European Sustainable Phosphorus Platform

SCOPE NEWSLETTER

Policies

European Union
Phosphate rock in EU priority list

The European Commission has included phosphate rock in its updated list of 20 Critical Raw materials.

Diet, health, environment
Nitrogen cycle impacts of dairy and meat intake

Replacing 25-50% of diet animal products by plant products would reduce nitrogen emissions by 25-40%

EU Fertiliser Regulation revision
Essential requirements for organic fertilisers and recovered nutrients

EU Fertiliser Regulation recast, under discussion, will facilitate placing on the market of organic and recycled nutrient products whilst ensuring safety and quality.

Phosphorus on the farm
Making best use of nutrients

Copa-Cogeca workshop agricultural productivity and quality, nutrient efficiency and the environment.

Phosphates 2014
Phosphate industry challenges and opportunities

The CRU Phosphates 2014 conference brings together industry to examine developments and perspectives.

Webinar
Proposing solutions for a circular P economy

WAF webinar sees solutions for P-recycling from sediments proposed by Teknikmarknad.

→ Horizon 2020

Agriculture legislation
Different European regulation of P application

Legal frameworks for land P application vary widely between EU member states, do not address risk of losses.

P-recovery and recycling

RephosmasterTM
Processes for P-recovery demo wastewater

Two Rephosmaster™ struvite crystallisation processes tested full scale in wastewater treatment plants in Japan

US dairy industry
Manure digester nutrient recovery potential

N and P recovery in anaerobic digestion of US dairy farm wastes could be worth 470 and 320 million US$.

RecoPhos
P-recovery from sewage sludge incineration ash

The thermo-reductive RecoPhos recovers P as elemental P or phosphoric acid and reduces iron phosphates losses.

Phosphorus flows

Phosphorus recovery
France achieving 50% P-recycling from wastes

Around 50% of P in waste streams is recycled in France, with important loses to eutrophication and to landfill.

Xiamen City
Sustainable urban biochemistry

Nutrient urbanisation and approaches to restore urban nutrient sustainability.

→ Agenda

The partners of the European Sustainable Phosphorus Platform

Thames Water · Outotec · Nutrient Platform NL · PAPA Phosphoric Acid & Phosphates · ICL Fertilizers Europe · United Utilities · Ostara · Fertilizers Europe · NuReSys · Kompetenzzentrum Wasser Berlin · Ecophos · Severn Trent Water · Science Campus Phosphorus Research Rostock · Vlaams Nutriëntenplatform · Lancaster University · Fachhochschule Nordwestschweiz · Wetsus · Baudirektion Kanton Zürich AWEL Amt für Abfall, Wasser, Energie und Luft · Biorefine Cluster Europe · Phos 4 Ever · Kemira · SEI Stockholm Environment Institute

Sustainable phosphorus policies

European Union

Phosphate rock in EU list of 20 Critical Raw Materials

The European Commission has updated its list of "Critical Raw Materials", increasing from 14 to 20 materials, and adding phosphate rock. The EU's Critical Raw Materials are defined by a high risk for supply security, compounded in the case of phosphate rock by non-substitutability, and high economic importance.

The updated list results from **analysis of 54 non-energy, non-food materials including both abiotic and biotic materials**. The raw material included in the EU Critical Raw Materials list is "**phosphate rock**", of which Europe has only very limited resources (in Finland) and is largely dependent on imports. The "Profiles" report which supports the designation of the 20 Critical Raw Materials notes that the principal use of phosphate rock is in fertilisers, that **demand is expected to increase** (because of growing world population and so need for food), and that there are **no alternatives** in fertilisers or animal feeds.

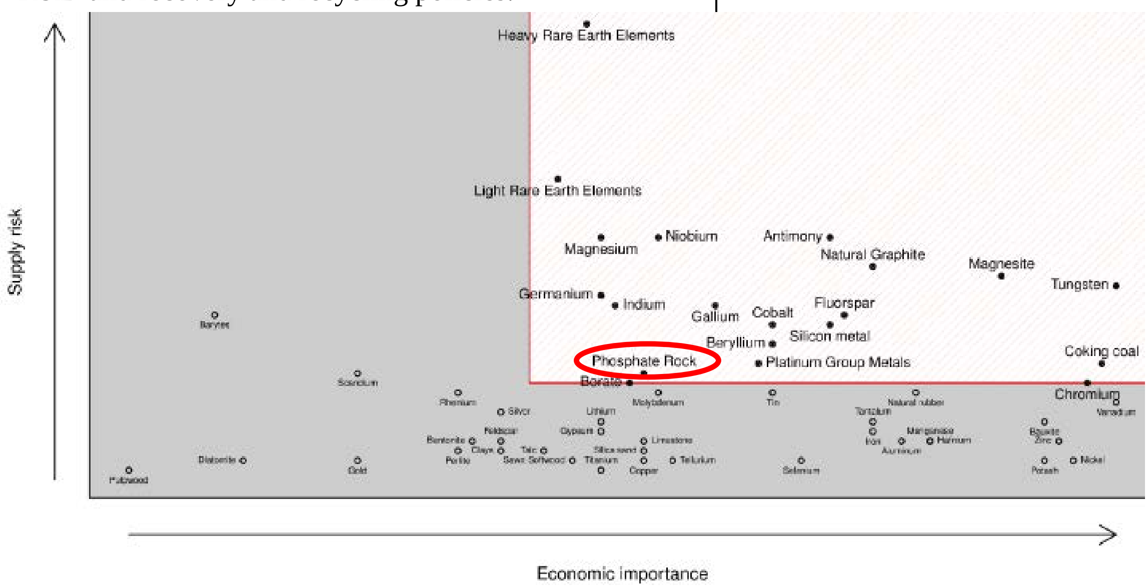
European policies to address raw materials criticality and dependency include improving efficiency of materials use and recycling, waste policy and international cooperation to address supply security. The inclusion of phosphates in the European Critical Raw Materials list will **drive development of EU policies to promote sustainable phosphorus management**, data gathering on resources and use, R&D and recovery and recycling policies.

Unclear analysis

The report is somewhat unclear in places as to whether it is referring to phosphate rock, phosphoric acid, or processed products (fertilisers, white phosphorus for specific industrial applications). For example, a "supply chain diagram" is presented where phosphate rock is first processed to 'phosphorus' and then converted to fertilisers, whereas fertilisers are manufactured from phosphate rock directly and/or phosphoric acid. The 'Profile' report states that "Phosphate rock is not recyclable". This is strictly true, but **it is misleading as the phosphates present in waste streams can of course be recycled**, and indeed already are widely recycled through agricultural use of sewage biosolids, manures, other composts and digestates and recycled phosphate products.

Phosphate rock "supply risk"

Phosphate rock is considered by the EU Commission report to be subject to "**high supply risk**" because of concentrated production in three main countries (China, Morocco, USA), with high "corporate concentration" in production (small number of producer companies with large market share). World deposits are considered to be widely distributed, with the biggest deposits stated as being in northern Africa, China, the Middle East and the USA. Additionally, there are large seabed deposits, but these are not considered to be economically accessible at present. Despite predicted growth in world demand of 2%, **supply is expected by the Commission report to show a large surplus until 2020**.



European Commission press release "20 critical raw materials - major challenge for EU industry", 26th May 2014 http://europa.eu/rapid/press-release_IP-14-599_en.htm

EU Critical Raw Materials home page, access to Critical Raw Materials profile reports, etc: http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm

Diet, health, environment

Nitrogen cycle impacts of Europe's dairy and meat intake

The authors estimate the large scale effects of reducing by 25-50% meat, dairy and eggs in the European diet (replacing by plant based foodstuffs). Nitrogen emissions and nitrogen use efficiency, greenhouse gases, cropland surface needs, population health impacts and food product imports/exports are estimated. The authors note that there would be a "large economic impact on livestock farmers and associated supply-chain actors".

The **alternative diets were modelled with reductions of 25-50% in average EU-27 intake of beef, dairy, pork, poultry and eggs**. The -50% scenario is detailed in the published paper, the other scenarios are presented in supplementary material. Reductions are differentiated between different countries in Europe as a function of current levels of animal products in diet, and diet scenarios calculated in each country before bringing together to calculate the European total.

With these regional differences taken into account, the **-50% scenario is expected to stay reasonably well within public health guidelines for intakes of proteins, micro-nutrients and vitamins**, whilst accommodating variations between individual diets into the average. The substitution of meat and dairy products was assumed to be by cereal-based foodstuffs on a calorie basis, unless the protein intake dropped below recommended levels in which case pulses were added to the scenario diet which occurred for one country only in the -50% scenario. S**heep and goat meat consumption was maintained stable, because of the role of these animals in maintaining extensive grasslands important for biodiversity**. Fish consumption was also not modified.

Livestock feed consumption

Livestock feed requirements were estimated to be reduced proportional to the reductions in meat and dairy in the diet, using current feed data from the CAPRI model. Reductions were adjusted between the four main feed components (protein-rich feeds, energy-rich cereals, roughage, forage maize) according to N content in total feed. Use of local by-products (eg. from food oil or beer production) were not reduced. All calculations were made on a country by country basis, then aggregated to EU27.

Under the -50% meat-dairy scenario, total livestock feed needs are reduced from c. 520 to c. 285 million tonnes/year, a 90% reduction in forage crops grown on arable land (because the scenario favours maintaining grassland production), a -46% reduction in energy-rich feed crop imports.

Land use

Cropland requirements are reduced with the demand for livestock feed. The -50% meat-dairy scenarios results in 9.2 million ha of (mainly intensive) grassland and 14.5 million ha of arable land no longer being needed to produce livestock feed

This was modelled in two scenarios, one with world high food prices, where freed land was mainly converted to arable production of cereals for the world market, the other '**greening**' where land is converted to perennial bio-energy crops (canary reed grass, switchgrass, miscanthus, poplar, willow, according to location). Permanent grassland is assumed to be maintained, but nitrogen fertilisation reduced to respond to lower production needs.

Nitrogen use and emissions

Nitrogen cycle and greenhouse gas emission impacts of the estimated changes in livestock numbers, livestock feed production and cropland use were derived using the MITERRA-Europe model, with input from CAPRI (Common Agricultural Policy Regional Impact), GAINS (GHG-Air pollution Interaction and Synergies), NUTS-2 and FAO fertiliser consumption data. This generates estimates of N, N_2O, NH_3, NO_x, CO_2, CH_4, N_2O emissions, both to air and leaching.

For the -50% meat-dairy scenario, under the 'greening' scenario above, nitrogen fertiliser use is reduced from 11.3 to 8.0 MtN/year, and emissions of nitrates to ground and surface water and ammonia (NH_4) to air are both reduced by -40%. The authors note that this would **reduce eutrophication risks and water quality problems**

The **NUE (nitrogen use efficiency)** for the whole food system (EU27) would increase from 22% to 47% (high food prices scenario) or 41% (greening).

Under the greening scenario, net greenhouse gas emissions from agriculture would be reduced by -42% (CO_2 eq.), or -19% under the high food prices scenario.

Human health

Human consumption of cereals increases by 10 – 49% with the meat-dairy reductions, and the diet protein intake decreases c. 10%, but is still on average +50% higher than WHO-specified dietary requirements. In the -50% scenario, diet intake of saturated fats is reduced by 40%, and red meat is reduced from 89g to 46 g/person/day, bringing both close to or within WHO RMDI recommendations. The authors indicate that **significant positive public health impacts can be expected** as reduced risks of cardiovascular disease, stroke, colorectal cancer, plus indirect benefits through lower use of animal antibiotics, reduced drinking water nitrates and reduced air particle pollution (related to NH_4 emissions).

The authors note that this **health impacts would be even more positive if the calorie intake of the meat-dairy was not replaced** (current EU diets have an energy intake significantly higher than necessary or optimal for health) or if part of the meat-dairy was replaced by fruit and vegetables rather than cereal-based products. However, in the latter case, environmental gains would be lesser because, in general, land use and greenhouse gas emissions from fruit and vegetable production are higher than for cereals (per calorie in the crop). Also, intake of micro-nutrients, in particular calcium and iron, would need to be monitored and possibly compensated or adjusted, as these are already low in many European diets.

The authors note that **public policies would be necessary**, firstly to achieve such a reduction in meat-dairy intake, and secondly to facilitate adjustment of the strongly impacted livestock agriculture sector and related industries (livestock feed, animal product processing). Policies to move European diets to lower meat-dairy content could include: public procurement, public information, abolition of indirect and hidden subsidies to livestock production, direct taxation of meat and dairy products (to increase their price) or indirect taxation (for example by taxing environmental effects such as nutrient releases or greenhouse gas emissions).

The impacts of the different scenarios on phosphorus (consumption, use efficiency, environmental losses, levels in human diet) are not assessed in this study and it would be interesting to extend the methodology developed to these questions.

"Nitrogen on the Table"

NOTE: see also the new **UN-ECE report "Nitrogen on the table: The influence of food choices on nitrogen emissions and the European environment**". Executive summary published by CEH on 25th April 2014: *http://www.ceh.ac.uk/news/press/whywhatweeatmatters.asp* The full report will be published soon. This is the result of the work of the Expert Panel on Nitrogen and Food of the Task Force on Reactive Nitrogen under the CRLTAP.

"Food choices, health and environment: Effects of cutting Europe's meat and dairy intake", Global Environmental Change, in press, 2014
http://www.sciencedirect.com/science/article/pii/S0959378014000338

H. Westhoek (a), J-P. Lesschen (b), T. Rood (a), S. Wagner (a,b), A. De Marco (c), D. Murphy-Bokern (d,e), A. Leip (f), H. van Grinsven (a), M. Sutton (g), O. Oenema (b). a = PBL Netherlands Environmental Assessment Agency, P.O. Box 303, 3720 AH The Hague/Bilthoven, The Netherlands. B = Alterra, Wageningen University and Research Centre, P.O. Box 47, 6700 AA Wageningen, The Netherlands. c = ENEA, CR Casaccia, UTTAMB-ATM, Via Anguillarese 301, 00123 Rome, Italy. d = Cranfield University, Bedford, United Kingdom, e = Lohne-Ehrendorf, 49393 Lohne, Germany. F = Joint Research Centre, Institute for Environment and Sustainability (IES), Via E. Fermi 2749, 21027 Ispra, Italy. g = NERC Centre for Ecology and Hydrology, Edinburgh Research Station, Bush Estate, Penicuik, Midlothian EH26 0QB, United Kingdom

EU Fertiliser Regulation revision

European essential requirements for organic fertilisers and recovered nutrients

The revision of the EU Fertiliser Regulation 2003/2003, currently under discussion, is intended to widen the scope of the Regulation to include inorganic, organo-mineral and organic fertilisers, organic soil improvers, liming products, growing media, plant bio-stimulant and agronomic fertiliser additives. This will considerably facilitate the placing on the market both of organic products containing recycled nutrients (e.g. processed biosolids, digestates, composts, biochars) and inorganic recovered phosphate products (e.g. struvite, phosphates recovered from sewage sludge, incineration ash).

Fertilising materials which are certified to comply with the new essential requirements outlined in the EU Fertiliser Regulation (minimum nutrient content, quality and safety criteria) will be **authorised to be placed on the Internal Market (transported and sold across the European Union),** whereas as present such products registered as “fertilisers” in one Member State cannot be exported or require a new registration dossier for sale in another Member State (except in cases where they has been mutually recognised by the authorities of the importing Member State).

The European Sustainable Phosphorus Platform (ESPP) and Fertilisers Europe (*www.fertilizerseurope.com*) organised a meeting with participation of the European Commission on 6th February 2014. **Stakeholders welcomed the proposal to widen the EU Fertiliser Regulation, because it will enable innovation and flexibility, and facilitate the marketing of new types of products, important both for recycling and recovery of nutrients, and for developing new phosphorus fertilisers for improved crop efficiency or to reduce environmental losses**.

They underlined the importance of the Regulation to ensure Europe-wide, harmonised, accreditation of innovative recycled nutrient products, so enabling them to be put on the market and traded throughout Europe.

Coherence with other regulations

Stakeholders at this meeting considered important the harmonisation of the Fertiliser Regulation with other regulations.

It was noted that clarification is needed regarding the application of **REACH (European chemical regulation)** for substances leaving the waste status. Confirmation is needed that stable digestates are exempted from REACH (compost is already exempted) and clarification is needed regarding the application of the exemption of certain REACH requirements for “recovered products” (art. 2(7)d of REACH, see SCOPE Newsletter n° 98). The European Sustainable Phosphorus Platform has addressed questions to the European Commission on both of these points, supporting the European and German Biogas Associations’ positions concerning REACH exemption of digestates.

There is also a need for coherence with the **Animal By-Products Directive** and the **Nitrates Directive**. In particular, fertiliser products recovered from manures are currently penalised by the limitations for spreading “processed manure” as defined in the Nitrates Directive (see SCOPE Newsletter n° 100). This could be resolved if the criteria defining “mineral fertilisers” under the revised Fertilisers Directive were considered to also define a product as no longer being considered as “processed manure” under the Nitrates Directive.

Accreditation

The EU Commission suggested that a list of accredited organisations, entitled to deliver the “EC” conformity certificate (product conform to the revised EU Fertiliser Regulation criteria = can be sold throughout Europe) will be defined, based on Member State proposals for certification bodies working according to the accreditation principles. This will be particularly important for waste-derived products (recovered nutrient products) as they will be subject to such third-party certification before allowing their placing on the market. It is also important to improve circulation between Member States of information about non-conform products found on the market in order to ensure that they are withdrawn in a consistent way throughout Europe.

All products marketed under the revised Fertiliser Regulations would have to be identified in one of the different product sub-categories (inorganic fertilisers, organo-mineral and organic fertilisers, organic soil improvers, liming products, growing media and plant bio-stimulators) depending on their nature and characteristics. The choice will be made by the producer, who will have to demonstrate that their product fulfils the quality and safety essential requirements defined for this specified product sub-category.

Organo-minerals, blends, mixtures

The category of “organo-mineral” fertilisers may not be retained. In this case, presumably, such products would be treated in the same way as mixtures or blends of organic plus inorganic products. It could be expected, in this case, that **both the inorganic component and the organic component should conform to relevant safety criteria for that category**. Recovered products containing both inorganics and organics could also be treated thus.

End-of-Waste

It currently looks likely that European End-of-Waste criteria for composts and digestates will not be adopted by the European Commission (see SCOPE Newsletter 99), but that existing national End-of-Waste criteria would remain in place, and other Member States may develop such criteria.

It was noted that if there are no European End-of-Waste criteria in place, then **wastes cannot cease to be waste (under the Waste Framework Directive 2008/98/EC)** and will not cease to be waste simply because they respect (revised) Fertiliser Regulation essential requirements: wastes or products from processed waste would thus remain subject to traceability obligations and other relevant waste legislation unless they go through national End-of-Waste Criteria.

However it seems that this situation might evolve during the inter-services consultation in view of the adoption of the proposal for a revised Fertilisers Regulation which highly depends on the adoption of this EU End-of-Waste criteria to **avoid market fragmentation due to the co-existence of diverging national End-of-waste criteria**.

Quality and safety criteria

The EU Commission has circulated for comment (Fertilisers Working Groups 17/3/2014 and 2/6/2014) **draft quality and safety criteria for the different categories of product to be covered under the recast Fertiliser Regulation**.

These include proposals for criteria for minimum phosphorus, nitrogen and potassium content, micronutrients, for organic matter and for maximum levels for contaminants (heavy metals, PAHs, pathogens, viable weed seeds, solids such as glass, metal or plastics). See below.

Product physical and handling quality specifications, such as water content and uptake, caking, density, physical resistance (adaptation to spreading equipment), granulometry, will not be defined by the Fertiliser Regulation, but will be left to the market. However, user safety information will be required just as is the case for any product (Classification & Labelling Regulation information about risks such as skin or eye irritation, respirable dust if relevant …).

As explained in SCOPE Newsletter 98, **cadmium limits for inorganic fertiliser** are proposed at 60 mgCd/kgP_2O_5 (with the possibility for Member States to enact lower limits at 40 or 20 mg Cd where their local protection goals justify it). For other heavy metals, the proposed limits are as follows, with different limits (per kg dry matter) for different

Proposals circulated for comment by the European Commission

Possible maximum contaminant levels (mg/kg dry matter) ***

Contaminant	Inorganic fertilisers	Inorganic micronutrient fertilisers	Organic fertilisers	Liming materials	Growing media	Organic soil improver
Cadmium	1.5-3 *	200	1.5-3	3	3	1.5-3 *
Cr VI	2		0.5-2	Pending	150 **	0.5-2
Hg	2	100	1-1.3	2	1	1-1.3
Ni	120	2000	50	90	90	50
Pb	150	600	120-150	200		120-150
As	60	1000		120		
Cu			200		230	200
Zn			600		500	600
PAHs			6			6
Salmonella spp			Zero in 25g			
E. coli			1000 CFU/g			
Viable weed seeds			2/litre			
Macroscopic impurities			0.5% > 2mm			

* Applicable for products < 5% P_2O_5. For products > 5% P_2O_5 = see above. ** = Cr total
*** Circulated for comment to the EU Fertilisers Working Group meeting of 17/3/2014

product categories because of the different application rates.

If producers of recycled or organic products consider that they would have difficulty meeting the above contaminant limits and that higher levels could be considered for certain products, whilst ensuring consumer safety as a function of product application levels, then they are invited to indicate such points.

Raw sewage sludge

The EU Commission also suggests to exclude "raw sewage sludge" from the recast EU Fertiliser Regulation. **Further work will therefore be necessary to define when a product is considered to be sufficiently processed to be certified under the recast Regulation** (and not to be excluded): stabilised – dried – granulated sewage sludge? composted or anaerobically digested sewage sludge (digestate)?

It is further suggested to exclude raw manures, except where these are traded. This exclusion enables farmers to reuse their own manures or to maintain local reuse circuits, and should probably be defined to exclude manures where quantities traded (either for free or for payment) are below a certain threshold tonnage/year/producer or where the trade is between nearby farmers. As above, clear exclusion criteria need to be defined.

Further work is probably also necessary to address the question of trace organic contaminants, such as pharmaceuticals, hormones, plasticisers and other organic chemicals. Stakeholders at the meeting organised by ESPP suggested that products should be exempted from testing for such substances where the production process means that they should not be present (e.g. inorganic fertilisers produced from phosphate rock, recycled phosphates from thermal processes such as biosolids incineration) but that other products should be required to demonstrate that any traces of such contaminants do not pose risks for health or the environment through product use as a fertiliser, using a risk assessment based approach and a minimum of testing, in order to guarantee consumer and environmental safety.

It is noted that there are significant **sampling challenges** for products which may not be fully homogenous, e.g. manure or compost. Stakeholders emphasised that Fertiliser Regulations should ensure better safety levels than sludge spreading regulations, taking in all cases the most stringent existing regulations in Member States.

NOTE: all information in the above article should be considered as "work in progress" in that the EU Fertiliser Regulation revision is currently in the discussion and preparation phase.

EU Fertilisers Working Group
http://ec.europa.eu/enterprise/sectors/chemicals/specific-chemicals/fertilisers/index_en.htm

Phosphorus on the farm
Making best use of nutrients

Copa-Cogeca (European Farmers, European Agri-Cooperatives) organised a workshop on "Making best use of nutrients", 26th March, to discuss different challenges related to nutrient management in agriculture, including productivity, quality and economy, including nutrient efficiency, recycling, good agricultural practices and nutrients in water quality policies and in the Common Agricultural Policy.

The workshop brought together farmers' representatives and cooperatives from some 15 countries, and enabled informal dialogue with stakeholders from environmental NGOs, industry and policy makers.

Arnaud Petit, Copa-Cogeca, opened the workshop by emphasising the essential **need for efficient and environmentally compatible management of nutrients in agriculture**. He noted that nutrient recycling must be a key point of Europe's "circular economy" policy, corresponding to Copa-Cogeca's "Green Growth" objectives.

Agricultural nutrient recycling

Adrian Gonzalez, Cooperativas Agroalimentarias, Spain, presented experiences of a biogas plant fed by manure from a 3 300 cow dairy farm as well as other local manures and in a trial selectively collected municipal food waste. Situated in a warm, arid area of Spain, crops are grown and digestate can be used all year round. **The liquid fraction of digestate is sold at 2€/tonne (delivered and spread)** and is used on 4 000 ha of irrigated land with a radius of 17 km, the solid fraction is sold at 5€/tonne (price at digester) and used on 1 000 ha up to 50 km. Farmers have confirmed satisfaction with both fractions as improving degradation of organics such as straw (liquid fraction) or providing P and contributing to soil carbon (solid).

Mr Gonzalez emphasised the **administrative difficulties encountered**. Spain's national fertiliser regulations recognise compost but not digestate. Although the cooperative's digestate respects the German standard RAL GZ 245, it is not recognised as End-of-Waste nor as a fertiliser. This makes the use in the nearby regional national park difficult (where farmers wish to use it as an organic fertiliser) and poses problems with canning companies due to the current "waste" status of digestates.

Jeanet Brandsma, LTO (farmers' organisation) Netherlands, presented experience in a farm with 270 dairy cows. **Innovative flooring reduces ammonia emissions, thus increasing N content in the slurry** (drop down lattes act like valves preventing ammonia rising). Careful management means that, after screw press solid/liquid separation of the manure slurry, the solid fraction can be used as bio-bedding for the cows (soft, high fibre content), replacing other bedding material to be purchased. The liquid fraction is put as a nutrient source to land, showing quite good results on grassland.

The Netherlands national farmers' association has developed the ICT tool ANCA (Annual Nutrient Cycling Assessment) to ensure efficient and balanced nutrient application, including using the thicker fractions of manure slurries for slow-release nitrogen.

Carl Dewaele, NuReSys, Belgium, emphasised the **potential for nutrient recycling from sewage, manure and other agri-food waste streams**. He presented struvite precipitation, as a technology which is today operative full-scale in a number of sewage works and food processing industries showing an interesting ROI (return on investment); a pilot plant applied on manure treatment will shortly be installed. Several companies today have operational processes, including NuReSys www.nuresys.org, Ostara (Thames Water, see SCOPE Newsletter n°99), Berlin Wasser (SCOPE 101). The NuReSys-P technology will shortly be applied as a struvite recovery installation directly in a manure-fed anaerobic digester outflow (upstream of solid/liquid separation) bringing the advantage of avoiding incrustation problems in the filter press/centrifuge.

Peter Brouwers, LTO, The Netherlands, indicated that work on **production of mineral concentrates from manure shows that these can be consistent and have nitrogen "efficiencies" comparable to inorganic fertilisers**. Quality of recovered nutrient products is essential, in order to ensure a profitable market. LTO is asking for derogation under the Nitrates Directive to allow their use to the same limits as inorganic fertilisers.

Tiffanie Stéphani, DBV (German farmers' union), presented the situation in Lower Saxony, Northern Germany: 9 000 livestock farmers, producing 2 million tonnes/year of manure, but nonetheless a further 300 000 tonnes/year of manure imported and used by arable farmers, 1 500 biogas plants operational. The arable farmers' **expectations of processed manure products** are a good price (including transport), high nutrient content, guaranteed safety (contaminants, pathogens), compatibility with spreading equipment, avoidance of odour/ammonia problems. Processes such as **Optithermo** (drying with ammonia capture) are available, but are not economic. German fertiliser regulations cover such organic products, providing quality assurance to farmers, but the Nitrates Directive limits the application of manure regardless if processed or not and thus poses an obstacle to its use, leading to a situation where arable farmers prefer mineral fertilisers.

Common Agricultural Policy (CAP)

Claire McCamphill, EU Commission DG Environment, summarised implications for agricultural nutrient management of the **EU Water Framework Directive (WFD).** The WFD requires Member States to ensure that all surface and groundwater achieves "Good" status by 2015, with possibilities of derogations to 2021 or 2027. From the analysis of the first cycle WFD plans, it is clear that nutrients still pose a major obstacle to achieving good quality water in the EU. The WFD is focused on outcomes ("Good" status) and it is up to Member States to work out what measures they will put in place in what areas to achieve this goal. There has been worrying little progress made on this in the first cycle of the WFD. Member States have requested too many derogations related to agricultural nutrients, in many cases without adequate justification.

Ms. McCamphill explained that **the WFD goes beyond the Nitrates Directive, requiring mandatory measures** not just in Vulnerable Zones but in all areas that drain to surface or groundwater bodies where nutrient pressure has been identified. She notes that

WFD measures are foreseen to be integrated into "cross compliance" (that is, CAP direct payments to farmers will be conditional to respect of certain relevant WFD measures). The commission is to come forward with a proposal on this in the coming years. Therefore, Member States make sure that they have defined what these measures are and that they are working now with farmers to implement them, so as to reduce the likelihood of negative impacts on farm subsidies when they do become part of the cross-compliance framework.

It is recognised by the WFD that additional measures will be needed to fully restore aquatic ecosystems, and in this regard **CAP Rural Development Programme (RDP) funding will be important to implement specific actions** that can supplement efforts taken to reduce nutrients at source. Such measures can include wetland restoration, vegetated buffer strips, afforestation, arable reversion in certain targeted areas. Ms. McCamphill reminds that CAP pillar 2 funding should target the delivery of public goods where action is needed most, and not be a general top up subsidy to all farmers.

Peter Nörring, DAFC (farmers' organisation), Denmark, reminded that farming inevitably has impacts on surface and groundwater which cannot be completely avoided, unless all land is returned to natural forest cover. Nitrogen losses increase with higher productivity and tend to inevitably move to groundwater. Nitrogen losses are generally higher using organic fertiliser products. **Farmers need advisory systems, demonstration of new techniques, not further mandatory obligations and increased bureaucracy through cross compliance**. Solutions should be researched and tested which enable to combine production of quality crops (e.g. bread wheat) with reduced nutrient losses, for example wetlands restoration and appropriate buffer vegetation.

Olivier Diana, EU Commission, DG Agriculture, noted that the two pillars of the CAP contribute to improving nutrient management:

- Under cross compliance already today, all direct **payments under CAP are subject to respect of water quality legislation**, e.g. Nitrates Directive obligations
- Under **Good Agri-Environmental Practices**, possibility to fund buffer zones for water pollution prevention
- Under **CAP "Greening measures" (First Pillar),** crop diversification, permanent grassland and 5% Ecological Focus Areas in arable land (can be used for buffer strips, catch crops, nitrogen-fixing crops)
- **Rural Development Programme RDP (Second Pillar)** funding to be used for priorities 4 and 5: improving ecosystems, resource efficiency and climate change
- **Farm Advisory Service**: includes assistance for farmers towards achieving Water Framework Directive objectives
- **European Innovation Partnership** works to promote innovative, efficient and profitable nutrient management
- Part of the **EU's R&D budget (Horizon 2020)** is now managed by DG Agriculture and can be used to develop and demonstrate nutrient management

Mr Diana concludes with the need for an inclusive approach, involving cooperation between the EU Commission, Member States, river basin bodies and local stakeholders, and for an integrated approach including the Water Framework Directive, the Nitrates Directive, CAP implementation and R&D.

Ecological nutrient management

Marta Kalinowska, WWF Poland, presented **WWF's Baltic Sea Farmer of the Year Award** *www.panda.org/baltic_farmer*. This award annually recognises individual or cooperative farmers in the Baltic catchment who are implementing exemplary practices in nutrient management. Each year one farmer prize-winner from each Baltic catchment state plus an overall winner are selected.

Farm practices awarded to date have included amongst others:

- Balanced fertilisation
- Creation of wetlands
- Artificial ponds as nutrient traps
- Use of nitrogen "catch" crops, undersown crops or all-year ground cover
- Permanent grassland buffer strips
- Appropriate application of manure to recycle nutrients
- Crop rotation systems
- Reduced tillage
- Soil liming

Zanda Krüklite, Farmers Parliament, Latvia, presented experimentation and demonstration of nutrient loss mitigation and nutrient recycling in the **Baltic Compass and Baltic Compact projects** (*www.balticcompass.org*). Small dams in streams have not showed to very effective in reducing nutrient losses after first year of trials, but "2 step ditches" (drains with different bank layers) can be effective in reducing soil erosion and transport of nutrients (further work is needed to better define the best type of bank management: grass or trees). Controlled drainage, with retention of water in drains in winter (raise water table) to create anoxic zones can be effective in reducing nitrogen leaching and phosphorus runoff (further work is needed into ammona/NO_x losses and impacts of winter soil saturation on fertility).

Testing of biomass anaerobic digestion has shown difficulties in operation, but satisfaction of farmers with the digestate product. There are also regulatory difficulties for recognition of the digestate as a product.

Ms Krüklite underlines **the need for multidisciplinary R&D involving practitioners in the field**, testing of different techniques adaptation to local specific cases, dissemination and outreach to farmers to provide support and advice. She recommends *http://agro-technology-atlas.eu/* as a reference site for nutrient management techniques, enabling identification and referencing of best practice.

Regulatory challenges to nutrient recycling

Vincent Delvaux, EU Commission DG Enterprise, presented the **work ongoing to review the EU Fertiliser Regulation** (see in this Newsletter). The objectives are to widen the scope to cover organic fertilisers, organo-mineral fertilisers, soil improvers growing media and plant bio-stimulators, so facilitating the placing on the market of these products, harmonising information and labelling and reducing administrative burdens for companies and member states (one EU product registration for all fertilisers), whilst ensuring fertiliser quality and safety (nutrient content, contaminants, product properties). For farmers, this should bring advantages of more product competition (lower prices) and more innovative fertiliser products adapted to specific local requirements.

Mr Delvaux indicated that **the European Commission hopes to base the Fertiliser Regulations update, for composts and digestates, on the JRC proposed "End-of-Waste" criteria** (see SCOPE Newsletter n° 99), but that these criteria will at present not be adopted as European "End-of-Waste" criteria (under the Waste Framework Directive). Digestates or compost for which sewage sludge was used as an input ingredient would be excluded. Nutrients in such materials could then be used and recycled on farms under national biosolids application regulations (with waste status) or could go through national "End-of-Waste" regulations (where defined) and so be used nationally as a "product" (but not traded across Member State borders).

Inorganic fertilisers (e.g. struvite, ammonium sulphate …) recovered from sewage are however expected to be covered by the revised Fertiliser Regulation, subject to respecting the quality and contaminant requirements.

Bartosz Zambrzycki, EU Commission DG Environment, emphasised **the EU Commission's position that it is necessary to develop user confidence in composts and digestates**, as stated in the Communication on future steps in bio-waste management in the European Union - COM(2010)235 final. He confirmed that the implementation of the draft "End-of-Waste" criteria for composts and digestates is currently discussed in the context of their integration into the Fertiliser Regulation revision.

Max Schulman, MTK (farmers' organisation), Finland, emphasised that **grain producers need fertilisers to achieve productivity and product quality**. He emphasised the challenges of reducing phosphorus use. Research is needed to ensure that this does not result in negative side effects such as reduced disease resistance, lower performance of winter crops, lower grain quality. R&D is also needed to address improving nutrient management without increasing costs for farmers.

Mr Schulman noted that **increasingly there are regions of Europe with a nutrient excess in manures, and other farming areas which need nutrients**. The revised Fertiliser Regulation must facilitate recycling processes, producing nutrient products from manures which enable this transfer.

It is important for farmers that recycled nutrient products are guaranteed to be safe, without heavy metals, or pharmaceuticals which might come from sewage biosolids, herbicide residues which may be found in some crop by-product digestates, or other contaminants. Therefore, MTK wishes sewage sludge biosolids input to be excluded in the revised Fertiliser Regulation.

On the other hand, **farmers should be allowed to recycle their own manure, or that of their colleagues locally, without bureaucracy or constraints**. Manure as such should therefore not be covered by the Fertiliser Regulation, although of course some testing and guidance is desirable in order to ensure balanced nutrient management.

Benjamin Balloy, APCA France (national federation of chambers of agriculture), emphasised that farmers' are not waste recyclers. Their **priority is the recycling of farmyard manure**, not municipal waste. Agricultural product quality and safety are more important than recycling. The revised Fertiliser Regulation should therefore ensure product quality, safety and agronomic value, and should limit entrants used in production of fertilisers.

Municipal biowastes should only be accepted as raw material for biogas plants if collected separately. **Sewage biosolids should be refused as an input in Fertiliser Regulation or "End-of-Waste", in order to guarantee traceability.** This raises questions about materials recovered from sewage streams (e.g. struvite): how to verify that there are no organic contaminants? Sewage biosolids can nonetheless be reused and nutrients recycled locally in agriculture, with appropriate quality controls, under specific local management systems.

Arnaud Petit, Copa-Cogeca, concluded the workshop, indicating that **Copa-Cogeca as European umbrella organisation will continue to work around nutrient management and nutrient recycling**, in particular regarding:

- A **vision** for nutrient sustainability in agriculture
- Follow-up on **market and technologies development** for nutrient recycling
- **R&D** into nutrient management, including innovation within the EU agriculture and water EIPs
- **Regulatory**: Nitrates Directive, CAP, Fertiliser Regulation recast, Water Framework Directive.

Information: COPA-COGECA "The Future CAP after 2013 Copa-Cogeca proposals for green growth" http://www.copa-cogeca.be/img/user/file/PAC2013/pac2013E.pdf

Phosphates 2014
Phosphate industry challenges and opportunities

The CRU Phosphates 2014 conference brought together 380 delegates from 42 countries, 25 speakers, 15 technical showcase presentations, and 39 company stands, representing phosphate mining, processing, fertilisers, animal feed phosphates, technical phosphate applications and related industries. The 2013 conference (see SCOPE Newsletter n° 93) showed that considerable new phosphate mining sites with production potential are identified, and that the phosphate industry faces new challenges from concerns about sustainability. The 2014 conference confirmed these tendencies, with a continuing decrease in market prices for phosphates since 2011.

Phosphates 2015 (8th International Phosphates Conference) will take place in **Tampa, USA, 22-25 March 2015**. Call for papers is now open. *www.phosphatesconference.com*

Nick Edwards, CRU, opened and presented CRU, organiser of the Phosphates Conferences: 220 staff in 7 countries in different continents, dedicated to market and cost analysis and consulting for the phosphates, nitrogen and sulphur industries.

James Ortiz, Indagro (USA) Incorp, summarised expectations for the phosphate market in 2014. **Considerable new capacity coming onstream is likely to be balanced by increased demand this year, and prices are unlikely to increase significantly in the coming year**. Phosphoric acid capacity for example is expected to increase nearly 20% from 2013 to 2017. At the same time demand may increase in some regions, in particular Africa and South America with growth in agricultural production and investments in fertiliser distribution and use infrastructure. Europe may see continuation of the revival of phosphate fertiliser consumption which was noted already in 2013. The development of specialist fertilisers, including micronutrients or sulphur or slow-release, is expected to continue, particularly in the USA. China and India remain major questions as regards phosphate fertiliser consumption changes, depending respectively on price sensitivity and on possible changes to the government subsidy system.

Alberto Persona, CRU, presented CRU's new **methodology for assessing the cost structure of the phosphate rock industry**. This new approach takes into account not only the direct mining costs, but also the quality of the concentrate produced, the potential for downstream integration (processing to phosphoric acid or fertilisers) and access to specific markets (access to trade routes). This analytical framework is able to highlight the competitive position of expansions and existing operations, a particularly useful tool in a market with many projects trying to raise finance, and with strong incumbents increasing their downstream capacity. Examples were provided on the investment outlook for Brazil and China.

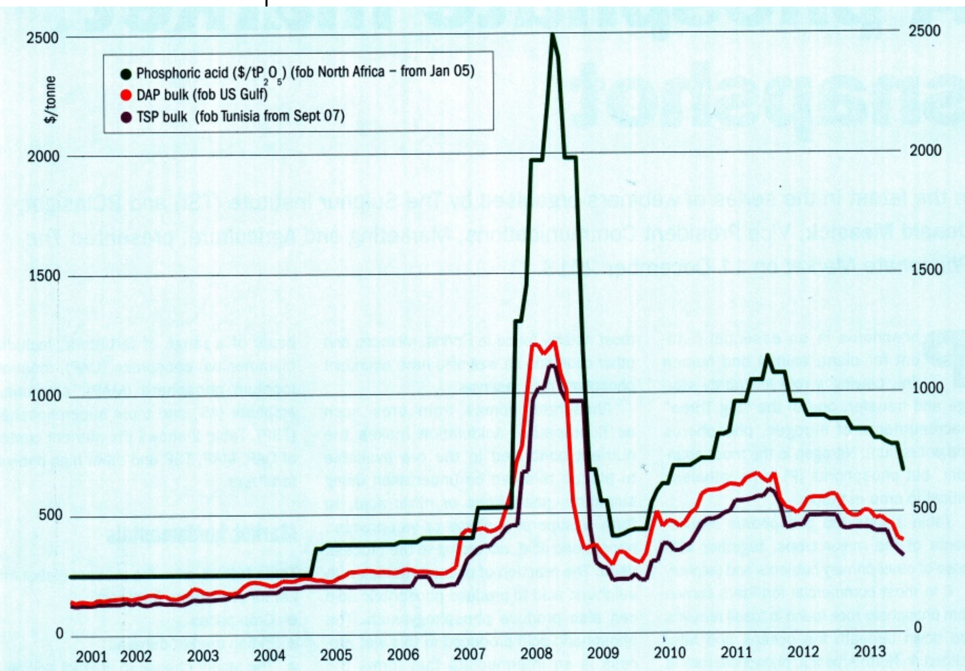
Mr Persona indicated that **current phosphate rock mining projects worldwide could increase production capacity by 30% over the coming few years** if they were to be realised. He notes that today around ¾ of the world's phosphate rock production is 'integrated' (processed by the producer to acid or fertiliser) and that this proportion is expected to rise to 85 – 90% in coming years.

Food and climate risks

Juan von Gernet, CRU, confirmed the difficulty of predicting market price developments and explained why predictions of stable or increasing prices presented at Phosphates 2013 proved to be wrong (prices continued to fall): the subsidy system in India continues to promote nitrogen rather than phosphorus fertiliser use whilst at the same time high fertiliser stocks in the country enabled response to demand with limited purchase on the international market. On the other hand, demand grew more in China than had been expected. **At times during the second semester of 2013, the market price for phosphate rock fell as low as or below short term marginal production costs, resulting in some rationalisation**. In 2014, phosphate fertiliser consumption increased in Europe (correction of use levels had fallen, after the 2008 price spike, below those necessary to sustain agricultural productivity) in Brazil and in Australia (good wheat harvest expected).

Mr von Guernet noted that China has recently announced the abandonment of its policy of self-sufficiency in food production and India may not be able to afford to subsidise phosphate fertilisers, so that **global total demand is likely to stagnate in 2014**. A more serious risk is the >50% likelihood of an El Niño event in 2014 which would considerably reduce food production, and so phosphate prices.

Matthijs Mondria, Robobank International, specialised in funding food chain industries and investments, reminded that world food prices (in particular grain prices) are closely linked to fertiliser prices. **The future will show contradictory tendencies**, such as the need to double world food production by 2050 (FAO), new land coming into agricultural production, low farm earnings depressing fertiliser market, the development of precision farming (so that fertiliser use levels in Asia can be expected to fall to levels currently in Europe) and balanced nutrient application. Fertiliser application is increasingly disconnected from agricultural productivity.



Graph of phosphate prices– with permission Fertilizer International 459, March-April 2014
https://www.bcinsight.com/fertilizer_international.asp

Improving phosphate use and precision products

Valérie Renard, Prayon, presented the company's new developments in phosphate fertiliser products, based on research and agronomic testing. The objectives are to optimise crop production whilst preserving nutrient resources and water. She presented Prayon's innovative iron-containing fertiliser, in which the iron is plant available (not tied up as iron hydroxide or iron phosphate). The iron is delivered in a polyphosphate, which is fully plant available. The product has proven to improve plant growth where iron is needed, avoid chlorosis and tipburn, is ultraviolet resistant and also prevents fertigation pipe clogging.

Terry Roberts, IPNI (International Plant Nutrition Institute), presented the Institute's programme for improving phosphorus use efficiency, based on the **4R Nutrient Stewardship (Right fertiliser source, Right rate, Right time, Right place** *http://www.nutrientstewardship.com/what-are-4rs*). He expressed concern that a number of "false concepts" continue to circulate in science, media and regulatory spheres, for example the idea that 'Peak P' could occur in the coming decades (whereas it is now clear that phosphate rock reserves and resources are considerable) or that 'P Efficiency' of crops is low (crops may only take up 20-30% of phosphorus in the year of application, but often 90% will be used over several years).

Nonetheless, IPNI underlines that **sustainability issues will become increasingly important in phosphorus management**: including development of phosphorus recycling to address local nutrient surpluses and conserve resources, pressure on cadmium levels, improving the efficiency of crop phosphorus uptake, both to reduce field P losses to surface waters and to use 'Legacy P' accumulated in some agricultural soils (see P-RCVN in SCOPE Newsletter n° 100).

New products and systems are developing to improve crop P uptake including biofertilisers, (microorganisms which secrete chemicals which release P in the soil), enzyme products (e.g. phosphatases which release P from organic complexes in the soil), chemicals which sequester iron and aluminium so releasing P, crops with increased root surface or whose roots secrete P-releasing chemicals, …

Phosphates for animal feeds and food products

Yannick Vancoppenolle, Ecophos, explained that expected growth in world population and in GDP (so increased meat and dairy in diet) are expected to result in overall increasing demand for animal feed phosphates, both for meat production and in aquaculture. Feed phosphate prices continued to fall in 2013, but remain +25% higher than in 2006 (pre price peak) and are expected to be stable or rise in 2014.

Ecophos' vision is to feed the world from low-grade phosphate rock and secondary (recycled) phosphate streams. The company is a world leader in animal feed phosphates, after integrating Aliphos. A new factory producing 200 000 tonnes/year of DCP (Di Calcium Phosphate, animal feed ingredient) is being built at Dunkerque, on the North France coast, opening 2016. This site will be able to take secondary phosphates such as sewage sludge incineration ash or manure incineration ash as input material.

The Ecophos process does not produce phosphogypsum (calcium phosphate precipitate) but produces soluble calcium chloride (which can be discharged to the North Sea). Depending on the phosphate rock or secondary phosphates used and on the purity requirements of the product (fertiliser, feed phosphates …), contaminants and impurities can be concentrated in a low-volume hazardous waste streams (e.g. typically from phosphate rock c. 95% of heavy metals are removed in this way with < 5% of inflow contaminants in the calcium chloride discharge and < 5% of inflow contaminants in the final DCP product).

Ajay Mahajan, Aditya Birla Chemicals, indicated that **food and technical phosphate use in Asia is expected to more than double in the coming decade,** with increases in population, GDP, and industrial and agro-food production for export, including uses in human foodstuffs and beverages, home care products, fire safety, drinking water treatment and metals/electronics industries. Detergents are the only application which is expected to decrease. Asia's current technical/food phosphate production capacity exceeds market demand and the industry is changing to become quality and specification driven, including health, consumer and liability aspects. This will enable Asia's food/technical phosphate industry to increasingly export to Western markets.

Possible new developments

Patrice Christmann, BRGM, presented the **potential for extraction of rare earth / precious metal elements from phosphate rock and/or phosphogypsum**. World demand for a number of these elements is expected to continue to rise, in some cases significantly, in particular with use in electric motor/generator magnets (e.g. in offshore wind energy) and in batteries (e.g. electric vehicles). Rare earth elements could in theory be worth around 25% of the value of phosphate in phosphate rock. Significant R&D work has been carried out and continues underway, but to date no economic extraction process has been developed.

Sheena Patel, CRU, presented the **single super phosphate (SSP) market**. Globally, SSP accounts for around 15% of P_2O_5 demand and its use is particularly important in a number of specific countries including Brazil and India, where soils are largely sulphur deficient. In both of these countries, SSP has long been used. SSP's independence from the ammonia production process means that it has relatively low investment costs, offering a cheaper form of phosphate fertilizer, relative to DAP and MAP on a product basis. And its widespread use in both of these countries has been encouraged given that there are significantly more producers manufacturing SSP than any other form of fertilizer.

SCOPE editors' note: SSP has as high bulk / low phosphate content, so is principally used close to production sites. Possible contaminants in the phosphate rock are spread with the fertiliser (there is no phosphogypsum stream in the production process).

Willem Schipper, industry consultant, presented the wide range of **uses for which elemental phosphorus (P4 = white phosphorus) is essential**. This includes some well known examples like herbicides (glyphosate = Roundup), flame retardants, phosphonates (used e.g. in water treatment, energy exchange systems …), electroless nickel plating, lubricant additives, lithium ion batteries. On the other hand, food phosphates and even very pure phosphoric acid (e.g. for electronic circuit and chip production) can use phosphoric acid from the "wet acid" route after multi-phase solvent purification. Europe's only P4 producer disappeared in 2012 (Thermphos closure). Across the world there are now only four countries producing P4: USA (Monsanto, principally for glyphosate), Kazakhstan (Kazphosphate), Vietnam (several producers), China (tendency to stop production as energy prices increase to real market levels and implementation of environmental regulations will leave only large operators in the long run). Some new opportunities to make P4 e.g. from waste were also addressed.

Beyond 'Peak P': real drivers for P recycling

Friedrich-W. Wellmer, retired from BGR Germany, predicted that 'Peak Phosphorus' will not occur in the short-medium term. The reserve/production ratio for phosphates is considerably higher than for many metals. Phosphorus is a non-renewable resource and peak production will inevitably occur at some time in the future, but it is important to not imagine that this will be soon. Phosphorus consumption is demand driven (as a function of prices and needs), not supply driven. **It is nonetheless important to reduce waste of phosphorus, not only to conserve the non-renewable resource, but importantly because of the environmental effects of phosphorus losses**, and there is a considerable potential for increasing phosphorus use efficiency in the food chain.

Anthony Zanelli, ICL Fertilizers Europe, explained that using local sources of secondary phsophates is important for the **social licence to operate** for the ICL Amfert fertiliser factory near Amsterdam: the factory provides a solution to local phosphorus excess management issues. Furthermore, **the economics are positive and make this a real business opportunity**.

Antoine Hoxha, Fertilizers Europe, also emphasised that a number of regions in Europe face considerable local nutrient excesses (manure from concentrated livestock production, sewage biosolids in large conurbations). A range of technical solutions are developed to recycle these nutrients. **Depending on local conditions and logistics, the business case for the fertiliser industry can be positive.**

Rob de Ruiter, EcoPhos, explained that the company's process enables production of high quality phosphate products from secondary phosphate materials (recycling), see above. This will enable the development of "urban mines" **producing phosphate products to feed the world from waste streams**. Innovative technology enables competitive advantage and positive economic business case.

Arnoud Passenier, Netherlands Ministry for Environment and Infrastructure, presented the European Sustainable Phosphorus Platform of which he is President. Independent of debates about phosphate reserve and resource levels, **the challenge of phosphorus sustainability is here to stay**. World demand for phosphorus will increase, with population growth, increased animal products in diet, and with biofuels and bio-resource production. World P price volatility will result from the linkage to food prices and possible impacts of climate change or politics, with price spirals as poor farmers cannot afford fertiliser when prices are high, resulting in lower harvests, and so further food price increases. There is therefore a **fundamental need for more efficient use of phosphorus, including recycling**. This is also essential to reduce environmental impacts of phosphorus losses (eutrophication).

The **European Sustainable Phosphorus Platform** (ESPP), and the now-starting **North America Phosphorus Partnership** (NAPP), emphasise **cooperation between industry, science, stakeholders and regulators, and mutual gains approaches**

Phosphorus recycling

Panel discussion centred around why phosphate recycling is developing so slowly, identifying the following challenges and **concluding that important opportunities exist**:

- The need for a **stable regulatory context**
- **Difficulties with current regulations** which are not adapted to recycling
- Lead-in time for **investment**
- Need to match recycling technologies to product **market needs**
- **Unrealistic expectations** from operators producing phosphate-containing waste streams or by-products, who expect the phosphorus to become an income, whereas generally it will be rather a zero income or a recycling gate price (but with an economy in waste disposal costs)
- Recycling requires a **new industry structure and/or logistics** to adapt to relatively small-scale, decentralised waste/byproduct streams and local production of recycled products
- **Importance of cooperation** between different industry sectors and users, and dialogue, including with stakeholders and regulators

Phosphates 2015 (8th International Phosphates Conference): Tampa, USA, 22-25 March 2015. Call for papers is now open.
www.phosphatesconference.com

Webinar

Proposing solutions for a circular Peconomy

The webinar on phosphorus sustainability organized by Humanitarian Water and Food Award (WAF) on 17th April addressed the importance of phosphorus for food security from a soil to soil perspective, looked at technologies proposed by Teknikmarknad for remediating marine and freshwater sediment phosphorus accumulation and discussed economic mechanisms for promoting a circular economy for phosphorus.

Award applications manager **Stephen Hinton** described WAF's perspective: given that supplies of mineral phosphorus are depleting, and food prices are rising, for there to be world food security society needs to create a soil to soil circular economy for phosphorus.

Two things about phosphorus (P) make it a priority. Firstly, it is a limiting factor. The more P that is removed or reduced, the lower the threat of algal blooming. Secondly, it is non-renewable. Today we rely on mining which in turn relies on cheap energy. **A true sustainable, circular, economy uses a soil to soil perspective for P.** As the concentration of P in living things is several magnitudes larger than in the environment our very survival rests on this circular economy functioning properly.

WAF believes that **food security (and thereby awareness of the importance of phosphorus) should be at the centre of every company's CSR (Corporate Social Responsibility) program**, regardless of whether they produce food products. Says Stephen Hinton: "the reason employees go to work is to get paid so they can put food on the table for their families. So all businesses are in the business of providing food security for their employees, suppliers, retail outlets and so on."

Stephen Hilton connects food security with entrepreneurship; "if you are hungry you cannot be at the top of your game and creative. Well-fed people can contribute to society and contribute to prosperity. Prosperity creates more business opportunities. Everyone wins."

Teknikmarknad sediment P-recovery technology

One way to kick-start the circular phosphorus economy is being explored by a technology firm spawned off from KTH, the Royal Institute of Technology, Sweden. **Bengt Simonsson from Teknikmarknad** described their "Density Sorting Dredging". This technology works like a giant vacuum cleaner, gently extracting different fractions from the seabed. **This technique does not stir up sediment to release nutrients, but other impacts on the ecosystem would need to be studied on a case by case basis**.

Cheaper, cleaner sources of P are promised and the organic sediment layers can be digested to produce biogas as well as components for fertilizer. There is a good business case removing sediment rich in P just to restore aquatic environments. Decades of emissions to the Baltic Sea have brought it to the point where internal sediment release is now many times larger than the current inflow, so causing eutrophication and expanding anoxic sea-beds.

Teknikmarknad is looking into ways to finance P recovery using a **phosphorus release tax approach**. Raising fees will generate money to invest in sediment removal. At the same time, the recovery will itself generate an income for the municipality that it can use to reduce costs elsewhere, or to simply lower other taxes so the effect on the overall economy will be neutral.

Teknikmarknad's approach is based on the mechanisms developed by the Swedish Sustainable Economy Foundation. The Foundation's economic expert, **Anders Höglund** presented the approach his organisation has developed based on control engineering (see SCOPE Newsletter 103).

Called **flexible pollutant fees, or flex fees**, the idea is to put surcharges on behaviour that is associated with externalizing pollution costs (like emitting phosphorus to waterways) and to redistribute the money collected to citizens so they can spend it back into the economy (lowering municipal taxes is a form of redistribution). Increasing surcharges at regular intervals will encourage the market to invest in alternative ways to deal with the pollutant. As it gets increasingly relatively expensive to emit phosphorus, the market will invest in P recycling technology, which in turn will generate cheaper sources of P for farmers to use.

Says Anders Höglund: "The technology exists to circulate P. The scientific arguments are sound. A relatively minor fee can set the change in motion, putting P back on the land and making sure it stays there. Forever."

To register to see the recorded version of the 17th April webinar and to download the powerpoints:
http://csrwebinars.avbp.net/?p=109

Agriculture legislation

Different European regulation of phosphorus application

There is no EU legislation addressing phosphorus use. National regulatory limits are generally based on the Nitrates or Water Framework Directives, the Industrial Emissions Directive (ICPE for large farms) or the Common Agricultural Policy. Regulations restrict differently fertiliser application rates, use of different types of material (manure, organic fertiliser, biosolids …), manure processing/use and buffer zones of different widths.

In most member states, application limits vary with crop type, whereas in only a few cases do limits vary with soil P status. The authors underline that policies would be more effective in reducing P losses if high loss-risk areas were targeted and if a more agro-environmental based approach were used.

The authors note that because **there is no European legislation directly addressing phosphorus**, information regarding applicable national regulatory frameworks is not easily available. This report was compiled by contacting experts in 23 member states/regions in late 2013/early 2014.

Only a minority of the states/regions assessed have regulation in place which directly limits phosphorus application: Flanders (Belgium), Estonia, Brittany (France), Germany, Ireland, Northern Ireland, Norway, Sweden, The Netherlands). Two others (Luxembourg, Finland) request limits in CAP Agro-Environment programmes. Not all states/regions limit all types of phosphorus application.

Disparate and non-coherent limitations

Detailed tables are presented comparing regulations applicable in different countries/regions as regards:

- Phosphorus application limits
- Types of material covered by limits (mineral fertiliser, manure, sewage biosolids, compost)
- P application standards for different crops

The authors underline that **comparison of regulations between different countries/regions is very difficult because phosphorus limits are expressed differently**, in some cases varying for crop types, for soil phosphorus status, for crop yield. Some countries/regions only limit P applied by chemical fertiliser or by manure. The authors have recalculated limits expressed in different units (e.g. kgP) to present all figures as kg P_2O_5/ha/year.

Furthermore, **control systems are very different**. Not all countries/regions require mandatory submission of information about nutrient management to authorities. Inspection rates and annual updates under the Nitrates Directive are also variable.

Flanders and Brittany have the lowest maximum phosphorus application limit (highest level of application authorised for any crop) at 95 kg P_2O_5/ha/year). **Ireland** has the lowest minimum limit: for some crops on soils with high P status, the P application limit is zero.

Inadequate and inappropriate regulations

Some countries/regions with high soil P status and high P concentrations in surface waters have no extensive P application limits, in particular in North West Europe (e.g. parts of England, Wales, Poland, France), suggesting a **significant inherent risk of agricultural contribution to eutrophication**.

The authors underline that the objective of phosphorus application limitation is to **limit P losses to surface and ground waters, in order to reduce eutrophication risks**. Therefore, application limits should be related to risk of losses, and targeting phosphorus use in high loss-risk areas will probably give the best results in water quality improvement. P loss risks depend on soil P availability (P status, P fertilisation), transport (slope, soil texture, drainage …) and connectivity to surface waters. These factors need to be taken into account in an agro-environmental P fertilisation approach. A first attempt is e.g. the "Phosphorus Index" (Heathwaite et al. 2003), although some reservations and adaptations for specific situations (e.g. leaching) are needed (Schoumans et al. 2013).

At present, no country/region regulation system takes into account both soil phosphorus status and phosphorus risk loss, suggesting that a more environmental approach to phosphorus fertilisation limitations would be generally effective in reducing cost-effectively phosphorus losses to surface waters.

In addition, phosphorus balance regulatory systems can be developed where application is limited according to soil type, crop and yield.

Buffer strips

In parallel to P application limits, all the countries/regions assessed have some **requirement for "buffer zones"** along waterways, but in many cases this is only obligatory in Nitrate Directive NVZs (Nitrate Vulnerable Zones). Again, regulations are variable and inconsistent, with buffer zone width requirements varying for different fertiliser materials (in some cases a wider buffer is required for manure application than for mineral fertiliser application), from 0.5 – 35 metres (up to 500m in some specific cases in some countries/regions, e.g. coastal shellfish production areas), for different buffer specifications (vegetation, permanent grassland), with grazing authorised or not. In most, but not all countries/regions, the buffer zone area can be included in the field fertiliser application limit calculation.

"Agricultural phosphorus legislation in Europe", ILVO / Alterra Wageningen UR, ISBN 9789040303531, April 2014, 54 pages
http://www.ilvo.vlaanderen.be/Portals/68/documents/Mediatheek/Phosphorus_legislation_Europe.pdf *or* http://edepot.wur.nl/300160

F. Amery, Institute for Agricultural and Fisheries Research (ILVO), Plant Sciences Unit - Crop Husbandry and Environment, Burg. van Gansberghelaan 109, 9820 Merelbeke, Belgium
fien.amery@ilvo.vlaanderen.be

O.F. Schoumans, Alterra Wageningen UR, PO Box 47, 6700 AA Wageningen, The Netherlands oscar.schoumans@wur.nl

P-recovery and P-recycling

Rephosmaster[TM] Processes for P-recovery demo wastewater

Two novel struvite recovery processes, adapted to specific characteristics, have been developed and are tested full scale in wastewater treatment plants in Japan.

The two processes have been designed with full consideration given to the specific characteristics (sewage components, chemical concentrations, flow rates, etc.) of wastewater or sludge generated from sewage treatment.

Full-scale plant: struvite recovery demonstration facility of National Institute for Land and Infrastructure Management, which was installed as a part of B-DASH project supported by Ministry of Land, Infrastructure, Transport and Tourism.

Specific design characteristics

The first process, **Rephosmaster[TM] CS**, features the treatment of wastewater with high concentrations of suspended solids, such as that containing anaerobic digested sludge.

The other, named **Rephosmaster[TM] FB**, is for the same with low concentrations of suspended solids, such as filtrate from dewatering and recycle flow.

These processes have been proven effective for not only recovering phosphorus as a resource, but also for the prevention of eutrophication which may result from residual nitrogen and phosphorous in the effluent.

Rephosmaster[TM] CS

Rephosmaster[TM] CS recovers struvite from anaerobic digested sludge in wastewater. Demonstration and verification tests using a full-scale plant and pilot-scale plant were as the following.

- Full-scale demonstration of using a 239 m3/d facility installed in Higashinada MWTP since 2013 (see photo 1)
- Pilot-scale verification tests using a 6m3/d facility installed in WWTP in 2011
- Full-scale verification tests using a 50m3/d facility installed in WWTP in 2007
- Pilot-scale verification tests using a 6m3/d facility installed in WWTP in 2005

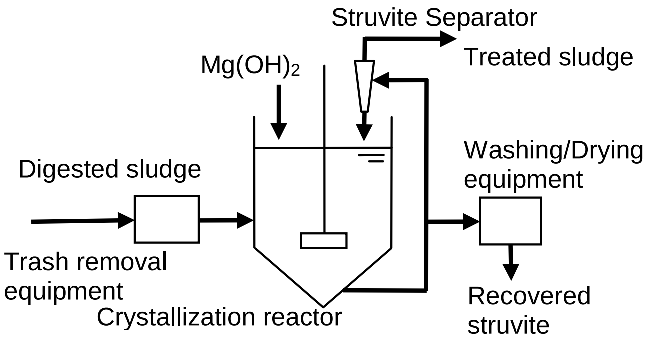


Figure 1 P-recovery process from digested sludge

An outline of Resphosmaster[TM] CS is illustrated above (fig. 1).

This process comprises trash removal equipment, a CSTR and a Struvite Separator. The viscosity of the digested sludge, containing several percentage of suspended solids, is higher than the viscosity of wastewater or sewage. To cope with this, a CSTR is used as the crystallization reactor to enable maximum seed crystal growth in the liquid. Almost all results of demonstration and verification tests indicated that **PO_4-P recovery rates were exceeding 90%**.

Moreover, the amount of hazardous metals in the recovered struvite was below the standard regulatory levels specified in the Fertilizer Regulation Act, Ministry of Agriculture of Japan. This established that struvite particles recovered by the process were suitable for use as a fertilizer.

Rephosmaster[TM] FB

In contrast, **Rephosmaster[TM] FB recovers struvite from filtrate in sewage wastewater treatment plants and night soil treatment plants**.

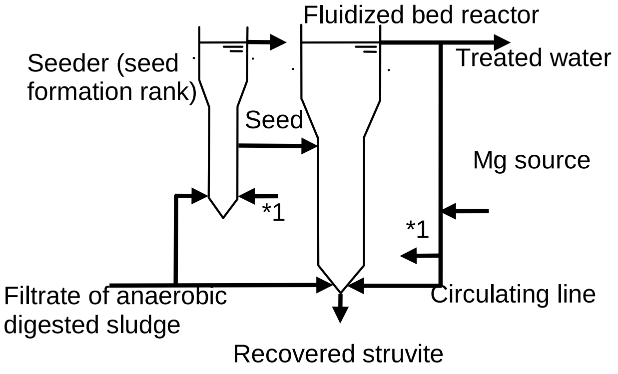


Figure 2 struvite-recovery process using a fluidized bed reactor with Seeder

An outline of Rephosmaster™ FB process is illustrated in Figure 2.

The verification tests conducted for this process were as the following.

- Full-scale plant in a 48m3/d facility designed for night soil treatment plant , constructed in 2014
- Pilot-scale verification tests using a 7.2m3/d facility installed in a night soil treatment plant in 2011
- Pilot-scale verification tests in a 20m3/d facility installed at WWTP in 2003

The process comprises a fluidized bed struvite reactor equipped with a seeder. The reactor system includes a fluidized bed reactor, capable of treating more than 80% of the raw water, and a seeder, which produces seed struvite to be used in the fluidized bed reactor. All results of verification tests indicated an **orthophosphate recovery exceeding 90 %,** as was the case of Rephosmaster™ CS.

Authors: K. Shimamura, Swing Corporation, 4-2-1 Honfujisawa, Fujisawa-shi, Kanagawa 251-8502, Japan shimamura.kazuaki@swing-w.com *and S. Watanabe, Swing Corporation, 7-18, Konan 1-chome, Minato-ku, Tokyo 108-8470, Japan* watanabe.shojiro@swing-w.com

US dairy industry

Manure digester nutrient recovery potential

A study by Informa Economics for Innovation Center for US Dairy (Feb. 2013) assesses the potential for energy and material recovery from manures and other local biowastes through anaerobic digestion (biogas production). The report estimates that nearly 2 700 digesters could be installed on large US dairy farms (based on AgSTAR data), producing energy with a market value of 413 – 894 million US$ (depending on whether as network injected methane, transport fuel methane or electricity), 467 m$ nitrogen and 323 m$ phosphorus fertiliser products, 217 m$ fibre/peat products plus up to 1 billion US$ in greenhouse gas/renewable energy certificates or equivalent and 575 million US$ savings in landfill tipping fees for the digested biowastes.

The AgSTAR (US Environmental Protection Agency) study (2011) estimated that installation of anaerobic digestion for manures would generally be feasible on dairy confined animal farm operations (CAFO) of >500 cows. **AgSTAR estimated at around 2 600 the number of such dairy CAFOs in the USA** in 2011. With the currently ongoing tendency to concentrate livestock production this is expected to increase to over 7 000 such dairy CAFOs by 2020 (Informa estimate).

Estimated at 150 kg/cow/day, daily manure production at the 2 647 CAFOs would be 108 million tonnes per year.

Valorising commercial food wastes

This Innovation Centre report considers that modern mixed plug flow and completely mixed anaerobic digester installations allow the use of substrates other than only manure, in particular commercial food wastes, so improving the economic viability of digesters. **The report also considers that nutrient recovery technologies now available also improve the economics of digester operation**.

The study assumes that dairy digesters take commercial food wastes as substrates, in addition to manures, but not domestic food waste (not currently separatively collected in most of the USA) and not other farm wastes (e.g. crop wastes). Food wastes have high bio-methane production potential, but also high nutrient content.

The report notes that **various factors will locally influence the feasibility** of this, such as food industry logistics and haulage distances, and that anaerobic digester design should be chosen carefully as a function of the expected substrate mix.

The **commercial value of energy recovered through anaerobic digestion** is calculated using State-specific electricity prices, citygate prices for pipeline natural gas, and prices for compressed natural gas as a vehicle fuel. Credits for this transport fuel under federal Renewable Fuel Standard (RFS2) or (locally) California Low Carbon Fuel Standard (LCFS) are taken into account. Other energy trading and subsidy systems taken into account are: California Greenhouse Gas Offsets (GHG), Renewable Energy Credits (REC), Renewable Identification Numbers (RINs).

Landfill tipping fees economised on the commercial food wastes taken by the digesters represent significant savings. State tipping fees vary from 24 – 64 US$/tonne and are increasing: federal average 8 $/tonne in 1985, 44 $/tonne in 2010.

Nutrient recovery and land savings

Total land area needed to "dispose of" nutrients from the considered dairy farms (2 647 CAFOs) is estimated to be 10 500 000 acres.

SCOPE editors note: this is not the area such that the nutrients would be applied as needed by crops, but the area as imposed by current spreading limits intended to environmental losses.

The input of other biowastes to the digesters would increase this land needed to 19 900 000 acres, because of nutrients (N, P) present in these wastes, particularly food wastes.

Nutrient recovery technologies, however, would reduce the land needed to only 7 600 000 acres (manure plus biowastes).

Digestate nutrients are considered to be recycled as (1) liquid ammonium sulphate, (2) **an organic phosphorus-containing material recovered from digestate and dried down to 10% water content, and (3) digestate fibres**. It is noted that farmers may not currently be equipped to handle and spread such products, so that market adaptation may be an obstacle to uptake.

Management plans, based on crop nutrient needs of different crops, are used to assess mineral fertiliser economised and nutrient requirements necessary to balance digestate N and P.

Nutrient recovery potential is estimated at 80% of digester inflow for phosphorus, 40% for nitrogen (potassium recovery is not considered). Market fertiliser prices are estimated at US$ 1 400/tonne N and US$ 3 000/tonne P (mid-valuation hypothesis). Total values of recovered nutrients are thus estimated for the 2 647 dairy CAFOs at **467 million US$/year for nitrogen** (mid-value, range 312 – 964), and **324 million US$/year for phosphorus** (range 162 – 418).

Digestate also contains fibre (anaerobic digestion resistant fibres), which can be valorised as bedding for animals, soil amendment or to replace peat moss. Based on the market size and value for such products, the digestate fibre is estimated to bring potential revenue of **181 – 231 million US$/year**.

Economic viability

The total estimated value of anaerobic digestion products (including energy, nutrients, fibre, credits/subsidies, and including commercial foodwaste as a co-substrate) is estimated to be **0.91 – 3.16 US$ per cow per day.**

Total investment for the 2 647 dairy CAFOs (installation of anaerobic digestion, electricity generation, co-product market systems) is estimated at c. 6.4 billion US$ (1 600 US$/cow). Taking into account potential revenues and operating costs, IRR (Internal Rate of Return) is estimated to be 12 – 64%.

Environmental benefits are assessed to be, in order of importance, diversion of organic wastes from landfill, carbon replacement of fossil fuels for electricity production and avoided impact of mineral fertiliser application.

"National market value of anaerobic digester products", Informa Economics, for Innovation Center for U.S. Diary, February 2013 http://www.quasarenergygroup.com/pages/National%20Market%20Potential%20of%20Anaerobic%20Digester%20Products%20for%20the%20Dairy%20Industry%20(4-01-13).pdf

AgSTAR 2011 (US Environmental Protection Agency) "Market opportunities for biogas recovery systems at US livestock facilities" http://www.epa.gov/agstar/tools/market-oppt.html

RecoPhos

P-recovery from sewage sludge incineration ash

The RecoPhos project (which receives funding from the European Union Seventh Framework Programme) started in 2012 to develop a completely new P recovery process from sewage sludge incineration ash (SSA). Although the core technique of the RecoPhos process, the so-called InduCarb reactor (see figure 1), works according to the same chemical principle as the Woehler process [Corbridge, 1995], several of its chemical-technical problems as the significant formation of the by-product ferrophosphorus should be overcome. In contrast to most other projects targeting the fertilizer market, the RecoPhos process will produce elementary phosphorus, thermal phosphoric acid or other derivates from it and therefore will deliver a base material for chemical industry.

The process aims to recover phosphorus from ash (SSA) from mono-incineration plants (incinerating sewage sludge not mixed with municipal solid waste or other wastes). This is a potentially attractive route for phosphorus recycling in situations where sewage biosolids cannot be recycled by reuse on agricultural land after appropriate treatment (e.g. sanitisation, composting, anaerobic digestion), for reasons of geography (insufficient cropland accessible, contaminants, regulation …)

Working principle:

Within the **InduCarb reactor** a susceptor bed consisting of lumps of carbon or graphite material is heated inductively to a temperature of ~1500°C. The slag formed from molten ash flows over the single susceptor lumps in a thin film where the reduction of the phosphates takes place. This quasi two dimensional volume for chemical reactions is one significant difference to the Woehler process (see figure 1b). As a result, similar to a blast furnace for steel making there is still a lot of open porosity within the InduCarb reactor to allow for a fast extraction of the P containing product gas which reduces the formation of ferrophosphorus at the same time. In addition a metal melt and slag is being produced.

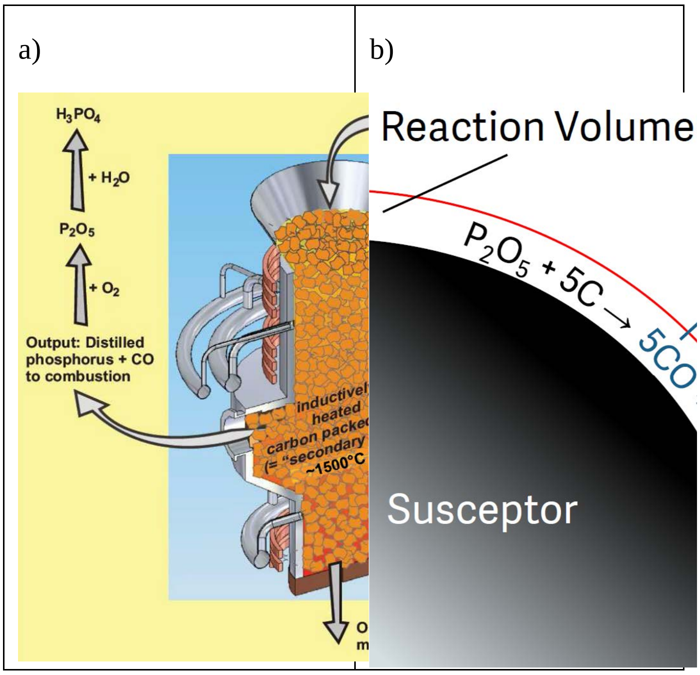


Figure 1: Working principle of the RecoPhos process

(a) SSA is fed on top of the InduCarb reactor and is melted at ~1500°C. The melt is flowing down the reactor where the reduction of phosphates is taking place. Elementary phosphorus is extracted from the reactor and reacted to phosphoric acid. The liquid melt/ slag will be cooled, granulated and can be used in certain industries. (Source: *http://www.recophos.org/c/mid,1364,Media_Centre/*)

(b) Sketch of the reaction zone within the InduCarb reactor: The molten SSA flows over the susceptor material where phosphorus compounds are being reduced to elementary phosphorus in a thin layer.

Results:

Based on batch scale experiments, the generation of a thermodynamic data base, intensive modelling and simulation, **a first set of batch and semi-continuous experiments were performed** (see figure 2) in order to prove the RecoPhos principle and continuously improve the process.

Within these experiments (with **up to few hundreds grams of SSA**) it could be shown that P removal, or P loss to ferrophosphorus respectively, is comparable to the Woehler process for the batch approach. In the semi-continuous setup P loss is already smaller compared to the Woehler process.

The **RecoPhos slag** itself is a further value stream to be exploited. Within an evaluation trial from lab sample tests it could be shown that it **fulfils the requirements to be used in cement industry**.

a) b)

Figure 2: Preliminary RecoPhos testing

(a) Batch scale setup: SSA mixed with carbon powder is put into the inductive heated to 1500°C. The phosphorus in the offgas is immediately oxidized, sucked through a washing flask and hydrolized to phosphoric acid. The impurities from the SSA are also collected in the washing flask.

(b) Bench scale reactor during the construction phase (Background: Reactor Vessel without induction coil; front: hot gas scrubber and absorption vessel)

Currently a bench scale reactor is being finalized which will be able to provide continuous feeding of several kg/h of SSA into the RecoPhos process. Valuable information will be generated with regard to P yield as a function of input material, e.g. upon usage of SSA from Al or Fe precipitation, slag additives, etc. It will furthermore allow fine-tuning of the respective parameters of the setup in order to optimize phosphorus and slag output.

This reactor and the experiments performed with it will be the basis for elaborating the design including a suitable offgas system of a pilot plant which is foreseen after the current RecoPhos project.

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 282856.

Corbridge, D.E.C. (1995). Phosphorus: An outline of its chemistry, biochemistry and uses. Elsevier. pp. 556.

Contact: Dr. Daniel Steppich, SGL Carbon GmbH, Werner-von-Siemens-Str. 18, 86405 Meitingen, Germany, daniel.steppich@sglgroup.com, *Phone: +49 8271 83 3511*

Phosphorus flows

Phosphorus recovery

France achieving 50% P-recycling from wastes

A national substance flow analysis (SFA) for phosphorus was carried out for France, based on a range of institutional, agricultural and industrial statistics for 2006 (most recent complete data available). The food system from agricultural products, through food processing and retail to households was assessed, looking at phosphorus flows in food processing waste, municipal waste and wastewater (households, small economic activities). P-losses in agriculture and upstream are not taken into account in this paper because they were published in earlier papers.

Assessments of phosphorus flows in the following waste streams were made:

- 1) food processing waste, which includes food processing handling waste, slaughterhouse wastes and industrial food production waste;
- 2) municipal wastewater; and
- 3) municipal solid wastes.

Household food waste phosphorus, calculated from waste tonnage x P content, was compared to the difference between phosphorus delivered to households in foods and estimated phosphorus ingestion in the French diet. Organic materials going to municipal solid waste collection/treatment systems was included, but not green or park wastes going to separate systems or being composted or stored directly.

Overall, organics were estimated to be 31% of municipal solid waste (dry weight basis), and to contain most of the phosphorus (4 kgP/tonne dry weight) in municipal solid waste, with much smaller additional contributions from textiles, sanitary textiles, paper/cardboard).

Municipal wastewater phosphorus content

Phosphorus in municipal wastewaters was estimated using data from the French Institute for the Environment (IFEN, 2009) which concluded **3g/person/day (phosphorus emissions from the connected population)**. This was considered comparable to wastewater treatment plant design values of 1.8 g/person/day for households plus **0.7 g/person/day for small economic activities**.

In France, nearly 80% of the population is connected to sewerage, around 15% to autonomous sanitation (septic tanks) and around 5% not yet connected to sewage treatment. Losses of phosphorus in wastewater due to household misconnections to sewerage systems were estimated at 10% and were assumed to reach surface waters.

Of a total 63 000 tonnes P/year in domestic sewage (including small economic activities) in France, 30% is estimated to be lost to surface waters and 70% to be removed into biosolids. 62% of the phosphorus in sewage biosolids is estimated to be reused in agriculture, with the remaining going to landfill.

P-recycling rates from wastes

Total phosphorus present in different waste streams was estimated at 63 000 tonnes P/year in municipal wastewaters, 44 000 tonnes P in municipal solid waste, 28 000 tonnes P in industrial and food waste streams (these streams include handling waste, slaughter houses and industrial food processing wastes).

P-recycling rates were estimated at 75% for industrial waste streams considered, at 47% for municipal solid wastes and at 43% for municipal wastewater. **Overall, P-recycling from wastes was thus estimated at 51% in France.**

The authors note that **this is significantly higher than for some other countries (e.g. Switzerland)** which have more conservative regulation concerning animal waste recycling and where sewage biosolids are not recycled to agriculture.

Losses upstream in phosphorus fertiliser production and in agriculture are not taken into account in this calculation and the authors present a summarised overview of agri-food system phosphorus flows in France showing 653 000 tonnes P/year input to agriculture (manures, fertilisers, recycled biosolids, …) compared to net crop uptake of 452 000 tonnes P/year, **that is around 31% P losses in farming**.

"Phosphorus recovery and recycling from waste: An appraisal based on a French case study", Resources, Conservation and Recycling, vol. 87, June 2014, pages 97–108
www.elsevier.com/locate/resconrec

K. Senthilkumar (a,b,c), A. Mollier (a,b), M. Delmas (d), Sylvain Pellerin (a,b), T. Nesme (a,b,e)

a = INRA, UMR 1391 ISPA, F-33140 Villenave d'Ornon, France. b = Bordeaux Sciences Agro, UMR 1391 ISPA, F-33170 Gradignan, France. c = Africa Rice Center (AfricaRice), East and Southern Africa, P.O. Box 33581, Dar es Salaam, Tanzania. d = Montpellier SupAgro, UMR 1221 LISAH, 34060 Montpellier Cedex 1, France. e = McGill School of Environment, McGill University, Montréal, QC, Canada. Email
senthilkumar.kalimuthu@gmail.com

Xiamen City
Sustainable urban biochemistry

Quantifies of N and P consumed in food in Xiamen City, China, and their fate in the environment, are calculated for 1991 – 2010. Nutrient urbanisation causes and impacts are discussed. Three approaches are proposed to mend the broken nutrient biogeochemical cycle: nutrient budget (material flow analysis), technology integration and innovation, risk assessment.

Nutrient urbanisation is characterised by high levels of nutrient consumption (related to the concentration of human population and food consumption), absence of or very low levels of nutrient recovery and recycling from wastes (related to the spatial separation of nutrient consumption from nutrient-requiring farmland), often accentuated by inadequate solid waste and waste water collection and treatment.

Today, only around 18% of phosphorus input to agriculture in China reaches humans in food products (Wang, J. Environ. Qual 40(4), 2011). Wang's study showed that of 67 million tonnes of phosphorus entering China's food production chain, 52% accumulated in soil and 24% was lost to the environment in animal production (60% of excreted phosphorus).

Urban nutrient consumption

Xiamen, a coastal city in South East China, tripled its population from 1991 to 2010, reaching nearly four million people. Quantities of nutrients consumed in food in Xiamen are shown for this period, indicating **an approximate tripling of nitrogen consumption, and a near quadrupling of phosphorus consumption**, reaching 1 800 tonnes P/year in 2010.

Fates of these food nutrients are shown, with **around 80% of food phosphorus ending in landfill, and smaller parts being lost to surface water, used on soils or accumulating in human bodies** (with the population increase). Given that nearly all phosphorus consumed in food goes to sewage, the relatively low loss to surface water corresponds to a high level of domestic waste water collection and treatment.

Restoring nutrient cycling

The authors suggest three routes to mend the broken nutrient biochemical cycling in urban areas:

- **Restoring the nutrient budget**, based on a material flow analysis to identify nutrient flows and potential recycling routes: recovery of nutrients from waste and wastewater streams for recycling back into agriculture.
- **Technology integration and innovation**: to improve waste collection rates and to transfer nutrients into organic fertilisers for agriculture
- **Risk assessment**: biosolids can contain contaminants, such as heavy metals, pharmaceuticals, personal care product residues in sewage or antibiotics, pathogens or antibiotic resistant genes (ARGs) in manures. Appropriate treatment technologies to remove or mitigate these contaminants should be combined with controlled application programmes to minimise possible risks.

"Managing urban nutrient biogeochemistry for sustainable urbanization", Environmental Pollution, 2014, http://dx.doi.org/10.1016/j.envpol.2014.03.038

T. Lin, V. Gibson, S. Cui, C-P. Yu, S. Chen, Z. Ye, Y-G. Zhu. Key Lab of Urban Environment and Health, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen 361021, China and Xiamen Key Lab of Urban Metabolism, Xiamen 361021, China tlin@iue.ac.cn

"The Phosphorus Footprint of China's Food Chain: Implications for Food Security, Natural Resource Management, and Environmental Quality", J. Environmental Quality, vol. 40, pages 1081-1089, 2011

F. Wang, L. Ma, F. Zhang, Key Lab. Plant–Soil Interactions, MOE, College of Resources and Environmental Sciences, China Agricultural Univ., Beijing, 100193, China; J.T. Sims, College of Agriculture and Natural Resources, Univ. of Delaware, 116 Townsend Hall, Newark, DE 19716; W. Ma, College of Resources and Environmental Sciences, Agricultural Univ. of Hebei, Baoding, 071001, China; Z. Dou, Section of Animal Production Systems, School of Veterinary Medicine, Univ. of Pennsylvania, 382 W. Street Rd., Kennett Square, PA 19348 zhangfs@cau.edu.cn

Horizon 2020 funding opportunities

The EU's R&D funding programme **Horizon2020** includes areas relevant to P sustainability.

The European Sustainable Phosphorus Platform invites expressions of interest to *info@phosphorusplatform.eu* from interested organisations, project consortia. Your information can be circulated to possible partners.

H2020 funding opportunities relevant to phosphorus management identified to date

Please note that the list below may not be complete. It is ESPP's analysis to date. The presentation made by ESPP of call content may not be accurate, and you are recommended to verify directly with the published call texts and obtain competent advice where useful.

***SPIRE-07-2015** – deadline = 19/12/2014*
http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2166-spire-07-2015.html
"Recovery technologies for metals and other minerals"

***WASTE 7-2015** - deadline = 16/10/2014*
http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-climate_en.pdf
"Ensuring sustainable use of agricultural waste, coproducts and byproducts", *includes "nutrient, energy and biochemical recovery from manure and other effluents"*

***SC5-11(b)-2014** - deadline = 10/3/2015*
http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-climate_en.pdf
"New solutions for sustainable production of raw materials"
(b) 2014 "Flexible processing technologies"

***SC5-13(f)-2015** – deadline = 10/3/2015*
http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-climate_en.pdf
"Coordinating and supporting raw materials research and innovation"
"Strategic international dialogues and cooperation with raw materials producing countries and industry"

***KIC Raw Materials** – deadline = 10/9/2014*
http://eit.europa.eu/newsroom-and-media/article/innovate-join-the-eit-and-spur-innovation-and-entrepreneurship-across-europe/
To address: raw materials – sustainable exploration, extraction processing, recycling and substitution.

Agenda

- ❖ 26-28 June, Gödöllö Hungary, **ORBIT 2014 Organic Resources and Biological Treatment** *http://orbit2014.com*
- ❖ 29 June – 3 July, Dublin: **20th International Conference on Phosphorus Chemistry** *www.icpc2014.ie*
- ❖ 2-3 July, London: IFS **International Fertiliser Society Conference** 2014 *http://fertiliser-society.org*
- ❖ 7 July, Rennes, France, l**aunch meeting France sustainable phosphorus network** *www.phosphorusplatform.org*
- ❖ 8-9 July, Rennes, Brittany, France, EU Commission/regions at work for the bio-economy **Converting bio-wastes to fertilisers** *ENTR-RENNES-WKSHP-2014@ec.europa.eu*
- ❖ 13-17 July, Harbin, China: **IWA Science Summit on Urban Water** *http://www.iwahq.org/28f/events/iwa-events/2014/urban-water.html*
- ❖ 21 August, Berge, Germany: **P-REX Regional Workshop** *www.p-rex.eu*
- ❖ 26-29 August 2014, Montpellier, France: **5th Phosphorus in Soils and Plants symposium** *http://psp5-2014.cirad.fr/*
- ❖ 1 - 3 Sept., Montpellier, France, 4th world **Sustainable Phosphorus Summit** *http://SPS2014.cirad.fr*
- ❖ 10-12 September, Basel, Switzerland, P-REX summer school (students, researchers, young professionals): **Implementation of P-Recovery from Wastewater - Why and How?** *www.p-rex.eu*
- ❖ 17 September, Kobyli na Morave, Czech Republic **P-REX Regional Workshop** *www.p-rex.eu*
- ❖ 27 Sept. – 1 Oct., New Orleans, **WEFTEC2014** (Water Environment Federation) *www.weftec.org*
- ❖ 30 Sept – 2 Oct, Alkmaar region, Netherlands **European Biogas Association Conference** *http://www.biogasconference.eu/*
- ❖ 7-8 Oct., Manchester, UK, **8th European Waste Water Conference**. Including: wastewater as a resource, nutrient factory. *www.ewwmconference.com*
- ❖ 20-24 Oct., Rio de Janiero **CIEC World Fertiliser Congress** *www.16wfc.com*
- ❖ 26-30 Oct, Kathmandu, Nepal, **IWA: Sustainable Wastewater Treatment and Resource Recovery** *http://iwa2014nepal.org*
- ❖ 3-5 Nov 2014, Long Beach, California **ASA, CSSA, SSSA** (US & Canada soil and agronomy) meetings, Water Food, Energy, Innovation for a Sustainable World *www.acsmeetings.org*
- ❖ 17-19th Nov., Manchester UK, 19th **European Biosolids & Organic Resources Conference**. Session on energy and resource recovery *www.european-biosolids.com*
- ❖ 4-5 December, Florence, Italy: 1st International **Conference on Sustainable P Chemistry** *www.susphos.eu/ICSPC*
- ❖ 11-12 December, Cambridge, England., IFS **International Fertiliser Society Conference** 2014 *http://fertiliser-society.org*
- ❖ 5-6 March 2015, Berlin: **2nd European Sustainable Phosphorus Conference** *www.phosphorusplatform.org*
- ❖ 23-25 Mar 2015, Tampa, Florida: **Phosphates 2015** (CRU) *www.phosphatesconference.com*
- ❖ 29 March – 3 April 2015, Australia. **Beneficiation of phosphates VII** *http://www.engconf.org/conferences/environmental-technology/beneficiation-of-phosphates-vii/*
- ❖ 4-8 May 2015, Morocco: **SYMPHOS** (dates to be confirmed) *www.symphos.com*
- ❖ 1 May – 31 Oct. **Expo2015** Feeding the planet, energy for life, Milano *http://en.expo2015.org/*

Nutrient Platforms

Europe: ***www.phosphorusplatform.org***

Netherlands: ***www.nutrientplatform.org***

Flanders (Belgium): ***http://www.vlakwa.be/nutrientenplatform/***

Germany: ***www.deutsche-phosphor-plattform.de***

North America Partnership on Phosphorus Sustainability NAPPS *j.elser@asu.edu*

US P-RCN (Sustainable Phosphorus Research Coordination Network) *j.elser@asu.edu*

P-RCN student network: *rimjhim.aggarwal@asu.edu*