **graphs of prices 2007 – 2012** for ammonia, DAP, MOP (muriate of potash), sulphur, sulphuric acid and natural gas (ICIS)

Download at: http://www.icis.com/fertilizers

Nutrients in the environment

France condemned for failure to implement Nitrates Directive

The European Court of Justice has upheld a complaint brought against France by the European Commission (see SCOPE Newsletter n° 86) for failure to adequately implement the EU's 1991 Nitrates Directive, in particular failure to designate ten areas subject to nitrate pollution as 'Vulnerable Areas". This designation leads to the implementation of action plans to reduce nitrate pollution of agricultural origin. Groundwater nitrate levels are high and are rising in some areas of France. In a separate, new action launched by the European Commission, France is accused of allowing excessive and inappropriate application of fertiliser and manure.

The EU Nitrates Directive requires Member States to monitor groundwater and surface water and identify zones potentially susceptible to be affected by agricultural nitrate pollution, to then designate the catchments of these zones as "**Vulnerable Areas**", and to introduce action programmes for these areas. These programmes must include closed periods (when mineral and organic fertilisers cannot be spread), limits to fertiliser application, and manure storage capacities.

Failure to designate nitrate vulnerable zones

On the basis of the 2007 report prepared by France on implementation of the 1991 EU Nitrates Directive (91/676/CEE), the European Commission considered that France had not designated as "Vulnerable Areas" some ten zones, situated in four of the countries river basin agencies, **despite their being subject to nitrate pollution or risks of such pollution**, for surface or ground waters. The areas concerned are in the Adour-Garonne, Rhône-Méditerranée, Rhin-Meuse and Loire-Bretagne river basin agencies.

After different exchanges with France, the Commission engaged a legal procedure to obtain implementation of the Directive, in June 2011. The European Court of Justice decision of 13th June 2013 validates the European Commission's action against France.

Inappropriate fertiliser and manure use

In a separate procedure, the European Commission launched in May 2012 an action against France for **failure to adequately implement the Nitrates Directive in "Vulnerable Areas"** as regards limitation of fertiliser application periods, capacities for stockage of manure, calculation of nitrogen dosages for balanced fertilisation, limitation of manure application quantities, application of fertiliser to sloping, frozen or waterlogged ground.

France has also been condemned by the European Court for **repeated violations of nitrates and pesticides concentrations in drinking water** (EU Directive 98/83/CE) in Brittany and in other areas of Western France

The French government has reacted by stating that "*this condemnation was predictable and sanctions previous governments' feeble actions*" and has indicated that new designation of "Vulnerable Areas" were signed in December 2012. Some 1,440 zones had been added to the list of vulnerable zones, where measures are required to limit nitrate pollution from agriculture, whereas 617 areas have been removed from the list because actions already taken have resolved nitrate pollution problems. Also, a further Ministerial Decree requiring **vegetated buffer zones**, reduced manure application on certain soils and requiring green cover on land will enter into application in September 2013.

Poland and the Baltic

The European Commission has also opened a European Court of Justice **action against Poland for failure to adequately designate "Vulnerable Zones" to ensure reductions of nitrate pollution.** The Commission considers that Poland contributes to excessive nitrate levels in the Baltic, mainly through agriculture.

The Commission has also sent warnings to **The Netherlands and Hungary for inadequate implementation of cost-recovery obligations of the Water Framework Directive**.

European Court of Justice case C-193/12: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:62012CJ0193:FR:HTML

European Court of Justice case C-237/12: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2012:217:0011:0012:EN:PDF

French Government statement: http://www.developpement-durable.gouv.fr/spip.php?page=article&id_article=33011

European Commission press release (Poland, Netherlands, Hungary): http://europa.eu/rapid/press-release_MEMO-13-22_en.htm

P-recycling as struvite

Brazil

Struvite precipitation from cola drink

Shelf life expired cola beverage was obtained from a local beverage industry and struvite precipitation tested in a lab-scale stirred batch reactor, by adding magnesium chloride and ammonium chloride and dosing pH to 8.5 – 9.5 using sodium hydroxide (2l vessel, stirred volume 1l, 200 rpm stirring for 20 minutes, 20°C).

The cola beverage was de-gassed by vigorous mechanical stirring for 5 hours before the experiments. The beverage phosphorus concentration was 415 mg PO_4/l (140 mgP-PO_4). **Magnesium and ammonium were dosed** at 1:1:1 molar ratio to the beverage phosphorus concentration. This concentration was reduced to 12 mgPO_4 (4 mgP-PO_4) after the struvite precipitation (97% phosphate removal).

XRD (X-ray diffraction) showed that that the precipitated solids were amorphous solids at pH 8.5, but pure struvite crystals at pH 9.5, with a particle size of around 0.25µm. They were also analysed using atomic force microscopy, surface area (BET), thermogravimetric analysis and infra-red.

The authors conclude that struvite can be precipitated from waste cola beverages, potentially enabling phosphorus recycling as fertiliser.

"Production of Struvite from Beverage Waste as Phosphorus Source", Materials Research, 16(1), pages 242-245, 2013
http://dx.doi.org/10.1590/S1516-14392012005000152

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Novel Electrodialysis: Selectrodialysis

Concentrating wastewater phosphate to improve P-recovery

A selectrodialysis (selective electrodialysis, SED) stack, consisting of repeating membrane units, was tested at the laboratory scale on pure chemical solution (phosphate plus chloride) and on potato processing industry wastewater treatment to concentrate phosphate. The concentrated phosphate stream was then fed to a lab-scale continuous stirred reactor, to precipitate struvite. An economical assessment is provided.

The SED reactor was a stack of three cell trios (influent, product and brine compartments), combining cation exchange membranes, standard anion exchange membranes and monovalent selective anion exchange membranes. The active area of each membrane was 0.0064 m^2, giving a **total membrane surface in the stack of 0.0192 m^2.** Flowrate was 30 litres/hour.

Sodium hydroxide was dosed to the product compartment to adjust to pH10 and applied current density was 31 A/m^2 (0.2A).

The system was first tested with synthetic solution containing only chloride and phosphate. It was then operated using **effluent from an UASB (upflow anaerobic sludge blanket reactor) treating potato processing wastewater** (Agristo NV, Harelbeke, Belgium) and concentrating the phosphate into the effluent from the outflow of a struvite precipitation reactor treating this wastewater.

Concentrating phosphate

The pure solutions were used to test phosphate concentration and electrical efficiency. **In the real wastewater effluent, the system also proved effective, with phosphate concentration in the 'product' liquor increasing over seven times**, from < 1 mmolP to 6.6 mmolP after 14 hours. An acceptable increase in phosphate concentration in the brine stream could be achieved with a shorter reaction time.

Inadequate quantities of product concentrate were produced to test them in a struvite reactor, but struvite precipitation experiments using simulated SED product (produced by adding phosphate to the UASB effluent) suggested that after struvite recovery the effluent would have a phosphate concentration comparable to the liquor used to receive the phosphate ions in the SED system.

An **approximate economic evaluation** was made based on these results, estimating that 1 kWh of electricity could produce around 60 g of phosphate (= c. 20g P) by using a full scale SED stack.

The authors conclude that the selective electrodialysis cell stack could be used to transfer phosphate ions from wastewater liquors into the effluent from a struvite precipitation reactor, producing a phosphate-rich stream to feed back into the struvite precipitation process, thus **improving the efficiency of phosphorus recovery for recycling**. Meanwhile, the SED stack also keeps a constant salinity of the struvite reactor and remove salts from the wastewater to reduce its disposal impact.

"Phosphate separation and recovery from wastewater by novel electrodialysis", Environmental Science & Technology, in print May 2013 http://pubs.acs.org/doi/abs/10.1021/es4004476

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Budenheim process

P-recovery from sewage sludge using CO2

A process patented by the specialist for phosphate chemicals Budenheim, uses carbon dioxide under pressure (but without high temperatures) to dissolve phosphate from sewage sludge solids then by progressive, controlled release of pressure, fractionally precipitate calcium phosphate (recyclable fertiliser component) separately from heavy metal. The CO_2 can be recycled after decompression; finally we have a neutral CO_2-balance. Opposite to other processes for P-recovery, which uses acid to decrease the pH value, the CO_2 in the Budenheim process can be recycled and reused

The process **recovers up to 50% of the phosphorus** present in sewage sludge in the first extraction cycle. It is possible to use multiple extraction cycles. **The process operates in liquid phase and at temperatures about 20 °C, no higher temperatures are necessary**.

The process has the advantage of significantly **lower energy requirements than thermal extraction** of phosphate from ash, no addition of chemicals (other than the use of CO_2). Also in the Budenheim-process **all kinds of sewage sludge can be used, even from waste water treatment plants which work with phosphate-precipitation by iron-salts**. So there is no need to switch the Phosphate-elimination to biological Phosphate-elimination.

The CO_2 used can be recycled and CO_2 produced in sewage works digesters could possibly also be used, if captured and pressurised.

The process is currently being improved and **is being tested in a 1 m^3 semi-pilot plant**, following successful testing in a lab scale system.

US Patent Application, Wissemborski et al., US 2012-0070360, 22nd March 2012, original German patent application 11th May 2009.

Recycled phosphates quality

Recovered struvite contaminant levels and fertiliser value

Struvite from municipal sewage sludge and potato processing wastewater digester liquor was analysed for heavy metals and PCBs, showing conformity to fertiliser regulations. Struvite precipitated from potato processing wastewater was tested in pot trials for plant uptake of nutrients, micro-nutrients and of heavy metals.

In a 2010 study, **effluent from the sewage sludge anaerobic digester** of the Ankara Metropolitan wastewater treatment plant, Turkey, was centrifuged (4000 rpm) then the liquor used for beaker struvite precipitation experiments. Different pH and magnesium : phosphate : ammonium ratios were tested. The precipitated struvite was analysed for levels of heavy metals (Ni, Cr, Zn, Hg, As) and of PCBs.

In a further 2013 study, **struvite was precipitated from potato processing industry wastewater**, studying effects of phosphate concentration, ammonium concentration and pH. The fertiliser value of the recovered struvite was tested on corn (maze) and tomato plants in pot trials, assessing both plant growth (dry weight), nutrient uptake (N, P, K), micro-nutrient and heavy metal uptake (Mg, Fe, Mn, Cu, Zn), in comparison to application of pure NH_4NO_3 + KH_2PO_4 as model NPK fertiliser.

The 2010 study, **sewage sludge anaerobic digester effluent showed relatively low soluble phosphate concentrations**, around 21 mg PO_4-P/L, but this more than doubled after centrifuging to 51 mg PO_4-P/L, presumably by solubilisation of a part of the 392 m P-total/L in the effluent.

Ammonium in the centrifuged effluent was much higher (749 mg NH_4-N/L), and magnesium significantly lower (21 mg Mg/L in the centrifuged effluent). Therefore **magnesium and/or phosphate ions were added** (as magnesium chloride, phosphoric acid) to reach objective Mg:N:P ratios. *SCOPE editor's note: this might reduce somewhat the ratio of concentration of contaminant / phosphate in the recovered product.*

pH and ion ratios for struvite precipitation

Struvite was precipitated in 400 ml beakers, by stirring after reagent addition and with pH adjustment (NaOH dosing) at 250 rpm for 30 minutes, followed by 1 hour settling, then coarse filtration of precipitate and drying at 35°C for 24 hours.

Optimal struvite precipitation was found at pH 9 and Mg:N:P ratio of 1.5:1:1. Under these conditions, **89% of NH_4 and 95% of soluble phosphate were removed, as well as 40% of COD** (TCOD was 936 mg/L in the centrifuged effluent used for the beaker experiments). XRD analysis confirmed that the precipitate was struvite.

Contaminants in effluent and struvite

The sludge digester effluent contained significant levels of contaminants:

- Nickel: 3 mg Ni/L
- Chromium: 11 mg Cr/L
- Zinc: 51 mg Zn/L
- Mercury: 9 mg Hg/L
- Arsenic: 0.05 mg As/l
- PCBs: total PCB 0.005 mg/L

In the precipitated struvite, however, nickel, chromium and arsenic were below detection limits (respectively 1.3, 1.4 and 0.12 mg/kg). Zinc was present at 13 mg Zn/kg and mercury at 4.2 mg Hg/kg. **PCBs were not detectable in the precipitated struvite**.

The recovered struvite was thus conform to Turkey's legal limits for heavy metals in fertilisers: nickel, chromium and zinc were 2 orders of magnitude lower than legal limits, mercury was near but below the legal limit (5 mg Hg/kg).

The authors conclude that the recovered struvite is suitable as an agricultural fertiliser, and that the transfer of the organic pollutant PCBs from the sewage sludge digestion liquor to the struvite was negligible (below detection limits).

Potato wastewater struvite precipitation

The 2013 study used effluent from an **anaerobic digester treating wastewater from a potato chip factory in Kocaeli, Turkey**. This effluent had pH of around 8, soluble phosphate content 10 mgP-PO_4/l, magnesium at 22 g Mg/L and high ammonia concentration of 168 mg NH_4^+/L (because of degradation of proteins in the digester).

Concentrations of most heavy metal contaminants were below the detection limit: Al, Mn, Zn, Cd, Cr, Pb, As, Hg, Cu, Ni, Co.

Stirred beaker struvite precipitation tests were carried out using $MgSO_4$ and phosphoric acid to provide magnesium and phosphate dosing as required, and sodium hydroxide to adjust pH. A 3-factor, 3-level Box-Behnken design was used to assess optimal conditions for struvite precipitation (total of 15 different parameter combinations).

Optimal struvite precipitation showed to be at pH 9.5 and at magnesium:ammonium:phosphate molar ratio of 1.8:1:1.8.

The struvite precipitated from the potato industry treatment liquor was tested in plant growth pot trials, using a total of 12 pots each of hybrid corn (Lumina F1, 4 seeds per pot thinned to two plants) and tomato (one plant per pot), with 4 parallel pots of 3 different treatments: struvite as fertiliser, ammonium nitrate plus potassium phosphate as NPK fertiliser, no fertiliser added. In the fertilised pots, fertiliser was dosed only once at the start of the pot trials. Both plants were grown for 50 days, then fresh weight, dry weight, and content of different elements were measured: N, P, K, Ca, Mg, Cu, Fe, Mn, Zn.

Effective fertiliser

Fresh and dry weights of plants in the struvite-fertilised pots were significantly higher (+30% - +50%) than in the NPK fertilised pots, which were significantly higher than in the unfertilised pots. Also, average content (% dry weight) of phosphorus, nitrogen and magnesium were higher in the corn and tomato plants grown with struvite, than in those with NPK. Additionally, the N/K ratio, which is important in tomato plants, was better in the struvite pots.

Levels of copper and manganese were higher in corn plants in the struvite pots than in the NPK fertiliser pots, but lower in the tomato plants. Iron and zinc levels were lower in both corn and tomato plants in the struvite pots than in the NPK pots. **Nickel, chromium and lead levels were in some cases similar, in some cases lower or higher, when comparing the struvite to NPK pots. Cadmium, mercury and cobalt were below detection level in all plants**.

"The determination of fertilizer quality of the formed struvite from effluent of a sewage sludge anaerobic digester", J. Hazardous Materials, n°181, pages 248–254, 2010
www.elsevier.com/locate/jhazmat

A Uysal, Dept. Environmental Engineering, Suleyman Demirel University, Isparta, Turkey. Y. Yilmazel, G. Demirer, Dept. Environmental Engineering, Middle East Technical University, Ankara, Turkey. auysal@mmf.sdu.edu.tr

"Magnesium Ammonium Phosphate Production from Wastewater through Box–Behnken Design and Its Effect on Nutrient Element Uptake in Plants", Clean Soil Air Water (Wiley), in print, 2013
www.clean-journal.com

A. Uysal, B. Kuru, as above

Brussels, 3 October 2013

Decadmiation workshop

With the new European Sustainable Phosphorus Platform being launched, the new Fertilisers Regulation being drafted by the European Commission and the Green Paper on Phosphorus becoming available in the near future, phosphorus has become the centre of attention and feeds many discussions. Together with the increased focus on phosphorus (P), came the attention for cadmium (Cd). Cadmium is a heavy metal that naturally occurs in phosphate rocks, albeit at different concentrations depending on the origin of the phosphate rock. Several cadmium removal (decadmiation) technologies exist but none is used at industrial scale for fertilizer production.

The objectives of this decadmiation workshop are to:

- bring together technology providers, companies active in phosphate fertilizer production or the agricultural sector, knowledge institutes and regulators (both at European as national level)
- provide information on the state of the art in decadmiation technologies and give the platform to P fertilizer producers to demonstrate their developments in this area.
- give an update of the current and future Cd balance in European agricultural soils

To participate or for more information, contact Laetitia Six
Laetitia@fertilizerseurope.com *+32 2 663 31 49.*

Nutrient Platforms

Europe: *www.phosphorusplatform.org*

Netherlands: *www.nutrientplatform.org*

Flanders: *dh@vlakwa.be*

Agenda

Dates 2013 - 2014

- 28 – 31 July, Vancouver:
  IWA Nutrient Removal and Recovery
  http://www.wef.org/nutrients/
- 27-28 August, Helsinki:
  A greener agriculture for a bluer Baltic Sea
  www.gabbs.eu
- 9-13 September, Uppsala, Sweden:
  7^{th} International Phosphorus Workshop
  http://www-conference.slu.se/ipw7
- 17^{th} September, Poděbrady near Prague
  P-REX stakeholder workshop
  Markets and leglistation *www.P-REX.eu*
  and *http://www.asio.cz/en/p-rex-workshop*
- 3^{rd} October, Brussels,
  Fertilisers Europe decadmiation meeting
  www.fertilizerseurope.com
- 27-31 October, Berlin
  Global Soil Week "Losing Ground?"
  www.globalsoilweek.org
- 3-8 November, Tampa, Florida
  ASA/CSSA/SSSA + Canada SA agronomy meetings + SERA17: **Water, food, energy and innovation for a sustainable world**
  www.acsmeetings.org and
  http://www.sera17.ext.vt.edu/
- 6-7 November, Braunschweig , Germany
  Re-Water *www.re-water-braunschweig.de*
- 5-6 December 2013, Bruges:
  ManuResource 2013
  (manure management and valorisation)
  http://www.manuresource2013.org/registration
- 7-10 January 2014, Phoenix Arizona
  2^{nd} Sustainable Phosphorus US Research Coordination Network meeting.
  http://sustainability.asu.edu/research/project.php?id=704
- March 2014: Phosphates 2014 (CRU)
- May 2014, Morocco: SYMPHOS
- 25 Aug – 3 September 2014 (to be defined), Montpellier, France
  4^{th} world **Sustainable Phosphorus Summit**
  http://sustainablepsummit.net/