European Sustainable Phosphorus Platform

April 2015 n° 112

SCOPE NEWSLETTER

P and health – public consultation

European Food Safety Authority
Dietary reference values for P

EFSA proposes to not modify current DRV's for phosphorus

Industry and policy

ISO and CEN
Sludge recovery and recycling standards

Work underway on standards for sludge recovery, recycling, treatment and disposal, including P- recovery processes

EurEau
Water industry calls for sustainable phosphorus reuse and recovery

EU water industry wants support for P-recycling and agricultural reuse of sewage phosphorus.

Scotland
Phosphorus in detergents

Survey indicates contribution to wastewater P from different detergents and cleaning products

CCM – Phos4Ever
Study of China's P industry

Market outlook study looks at China's P mining and processing industry and perspectives.

CRU Conference
Phosphates 2015 Florida

Annual industry meeting shows high level of sustainable innovation in mining and P processing technologies.

IWA Nutrient Roadmap
Sewage nutrient management perspectives

First phase of 25-year Nutrient Roadmap published by Water Environment Federation

Phosphorus recycling

Slaughterhouse wastewater
Struvite and energy recovery

Struvite precipitation, biological treatment and anaerobic digestion for resource recovery optimisation

RecoPhos (thermal) demonstration
White phosphorus from sewage sludge ash

Pilot demonstrated shows possible potential to economically produce P4 from sewage sludge or ash.

Phosphorus in agriculture

AMBIO
International Phosphorus Workshop IPW7

Special issue on P in agriculture identifies nutrient management challenges and research needs

Compost soil benefits
Soil restoration and contaminants

Compost application can combat topsoil loss so reducing contaminants

Manures
Crop P uptake or P loss?

Different manures were tested for P-availability, water and erosion P loss.

Soil phosphorus
Appropriate P-tests for different soils/crops

Performance of different soil P tests in predicting response to fertilisers: DGT method versus conventional soil P tests.

Environmental change
How soil acidification impacts phosphorus

Soil pH influences the accumulation of different phosphorus compounds in cultivated lands.

The partners of the European Sustainable Phosphorus Platform

P and health – public consultation

European Food Safety Authority
Dietary reference values for P

EFSA (European Food Safety Agency) has opened a public consultation to 21st April, on DRVs (Dietary Reference Values) for phosphorus. The 50 page report (by the EFSA NDA Panel) published for consultation examines phosphorus metabolism, biomarkers, possible links between diet phosphorus and health impacts (cancer, cardiovascular disease) and DRVs proposed by different countries or authorities.

EFSA concludes that the recent **data available does not justify modifying current status of phosphorus RDVs in Europe**, that is as recommended by SCF (Scientific Committee for Food) in 1993 that phosphorus intakes should be equimolar to calcium intakes. The report recognises that this is not fully satisfactory, as phosphorus in diet may be less taken up by the body (less bioavailable) than calcium.

No upper safety limit for phosphorus in diet is considered necessary. Minimum intake levels are proposed as 200 mgP/day for infants 7-11 months, 300 – 800 mgP/day depending on age for children, and 700 mgP/day for adults.

Diet P and health

EFSA summarises available data and concludes that **phosphorus intakes in diet are generally in the range 1 – 1.8 mgP/day**, usually higher in males.

Available studies relating phosphorus in diet to **bone health, cancer and cardio vascular disease (CVD)** are assessed. Only studies looking at possible relations to diet P intake (not relations to serum P levels) are considered. EFSA concludes that there is **no evidence justifying basing DRVs on any of these three health outcomes**.

This confirms EFSA's publication of two previous reports in 2013 (see SCOPE Newsletter n°99), which concluded that available relevant literature did indicate a **correlation (not necessarily causal) between serum phosphorus levels and CVD (heart disease)** or symptoms thereof, but that there was no evidence of a link to diet phosphorus levels.

These publications also concluded that there was no evidence of a link between diet P levels and cancer, and no evidence that higher diet P levels result in increased serum phosphorus (phosphorus is normally regulated by the kidneys).

"Draft Scientific Opinion on Dietary Reference Values for phosphorus", EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), 4 European Food Safety Authority (EFSA), Parma, Italy, 50 pages 2015.

EFSA "Public consultation on the draft scientific opinion on dietary reference values for phosphorus", open to 21st April 2015
http://www.efsa.europa.eu/en/consultations/call/150310b.htm

Industry and policy

ISO and CEN
Sludge recovery and recycling standards underway

A number of existing European technical specifications (prepared by CEN, the European Committee for Standardisation) already address sludge production, management and valorisation.

Discussion is underway to extend these to address phosphorus recovery and recycling from wastewater.

At the global level, work is underway on **ISO/TC (International Technical Committee) 275 "Sludge recovery, recycling, treatment and disposal"** including a specific working group on "Inorganics & nutrients recovery".

Sludges represent around 10 million tonnes dry solids per year in the EU, 8 million tonnes in the USA, and already 10 million tonnes in China, despite a relatively underdeveloped sewage network. It is estimated that if all wastewater from the world's urban population was collected and treated by 2017, some 83 million tonnes of sludge dry solids would be produced (ISO/TC 275 draft SBP). Wastewater treatment sludge increased 43% from 1992 – 2000 in the EU, with increasing sewage treatment, and sludge treatment and disposal can be up to 50% of sewage works operating costs (*Sylvie Baig, AFNOR, ISO/TC 275 meeting 2013*).

Sludges face increasingly tight regulatory limits and other pressures, in particular as regards **levels of heavy metals and other contaminants**. Regulatory limits are defined by **EU Sewage Sludge Directive 86/278/EC**, by land application limits for Class A and Class B treated biosolids in the USA, but also by effective bans or exclusions of sewage sludge use on land (e.g. Switzerland, The Netherlands)

The European Sustainable Phosphorus Platform (ESPP) is following these standards developments (CEN, ISO), representing ESPP members, and can transmit stakeholder positions and proposals.

Existing European CEN documents

Existing European documents, approved by CEN (European Committee for Standardisation) include:

www.cen.eu : see under menu "Members -> "Technical Bodies" then SEARCH by the relevant Technical Committee (TC) number

Under CEN/TC 308: Characterization and management of sludge

- CEN/TS 13714: Characterization of sludges. Sludge management in relation to use or disposal
- CEN/TR 13097: Characterization of sludges. Good practice for sludge utilisation in agriculture
- CEN/TR 13983: Characterization of sludges. Good practice for sludge utilisation in land reclamation
- CEN/TR 15809: Characterization of sludges. Hygienic aspects. Treatments
- CEN/TR 15473: Characterization of sludges. Good practice for sludges drying
- CEN/TR 15584: Characterisation of sludges. Guide to risk assessment especially in relation to use and disposal of sludges
- CEN/TR 13767: Characterisation of sludges. Good practice for sludges incineration with and without grease and screenings
- CEN/TR 13768: Characterization of sludges. Good practice for combined incineration of sludges and household wastes
- CEN/TR 15126: Characterization of sludges. Good practice for land filling of sludges and sludge treatment residues

Under CEN/TC 223: Soil improvers and growing media

- A number of Technical Specifications addressing labelling, specifications, determination of different chemical and physical characteristics

Under CEN/TC 165/WG 40 - Wastewater treatment plants > 50 PT

- A number of EN 1255 standards, see below

Under CEN/TC 260 – Fertilizers and liming materials

101 standards covering denomination, characteristics, analysis methods, including

- EN 15919 - Extraction of phosphorus soluble in 2 % formic acid
- EN 15920 - Extraction of phosphorus soluble in 2 % citric acid
- EN 15921 - Extraction of soluble phosphorus according to Petermann at 65 °
- EN 15922 - Extraction of soluble phosphorus according to Petermann at ambient temperature
- EN 15923 - Extraction of phosphorus soluble in Joulie's alcaline ammonium citrate
- EN 15956 - Extraction of phosphorus soluble in mineral acids
- EN 15957 - Extraction of phosphorus which is soluble in neutral ammonium citrate
- EN 15958 - Extraction of water soluble phosphorus
- EN 15959 - Determination of extracted phosphorus

CEN/TS 13714: Sludge management in relation to use or disposal

CEN/TS 13714 (July 2013, 23 pages) provides a **general outline of sludge management upstream and downstream of water treatment**, referring to all sludges covered by CEN/TC 308 (that is from treatment of sewage, drinking water and comparable industrial wastewater). This Technical Specification provides a number of terms and definitions and refers to definitions given in EN 1085 "Wastewater treatment – Vocabulary" and EN 12832 "Characterization of sludges - Utilization and disposal of sludges – Vocabulary".

CEN/TS 13714 starts from the **Waste Hierarchy: prevent, reduce, reuse, recycle, energy recovery, disposal**. The objective is to guide a strategic evaluation of recovery, recycling and disposal options. The specifications consider upstream actions: controlling industrial discharges into sewers to limit contamination, to protect the biology of the sewage works treatment process and to protect the health of workers and the infrastructure.

Different sludge treatments are outlined: water reduction, anaerobic digestion, composting, incineration, wet oxidation. Uses considered include methane recovery and land spreading. Component recovery is not addressed in detail, but it is noted that this is expected to develop.

Also, a **matrix for developing BPEO** (Best Practicable Environmental Option) for sludge use or disposal is provided.

CEN/TR 13097: Good practice for sludge utilisation in agriculture

CEN/TR 13097 (June 2010, 23 pages) assesses in detail the **use of sludges in agriculture as a source of nutrients, a soil improver or an alkaline amendment**. A strategic evaluation process of agricultural use is proposed based on sludge quantity, soil characteristics, agricultural requirements, environmental factors, logistics and stakeholder reactions.

Prescriptions are given for ensuring sludge quality, hygiene (cf. CEN/TR 15809), soil sampling, storage, application techniques, communications and marketing of land application.

Prescriptions concerning land application include: precision application, type of equipment (e.g. to minimise soil compacting) and planning.

Sludge is noted to offer the advantages of stabilising the soil surface and improving aggregate stability when incorporated, so **reducing soil erosion and thus limiting related phosphorus loss**.

Under CEN/TC 165/WG 40 - Wastewater treatment plants > 50 PT: EN 12255

EN 12255-part 11 (General data required) requires **measurement of daily sewage treatment plant loads of total phosphorus and nitrogen (KN, NH_4-N and NO_3-N)** are required. Trades and industries with significant discharges of these nutrients should be specifically identified. These should be considered in design loads. **Cost information** should include chemicals for phosphorus precipitation.

EN 12255 – part 13 Chemical treatment describes different **options for phosphorus precipitation** (iron, aluminium or calcium dosing, precipitation at different treatment points). Specifications for chemical safety, storage and dosing are given. Processes for solid/liquid separation after precipitant dosing are indicated, including flocculation, sedimentation and flotation.

EN 12255 – part 8 Sludge treatment and storage summarises stabilisation, disinfection, thickening, digestion, composting, dewatering and storage techniques. The **impact of return liquors phosphorus and ammonia loads** on the wastewater treatment process is identified as factor to be taken into account.

New developments in standardisation relevant to phosphorus management

CEN/SABE - Strategic Advisory Body on Environment of CEN - and its Environmental Monitoring Strategy Team (ENV) are currently assessing possible **standardisation needs concerning sustainable use, recycling and recovery of phosphorus**, as relevant to wastewater treatment and sludge management, but also to the **ongoing revision of the EU Fertilisers Regulation** and possibly other phosphorus sustainability issues. The final aim of this work is to provide recommendation in the form of a Position Paper on future needs for monitoring standards. This work is led by Valeria Dulio (INERIS).

ISO/TC 275 "Sludge recovery, recycling, treatment and disposal" was launched in 2013, after **standards on sludge use and generation were ranked as a priority** by the ISO International Workshop on Water (Kobe 2012) and the ISO ITFWA (Implementation Task Force on Water). The work is chaired by Christophe Bonnin (Veolia Water France) with secretariat by AFNOR, France (Arnaud Gaudrier).

The objective is to **define analytical methods and good practice guidelines to move from sludge disposal to sludge as a resource**, considering: recovery and recycling, energy recovery/biofuels, biopolymer production, mineral recovery and use of treated sludges on farmland. This ISO work will not address contaminant limit values, which are dealt with by national regulations. It will be taken forward in liaison with ISO/TC 190 (soil quality), 147 (water quality), 224 (water services), 282 (water reuse).

Seven working groups have been established under ISO/TC 275, including WG7 Inorganic and Nutrients Recovery (convenor: Tim Evans, UK).

NOTE: TC = Technical Committee, TS = Technical Specifications, TR = Technical Report
CEN Technical Committee 308, WG2" Guidelines of good practice in the production, utilisation and for disposal of sludges"
http://portailgroupe.afnor.fr/public_espacenormalisation/CENTC308WG2/index.html
CEN SABE Strategic Advisory Body on Environment
http://www.cen.eu/work/areas/env/Pages/SABEorganization.aspx
ISO Technical Committee 275 "Sludge recovery, recycling, treatment and disposal"
http://www.iso.org/iso/iso_technical_committee?commid=4493530

To find CEN standards and documents: www.cen.eu : see above.

EurEau
Water industry calls for sustainable phosphorus reuse and recovery

The European water industry association, EurEau, has published a five-page position paper "Phosphorus in sewage sludge", underlining that sewage sludge is a valuable source of nutrients, and that public policies should support sustainable agricultural sewage sludge use and phosphorus recycling from sewage.

EurEau represents Europe's drinking water and waste water service providers from both the public and private sectors. **This sector employs some 500 000 people**.

EurEau underlines that sewage sludge is a valuable source of nutrients, particularly phosphorus and nitrogen, of organic matter and of energy. Various digested, composted, thermally or chemically treated sewage sludge products are already available and used as fertilisers locally in Europe.

Waste water treatment, sludge treatment and recycling of sludge should be considered as a whole, and the entire process of **phosphorus reuse or recovery must be economically feasible, sustainable and adapted** to local conditions. In particular, protection of surface waters is the main reason for wastewater treatment, and is the priority for operators.

Agricultural use of sewage biosolids

EurEau emphasises that the **sustainable application of treated or digested sewage sludge in agriculture** should be promoted and encouraged, as it ensures not only nutrient recycling but also promotes the use of valuable organic carbon, so contributing to increased organic soil matter.

If sewage sludge cannot be applied to agriculture, phosphorus should be recovered from sludge waters, digestates or ashes. If phosphorus recovery is not feasible today, then **legislation should support the mono-incineration of sewage sludge** (not mixed with municipal refuse) and mono-storage, so that the ash can be retrieved for phosphorus extraction in the future.

European policies and circular economy

EurEau points to a number of EU and national **policies and regulations where changes are needed** to remove obstacles and facilitate phosphorus reuse and recycling from sewage sludge:

- **Policy** is needed to support the sustainable agricultural use of (treated) sewage biosolids
- Revision of the **EU Fertiliser Regulation** to harmonise and open the market for recycled nutrient products, whilst ensuring quality and safety
- **Incentives for phosphorus recovery** to develop best practices and to test cost-effective processes
- **R&D** to develop sustainable and cost-effective solutions
- Possible **incentives or requirements to use recovered nutrient fertiliser products in agriculture** or to blend them into fertilisers on the market
- **Mono-incineration and storage of sewage sludge** incineration ash should be legally facilitated.

EurEau underlines that sustainable phosphorus reuse and recycling can **foster innovation** and develop new local markets in a circular nutrient economy.

Water in the Circular Economy

In a further briefing paper (24th March 2015), EurEau calls to **include water in the European Commission's new Circular Economy proposals**, in particular to facilitate end-of-waste status for high-quality sludge based materials and secondary nutrient products from sewage sludge. This would provide an incentive to improve the quality of recycled sludge. Coherence should be ensured with the implementation of the Sewage Sludge Directive, which distinguishes sewage biosolids from waste, and has had the positive effect of improving source control measures to reduce contaminants in sewage sludge.

EurEau suggests that European Circular Economy policy should "***create incentives to stimulate the use of recovered phosphorus***" and should foster the implementation of facilities for P-recovery from sewage sludge.

Success stories from EurEau members already operating phosphorus recovery are presented (struvite recovery by **Aquafin**, Leuven, Belgium and by **Aarhus** Municipal Waste Water Treatment Plant, Denmark), concluding that the Circular Economy policy should include measures to facilitate access of recovered products to the European market.

EurEau Position Paper. 24 October 2014 "Phosphorus in Sewage Sludge" http://eureau.org/administrator/components/com_europublication/pdf/99decbaae07e91fa2e696cef1fa62001-2014.10.24%20EurEau%20PP%20on%20Phosphorus%20in%20Sewage%20Sludge.pdf

EurEau, 24/3/2015 "Briefing on water in a circular economy" http://eureau.org/administrator/components/com_europublication/pdf/774243a07df6787e8a06d087ed31486b-20150324-Briefing-on-Water-and-Circular-Economy.pdf

Scotland
Phosphorus in detergents

Questionnaire results from 119 homes in Scotland, combined with analysis of products from supermarkets, provide an estimate of the contribution to wastewater phosphorus from different types of detergent and cleaning product in the UK in at the time.

The survey was carried out by questionnaire from October 2013 to January 2014. A 58% response rate resulted in **95 responses** connected to septic tanks. Also, **24 responses** from households connected to mains sewerage (sewage treatment works) in order to confirm that detergents use practice was not significantly different.

Analysis was carried out on **80 different cleaning products and household detergents purchased from UK supermarkets in 2013**, including assessment of total and soluble phosphorus content: 32 laundry detergents (of which 5 were eco-advertised and specified septic-tank safe), 15 dishwasher detergents (of which 3 eco-advertised), 12 hand dishwash liquids, 7 fabric softeners, 9 general cleaning products, 5 hand soaps. The eco-advertised products did not carry an official EcoLabel mark.

Phosphorus load to wastewater from the different products was estimated from household survey replies concerning number of household occupants, cleaning product usage frequency, type of detergent used (differentiating between eco-advertised and non eco-advertised laundry and dishwasher detergents), manufacturers recommended dosage, and the average total P content of the product type calculated from the supermarket samples. This estimate therefore does not take into account possible failure of consumers to respect recommended doses, nor possible variation between products with different market shares (the average composition was calculated assuming that all sampled products had the same market share (within the two categories: eco-advertised or not).

Phosphorus loads from detergents

Using these data, phosphorus loads to wastewater from detergent use were **estimated at 0.147 kgP/person/year (0.40 gP/person/day) from dishwasher detergents and 0.007 kgP/person/year (0.02 gP/person/day) from laundry detergents**.

This estimated contribution from dishwasher detergents is considerably higher than previous authors (e.g. Gilmour 2008: 0.26gP/person/day). The authors suggest this may be because of the high % of households (78%) amongst respondents which use a dishwasher. They also underline the high P-content of dishwasher detergents sampled: phosphorus content of non eco-advertised dishwasher detergents ranged from 4.3% - 13.1% P, with an average of 3.2% P.

***Error in publication**: some figures in the published article are indicated as % P whereas they refer to % phosphate, a correction is pending publication. The figures here are in the correct units*

The very low contributions of phosphorus from laundry detergents suggest that **most laundry products on the market were already P-free**, probably as manufacturers were already respecting the effective EU ban on phosphates in domestic laundry detergents which entered into force on 30th June 2013 (EU Regulation 259/2012 of 14th March 2012, limitation to 0.5 gP/wash, which effectively prevents the use of phosphates as a detergent component).

No phosphorus in hand cleaning products

The authors note that **phosphorus is near zero in fabric softeners, hand dishwash products and hand soaps**, confirming that phosphates are not used as ingredients in these product categories. Levels are on average 0.2%P. in general cleaning products, and this low level combined with low consumption rates, results in negligible phosphorus contribution to wastewaters. The authors conclude that the phosphorus contribution to domestic wastewater from these product categories too insignificant to be considered.

The study indicated that **some products on supermarket shelves are not respecting labelling legislation**, in that four dishwasher or laundry detergents for which phosphates were not indicated on the label contained >0.2% phosphate (> 0.07%P), and in one case 35% phosphate (c. 10% P). Detergent legislation in Europe requires indication on the label of ingredients used at >0.2%.

Eco-advertised detergents not satisfactory

The household survey also indicated that one third of households which had tried eco-advertised detergents switched back to non eco-advertised products. Also **83% of households which had tried low phosphorus laundry or dishwasher detergents believe that they were not as effective as phosphorus-based products**, were more expensive and (for dishwasher detergents) were not widely available in most shops. The authors conclude from this that legislation is necessary to drive consumers to use low-P laundry and dishwasher detergents.

The survey also confirmed that **problems associated with septic tanks** are widespread. 30% of respondents admitted to having had problems with the tanks and/or soakaway, 22% admitted that the system was located within 30m of a water course, and 65% of the systems were not registered with the Scottish Environmental Protection Agency (this is only mandatory when a property is sold or for new installations).

The authors also analysed 17 different **trace or other metal elements in the different detergent products** (Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Nb, Si, Sr, Ti, W, Zn, Zr) with the objective of identifying elements which could be used as tracers to detect phosphorus originating from dishwasher detergents in wastewaters or septic tank plumes. They conclude that a number of elements are distinctive to dishwasher detergents (As, Na, Si, Sr, Ti, Zn, Zr). However, sodium and silicon are widely present in wastewaters from many sources so are unlikely to be useful as tracers. Strontium, titanium, zinc and zirconium levels were similar in eco-advertised and non eco-advertised dishwasher detergents, whereas arsenic levels were >2x higher in non eco-advertised dishwasher detergents.

"The contribution of household chemicals to environmental discharges via effluents: Combining chemical and behavioural data", J. Environmental Management, vol. 150, March 2015, 427-434 http://www.sciencedirect.com/science/article/pii/S0301479714006021
S. Richards, E. Paterson, M. Stutter, The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, Scotland, UK, P. Withers, Bangor University, Bangor, Gwynedd LL57 2UW, UK.

CCM – Phos4Ever
Study of China's P industry

CCM (Data & Business Intelligence) and phosphate industry experts Phos4Ever (an ESPP member) have published a comprehensive resources, market and technology study of China's phosphate industry, including rock reserves and quality, fertiliser perspectives, production of "yellow phosphorus" (impure P_4 white phosphorus), export policies and perspectives, in particular concerning industry vertical integration.

China is the second largest phosphate rock producer in the world, and the largest yellow phosphorus producer. China's internal **consumption of phosphorus is continuing to rise** 10% each year.The report assesses how large are China's remaining rock reserves, looking at quantity, quality and so production costs. Based on consumption projection, the report estimates how long these reserves will last before China meets national "**peak phosphorus**".

PEST (Political, Economic, Social and Technological) analysis of China's phosphate industry forecasts how industry will develop, looking at mining, processing, downstream users and export. **Technical yellow phosphorus user industries** are assessed, including glyphosate and phosphides.

Highly competitive

The report underlines that the current combination of pressure on rock reserves and falling rock quality, and slack downstream demand, causes a highly competitive industry context, with **some companies in difficulty**. As a consequence, production is expected to move towards high-value products, with primary products falling behind.

Companies will integrate upstream in China into phosphate rock mines with development of phosphoric acid technologies, purification and processing of middle or low grade phosphate rock.

These developments in China's phosphate and yellow phosphorus industry, combined with developments in China's export tariffs, will have significant impacts on downstream industries worldwide.

CCM – Phos4Ever "Forecast of Integrated Phosphorus Industry in China Executive summary", April 2015
http://www.cnchemicals.com/Product/ExecutiveSummary/2527/forecast-of-integrated-phosphorus-industry-in-china-edition-1-executive-summary

CRU Conference
Phosphates 2015 Florida

The yearly **"Phosphates" conference**, organized by CRU and in its eighth year, was held in North America for the first time (March 2015). The conference demonstrated the **high level of efficiency and sustainability innovation in the phosphorus mining and processing industries**.

A record number of delegates, over 400, from the mining and fertilizer industry, industrial and food grade phosphate producers, technology suppliers and scientists presented **innovative technologies** and showcased industrial implementation and were updated on world phosphorus market developments.

Phosphate rock markets

The CRU team gave **updates on fertilizer use and phosphate rock consumption**. A number of factors are impacting this, such as the dollar exchange rate, the type of crops planted worldwide and the weather (as also explained in-depth by **WorldWeather** in a separate presentation). For instance, climate slowed down consumption in India while an increase in soybean surfaces in Brazil boosted sales there.

Also, some **major changes in production capacity**, notably closures in North America and increases in Africa and Asia, affected regional and worldwide trade patterns. Predictions for the mid- and longer term were also presented, where further capacity changes will affect the current situation. New fertiliser and phosphorus demand from developing countries will have a further influence on this.

Further updates were provided on the **N and K markets which are closely connected to phosphate**. Also, the situation in China was explained separately, underlining the importance of this country in phosphate and fertilizers. The **Federal University of Lavras** explained the Brazilian fertilizer trends. An Asian perspective for industrial and food phosphates was provided by Aditya Birla.

Fertiliser efficiency

A vital message was delivered by **Mosaic**, who not only provided a detailed outlook on the P fertilizer business, but also presented a range of **innovations towards more sustainability in the fertiliser industry, contrary to the common perception that this is a very conservative sector**. This primarily concerns energy use and CO2 footprints as well as emissions. Mosaic also acknowledged that the current delivery mechanisms of phosphate fertilizers are not sustainable in the long run, as not all P is used by the crops or stored in the soil, resulting in losses which contribute to eutrophication, together with contributions from (excessive) manure application and improper sewage treatment. **Fertilizing needs smarter solutions that waste less, such as precision fertilizing systems**.

Simplot shared a long term fertilizer perspective based on population growth and changes in diet, with significant population growth combined with higher protein/calorie intake in the developing world.

PotashCorp updated the delegates on capacity and market developments in feed phosphates.

Prayon presented a precision fertilizer which delivers iron - together with main nutrients - to the crops.

Sustainable phosphorus

The message that P use can be more sustainable was also delivered by **Jim Elser of Arizona State University** and the Sustainable Phosphorus Initiative, who presented a thought-provoking perspective on the phosphate market based on **regime shifts and variance theories**. Phosphate prices are concluded to be subject to erratic changes occurring in unpredictable ways. He also provided an overview of P sustainability issues, including eutrophication and sustainable P management, and invited the delegates to join the **North American Partnership for Phosphorus Sustainability** (NAPPS *https://sustainablep.asu.edu/events*). This will provide an opportunity for industry, government, academia and NGOs in the USA and Canada to interact and exchange information and viewpoints.

Potential phosphate rock production

CRU tracks 46 so-called junior mines – **phosphate deposits which are under development**. Several of these new mining ventures were presented, providing a fascinating insight into the challenges of starting a new mine. Investment is very considerable, and lead times of a decade or more are common. Also, the location of the deposit that is to be mined is highly relevant, as logistics of incoming raw materials (eg sulphur, water, and power for a fertilizer complex) and outgoing products are strongly determining the feasibility of the mine. One of these mines (in Peru) offers a rare grade of rock that does not require any form of treatment to serve as a fertilizer (DAPR; Direct Application Phosphate Rock), thus creating a niche that few other rocks can fill.

OCP presented a range of **upgrades in capacity and improvements in their production systems**, including a slurry pipeline for rock transport and a new reserve deposit which is being developed to bring onto the market.

Improving phosphate processing

As always in this conference, a range of equipment, monitoring systems and process upgrades was presented to improve operability of MGA and fertilizer units, such as flotation/beneficiation and acid recovery improvements to achieve higher yields, and environmental improvements like emission reductions. **This serves as a powerful reminder that this industry is characterized by harsh conditions, with corrosion, scaling and wear contributing significantly to operational cost**. Also, technologies for improved cooling and gypsum stack management were presented to increase sustainability in this part of an MGA operation.

A large number of companies continue to work on innovation in processing equipment.

Purification

A notable feature of the Phosphates conference is the number of **technical presentations and showcases that focuses on impurities removal**. This is due to the importance these play in the overall value chain, especially in MGA manufacture. As such, the Phosphates conference is more technologically oriented than CRU's K and N conferences – these value chains are less affected by grade and impurity considerations.

Impurities in phosphate rock can be a nuisance, such as magnesium, cadmium and iron, and may need removal in some cases. Some rocks are virtually unusable for MGA production due to their impurities content. A number of solutions were presented for the removal of these impurities. **If such technologies are implemented successfully, rocks that are now unusable may become available for processing**. These developments will in all likelihood affect the world's reserves and reserve base as we now define these.

New market opportunities

On the other hand, other impurities such as uranium, fluorides and rare earths pose an opportunity for further valorization of phosphate rock if they are extracted. The possibilities for this – and the consequences for the regular MGA operation – were presented by a number of technology providers.

Also, several **technologies were presented to use low-grade rock**, via wet-chemical or thermal routes. This also underlines the rising interest in unlocking grades of rock that are now not seen as economically processable.

Summary prepared for ESPP / SCOPE Newsletter by Willem Schipper, one of ESPP's phosphate industry experts, WS Consulting wsconsulting@zeelandnet.nl

Phosphates 2015 International Conference & Exhibition (organised by CRU), 23-25 March 2015 - Tampa Florida, USA http://www.crugroup.com/events/phosphates/

Details of Phosphates 2016 will be communicated in upcoming SCOPE Newlsetters, on the CRU Phosphates website and on the ESPP website "Events" page.

IWA Nutrient Roadmap

Sewage nutrient management perspectives

WEF (Water Environment Federation), the Environment Defence Fund (EDF) and the Johnson Foundation at Wingspread have published the first phase of the Nutrient Roadmap, to implement a 25-year horizon nutrient management vision for smarter nutrient removal and recovery at waste water treatment plants, which should progressively become water resource recovery facilities (WRRF).

The 17-page Phase One report defines **matrices for addressing the major topics and subtopics** identified by the organisations' experts at the "Airlie Meeting", Virginia, February 2013. This will now be developed by a wider group of experts into a **Guidance Document**, addressing each topic, and supplemented with case studies and other resources, to be published in 2015.

25 year objectives

The Nutrient Roadmap fits into the overall 25-year objectives defined of "**next generation wastewater treatment having zero impact with regard to energy use, greenhouse gas emissions and nutrient discharge by 2040**". It is underlined that this will require "overcoming technical barriers, financial constraints and regulatory disincentives limiting nutrient removal, greenhouse gas emission reduction and energy neutrality in the treatment of wastewater".

The report takes as a basis the **existing WEF manuals** of practice on Design of Municipal Wastewater Treatment Plants (n° 8), Operation of Municipal Wastewater Treatment Plants (n° 11), and Nutrient Removal (n° 34).

Nutrient removal in wastewater treatment involves **economic and environmental trade-offs**, such as increased greenhouse gas emissions (N_2O), energy consumption in BNR (biological nutrient removal), interactions with biogas production and sludge dewatering. Biological phosphorus removal can, for example, decrease the efficiency of dewatering and require additional coagulant polymer use (compared to chemical P removal where iron or aluminium is present).

Biological nitrogen removal depends on sludge available carbon content, sludge retention time (and so installation size), temperature, dissolved oxygen, pH and possible inhibitory compounds.

Phosphorus removal can be achieved using chemical precipitation, biological phosphorus removal, nano methods involving membranes (e.g. reverse osmosis, nanofiltration, electrodialysis reversal), or a combination of these processes. Biological phosphorus removal is highly dependent on availability of volatile fatty acids (carbon source for phosphorus accumulating organisms PAOs) but also on control of anaerobic / anoxic / aerobic cycles and sludge (solids residence time, oxygen levels, temperature) and can be inhibited by the presence of nitrates, which is important in systems combining nitrogen and phosphorus removal.

Developing technologies are identified including **ANAMMOX** (anaerobic ammonia oxidation, see SCOPE Newsletter n° 89), **DEMON** (DEamMONnification: a biological process for nitrogen removal without carbon consumption by a combination of partial nitritation and autotrophic nitrite reduction) and struvite recovery.

Assessment matrices

The Nutrient Roadmap defines five topics, under which objectives are outlined according to three phases: plan, prepare & implement, evaluate & improve:

- **Supporting nutrient management**:
  - nutrient vision
  - staff development & alignment
  - financial viability
- **Understanding the environment**
  - data & characterisation
  - modeling
- **Product development**
  - marketing (of nutrient products, greenhouse gas offsets, including standards)
  - product production and control
  - public communications (and stakeholder relations, concerning nutrient recovery and reuse)
- **Evaluation of alternatives**
  - evaluation of nutrient removal and recovery processes as regards nitrogen removal, phosphorus removal and carbon: treatment levels, costs, improvement and optimisation, regulatory landscape
- **Risk management**
  - regulatory risk management
  - upstream innovation (e.g. water efficiency, upstream pretreatment, ecological sanitation, decentralisation of infrastructure, partnerships with other waste streams such as animal wastes to balance nutrients/carbon …)
  - innovation
  - infrastructure risk management (leaving space for future options)

Smarter Nutrient Management

This Nutrient Roadmap follows from previous work by the author organisations. The Johnson Foundation at Wingspread report "***The road toward smarter nutrient management***" (March 2014, 20 pages) identified drivers for change:

- increasing focus on **addressing eutrophication** challenges and restoring freshwaters,
- emphasis on **reactive nitrogen** (nitrous oxide N_2O, ammonia NH_3, nitrate NO_3 and others) which contribute both to eutrophication and to climate change,
- **pressure on global phosphorus reserves**
- opportunities for **nutrient recycling**.

The report notes the need to set goals for nutrient management and identifies key factors for success:

- an **innovative regulatory framework** aimed at optimising cost-effectiveness through flexibility and which facilitates experimentation,
- **technological advances** in nutrient removal and recovery (e.g. struvite recovery, urine separation …),
- **watershed-scale management**,
- including **carbon** in the nutrient management strategy
- improving **data** on nutrients.

Biosolids Factsheet

The WEF – National Biosolids Partnership factsheet on "***Phosphorus in Biosolds***" (May 2014, 19 pages) provides a summary of phosphorus in biosolids and in soils (behaviour, different forms, plant availability, soil P assessment). The document gives figures for P **solubility and runoff from fertilisers, manures and biosolids** (from Brandt 2004, see below) showing that P losses are much lower from biosolids, but suggesting that this is due to iron and aluminium concentrations (so this may not be applicable to biological P-removal biosolids).

The factsheet underlines that nutrient application regulations need to **distinguish between mineral fertilisers, manures and biosolids** and to take into account the solubility of phosphorus in the applied product, as well as the soil P status.

Phosphorus in biosolids

Brandt (2002 and 2004) analysed 41 sewage biosolid products (all after dewatering), plus 13 manures and Triple Super Phosphate fertiliser, for levels of aluminium, iron, calcium and total phosphorus and water extractable phosphorus (WEP = assessed by shaking the sample for one hour in water).

Total P in dairy manures was only 0.6 – 0.8%, of which 40 – 60% WEP. Total in poultry manures was higher, 1.3 – 2.6%, of which 13 – 28% WEP.

Total P in the dewatered sludges varied from 2 – 4%, with both higher and lower levels in some treated products (heat dried, composted, lime stabilised, advanced alkaline stabilised). % WEP varied considerably, from 0.6 – 7 %, but was higher in the biological phosphorus removal (bio-P) sludges from 7 – 24% WEP. Total P in the six bio-P sludges tested were similar to those from other sewage works.

The authors note (for all the products tested) that the % WEP is generally, but not exclusively, linked to the iron and aluminium content. These are generally high in the sewage sludges: 0.7 – 6.6% aluminium and 0.4 – 7% iron in the non bio-P sludges and 0.5 – 3.3% aluminium and 0.6 – 2% iron in the bio-P sludges. Fe and Al are low in manures (0.04 – 0.13% Al and 0.07 – 0.2% Fe) and in the TSP fertiliser (1% Al, 1.2% Fe).

The **high levels of aluminium and iron in some of the bio-P sludges suggest that some chemical P-removal dosing may also have been used.**

The authors note that the bio-P sludges show higher % WEP than would be expected from the aluminium and iron levels. The % WEP in heat dried sludges is significantly lower, whereas the % WEP after other treatments is variable.

Six "**Best biosolids management practices to reduce P losses**" are proposed and each is discussed:

- matching biosolids **application rates** with crop P needs or using a 3 to 5-year application cycle,
- maintaining an up-to-date nutrient management **plan**,
- implementing **farming practices** that minimize erosion,
- maintaining robust and adequately-sized vegetative **buffers**,
- **storing** biosolids properly
- applying **other residuals** to reduce P solubility.

Nutrient Roadmap Version 1.0, WEF (Water Environment Federation), the Environment Defence Fund (EDF) and the Johnson Foundation at Wingspread, 17 pages, September 2014 http://www.wef.org/nutrientroadmap/

"WERF (Water Environment Research Foundation), "Nutrient recovery state of the knowledge", December 2010 and September 2011, reviewed in SCOPE Newsletter 101

"Phosphorus in Biosolids: How to Protect Water Quality While Advancing Biosolids Use," WEF, May 2014. http://bit.ly/PBiosolids

"Enabling the Future: Advancing Resource Recovery from Biosolids," WEF, 2013. http://bit.ly/EnablingtheFuture *(reviewed in SCOPE Newsletter 101)*

"The Road Toward Smarter Nutrient Management in Municipal Water Treatment," The Johnson Foundation at Wingspread, March 2014. http://bit.ly/smarternutrient

Phosphorus recycling

Slaughterhouse wastewater
Struvite and energy recovery

A number of publications address resource recovery from slaughterhouse wastes. Proposed strategies include anaerobic digestion to recover energy (as methane) and struvite precipitation to recover nutrients and/or remove nitrogen from effluent

Jensen et al. assess the potential for energy and nutrient recovery from slaughterhouses, based on data from I such installations in Australia.

Methane and struvite recovery

The 6 sites assessed cover cattle and/or sheep slaughtering installations, with capacities of animals per day. Wastewater samples were collected at regular intervals over 4 days, at each site, from different processing streams and analysed for fat-oil-grease, total and organic carbon, total and soluble phosphorus, ammonia nitrogen, sodium and potassium.

Six **major processing wastewater streams** were identified, largely common to all studied sites: three red wastewater (slaughter floor, rendering, boning) and three green wastewater (cattle yards, offal, paunch handling). The authors note the relatively high temperatures of Australian slaughterhouse wastewaters, resulting from widespread use of hot water in sterilisation and cleaning, and low availability of cooling water.

Methane production potential was estimated using ml laboratory batch tests and nutrient recovery potential (as struvite) was estimated taking into account soluble phosphorus, ammonium nitrogen.

The authors not that traditional treatment, based on anaerobic lagoons is not optimal, requiring a large footprint and not compatible with energy and nutrient recovery. They recommend biological treatment, noting that high solids levels, fat-grease levels or low organic concentrations are likely to be relatively incompatible with high-rate anaerobic treatment (UASB or internal circulation reactors), and may require technologies such as AnMBR (anaerobic membrane reactors).

Rendering and paunch wastewater represent around 75% of the methane, potassium and phosphorus recovery potential in only 20% of the flow

Struvite recovery for nitrogen removal

In **Kabdaşlı et al.,** a 5-litre laboratory batch tests assessed struvite precipitation as a nitrogen-removal process before or after biological treatment of wastewater from a slaughterhouse located in Istanbul.

The slaughterhouse wastewater used has low suspended solids and grease, total nitrogen of 250-260 mgN/l (of which 210-220 mgN-NH_3/l) and orthophosphate 5-6 mgP-PO_4/l.

Experiments carried out were **struvite precipitation** from the raw slaughterhouse wastewater, struvite precipitation from the biologically treated wastewater and biological treatment of the wastewater after struvite precipitation. Struvite precipitation was achieved by adding Na_2HPO_4 to provide orthophosphate. Sodium hydroxide (NaOH) was also added to increase pH to 8 – 9.5.

Struvite precipitation showed capacity to reduce nitrogen to acceptable levels for discharge (30 mgN/l for struvite precipitation after biological treatment, 22 mgN/l for struvite precipitation in raw wastewater). Phosphorus levels were also acceptably low (14 or 25 mgP-PO_4/l) but only if struvite precipitation was operated at pH 9 or higher.

The amount of struvite sludge precipitated was significantly higher when precipitation was upstream of the biological treatment (2- 2.3 compared to 1 – 1.5 kg/m^3 wastewater treated) because in the former case the struvite sludge contained significant levels of organics. The struvite precipitation downstream of biological treatment also gave lower discharge COD values, but was not so effective for nitrogen removal

The authors conclude that **struvite precipitation downstream of biological treatment enables considerable cost reductions** (investment, energy consumption) for the biological treatment (enabling use of a high-rate activated sludge system instead of a low-loading system necessary for nitrification – denitrification), producing a quite pure struvite product suitable for recovery. Struvite precipitation alone (without biological treatment) results in a discharge suitable for emission into a municipal sewage system, but the recovered struvite has high levels of organic impurities (including organic nitrogen).

Full-scale recovery from fish processing

Crutchik, Señoráns, Garrido et al. have tested struvite recovery from wastewater from a fish processing and freezing plant in North-West Spain (Atlantic). This wastewater contained significant levels of seawater, providing a magnesium source for struvite precipitation. Initial experiments used a laboratory scale airlift crystallisation reactor (total volume 2.4 litres) continuously operated for a total of 217 days. A pilot plant was then tested at the fish processing factory (reactor volume 0.31 m^3), where a full-scale installation has been installed with a reactor capacity of 23 m^3 treating 400 m^3 of wastewater per day.

In the laboratory tests, **seawater was mixed with the fish processing factory wastewater to provide magnesium ions**. The full-scale installation operates downstream from an activated sludge biological treatment / nitrogen removal installation, after a settling tank decanter. A solution of free ammonia diluted in water was fed to the reactor as alkalinity and nitrogen source. The pilot installation was tested upstream of the biological / nitrogen treatment after pretreatment (homogenisation) only.

The **pilot scale tests** used two parallel struvite precipitation units, one airlift column similar to the laboratory tests, using air injection to ensure mixing, with a 3-phase baffle system to separate solids and supernatant at the top of the column, and double chamber completely mixed reactor (two stirred chambers in series) with a final settler. These reactors were run in parallel for 178 days.

Both of the pilot reactors tested achieved **c. 85% removal of soluble phosphorus** with an outflow soluble phosphorus concentration of 12 mg/l P-PO_4, but only on condition of significant NaOH consumption to maintain pH. The airlift reactor gave a struvite product with better dewatering characteristics.

Economic assessment

A cost assessment of the two struvite precipitation options (upstream or downstream of the biological wastewater treatment) looked at energy consumption, chemical reagent costs and solid waste management costs. This concluded that **struvite precipitation is less than half the cost of traditional P-removal using aluminium salts**, principally because of considerably cheaper chemical costs (over 50% of traditional P-removal costs) and avoidance of sludge disposal costs (around 25%). Struvite precipitation downstream of the biological treatment is marginally cheaper than upstream, mainly because of lower NaOH consumption.

The authors conclude that struvite precipitation from food industry wastewater produces a high-quality struvite product and can be economically competitive to traditional P-removal processes, depending on the availability of cheap or local magnesium sources or if the treated wastewater has high magnesium levels (as is the case for seafish processing).

"Analysis of the potential to recover energy and nutrient resources from cattle slaughterhouses in Australia by employing anaerobic digestion", Applied Energy 136 (2014) 23–31, http://dx.doi.org/10.1016/j.apenergy.2014.09.009

P. Jensen, T. Sullivan, C. Carney, D. Batstone, Advanced Water Management Centre, The University of Queensland, St Lucia, QLD 4072, Australia p.jensen@awmc.uq.edu.au

"Application of struvite precipitation coupled with biological treatment to slaughterhouse wastewaters"

I. Kabdaşlı, O. Tünay, P. Özcan, Istanbul Technical University, Civil Engineering Faculty, Environmental Engineering Department, Ayazağa Kampüsü, 34496, Maslak, Istanbul, Turkey kabdasli@itu.edu.tr

Environmental Technology, 30:10, 1095-1101, 2009 http://dx.doi.org/10.1080/09593330903136856

"Struvite crystallization versus amorphous magnesium and calcium phosphate precipitation during the treatment of a saline industrial wastewater", Water Science & Technology, 64.121, 2011, doi: 10.2166/wst.2011.836

D. Crutchik, J.M. Garrido, Department of Chemical Engineering, Institute of Technology, University of Santiago de Compostela, Rúa Lope Gómez de Marzoa, 15782 Santiago de Compostela, Spain dafne.crutchik@gmail.com

"Recuperación de fósforo mediante cristalización de estruvita en efluente de industria de productos congelados marinos", Tecnologia del Agua, 335, diciembre 2011

L. Senorans Rivas, S. Barros Prieto, 3R Ingeniería Ambiental, S.L., Vía Ptolomeo, 3 1°, Polígono del Tambre, 15890 Santiago de Compostela, Spain. G. García-Toriello Romero, Espina y Delfin, S.L., Vía Edison 9, Polígono del Tambre, 15890 Santiago de Compostela, Spain. J. Manuel Garrido Fernández, Department of Chemical Engineering, Institute of Technology, Universidad de Santiago de Compostela, Rúa Lope Gómez de Marzoa, s/n, 15782 Santiago de Compostela, Spain. juanmanuel.garrido@usc.es

RecoPhos (thermal) demonstration

White phosphorus from sewage sludge ash

The RecoPhos (thermal) project is an EU FP7 funded project to develop a new process to produce white phosphorus (P4) from waste, notably sewage sludge or ash. The electrical inductive heated InduCarb reactor is presented in SCOPE Newsletter n° 104.

A pilot RecPhos installation operated and demonstrated at Leoben, Austria, shows possible potential to economically produce P4 from sewage sludge or ash.

The process has now been tested in a pilot-scale reactor. The inductively heated reactor vessel (without feeding system, slag vessel and support structure) exhibits about 22 cm external diameter, about 97 cm internal height, **approx. 10 kg/h dry waste matter input feed**, in Leoben Austria. The reactor was presented and demonstrated to some 50 stakeholders on 24th of February 2015 (see *www. recophos.org* -> Events).

*NOTE: this process is **not in any way related to the German RecoPhos project** www.recophos.de which uses acid to extract phosphorus from sewage sludge ashes in a process similar to Triple Super Phosphate production, but then requires treatment to remove contaminants in order to possibly produce a useable fertiliser product.*

The RecoPhos (thermal) FP7 consortium consists of nine partners, from large companies to SMEs and academia. It is coordinated by Montanuniversität Leoben (Austria). SGL Carbon is the only large company in the consortium and is IP owner of the RecoPhos process and the designated exploitation partner of the project results.

White phosphorus (P4)

White phosphorus (P4) is essential as a raw material for many value-added organophosphorus chemical products, including catalysts, halogen-free flame retardants, water treatment and drilling additives (phosphonates), pharmaceuticals … It can also be used to produce extremely high-purity phosphoric acid for the electronics industry (micro-chip etching).

Photos: http://www.recophos.org/c/mid,1363,Events/

White phosphorus is usually made in an electric arc furnace by heating phosphate rock, gravel and coke to 1500 °C (e.g. "Thermphos" process). **Using sewage sludge ash in this process has been tried on an industrial scale**, but has the disadvantage that a significant part of the white phosphorus is lost to a by-product, ferrophosphorus, inevitably formed as a consequence of the high iron content in most sewage ashes. As a consequence the economics are unfavourable unless low-iron ashes are selected (e.g. separative incineration of biological nutrient removal sludges).

The Recophos process aims to rectify this by using an **innovative approach to heat the feedstock**. Ashes are fed onto an **inductively heated bed** consisting of coke or graphite (Inducarb furnace). The reaction is the same as in the classical process, but due to non-equilibrium conditions the phosphorus has little opportunity to form the byproduct and enters the gas phase quickly. Hence the phosphorus yield should be acceptable even with high-iron ashes.

An additional advantage is the **opportunity to use powdery input**, in contrast to the classical process which needs granulation of the phosphate feed: this avoids the initial sintering step which was required in the Thermphos process which involves both significant energy and operating costs and risk of dioxin emissions. On the other hand the optimized energy use of the classical furnace process cannot be matched by the Inducarb setup.

Demonstration

On the 24th of February in Leoben, project partners MU Leoben and SGL Carbon (patent holder of the technology) introduced the principle and the consortium and presented the operating pilot reactor.

The potential for raw material is 10 Mt/y of sewage sludge in the EU (expressed as dry material). The most interesting area for implementation is Germany, where some 300 kt/y of ash are available from sewage sludge monoincineration units (incineration not mixed with municipal solid or other wastes), corresponding to 18.5 kt/y of P. However the concept would work in any region with a suitable amount of raw materials present.

The project consortium considers that **sewage sludge could also be used directly in the process, by adding an upstream flash reactor**. This flash reactor may be used as a dryer, using recycling heat from the white phosphorus reactor, removing both water and heavy metals and halogens. At the same time it will produce a hot slag consisting of the mineral parts of the sewage sludge which can be fed into the InduCarb reactor.

Electricity consumption

The electrical energy use of the process was indicated to lie between 19 +/-2 MWh per ton of white phosphorus for typical SSA from municipal waste water treatment (13-14 for the classical Woehler process processing rock phosphate). Lower values can be achieved via hot feeding of the ash, which can be done by using cheaper heat sources to preheat the input and using uncooled ash output of an incinerator. The overall economics of the Recophos process will depend on the balance between investment, raw material and operational savings on one side, and energy expenses on the other. The consortium indicates that the overall outcome is competitive, although no detailed breakdown was given.

Project member **InsPyro** presented a thorough study in slag composition and melting characteristics as well as the reaction mechanism. The lower loss of white phosphorus to the byproduct can be confirmed by modelling. Unfortunately no experimental data on **P losses to ferrophosphorus** were provided. A comprehensive model for the reaction has been constructed with good predictive power for the experiments. Consortium member **HCPE** made a further detailed study on liquid and gas phase reactions and power distribution. Carbon monoxide is confirmed to be a crucial intermediate in the reaction mechanism. The need for an optimized slag composition was also clearly demonstrated by modelling and experiments to ensure good yields. Consortium member **M.I.T.** (Austria) indicated the potential to use the slag in concrete, which will positively impact the business model.

Delegates were then shown around the pilot setup which has a capacity of approx. 10 kg/h feed. No attempts were made to purify the white phosphorus output of the pilot setup: for reasons of safety the consortium decided to burn the output to phosphoric acid. However, during the lively discussion that followed the demonstration, it became clear that the **existing offgas and product treatment concepts from the classical process can be likely adapted without large issues**.

The project is being finalized and is available for further development by interested stakeholders.

Website: www.recophos.org

Presentation of the RecoPhos (thermal) pilot reactor and process: SCOPE Newsletter n° 104

Contact: Daniel Steppich, SGL Carbon;
Daniel.Steppich@sglgroup.com

Phosphorus in agriculture

AMBIO

International Phosphorus Workshop IPW7

The March 2015 special issue of AMBIO presents 14 papers from the 7th International Phosphorus Workshop IPW7, Uppsala, Sweden, September 2013 (150 participants). A **1-page synthesis of the conference conclusions** (in Sharpley et al.) provides a concise summary, identifying key challenges and research needs for six themes.

The 6 themes addressed by the conference were:

- **P management in a changing world** with an increasing demand for food: including implications of climate change, water efficiency, spatial separation of livestock and crop production, cost-effective P-recovery from manures, development of mineral/organic fertilisers
- **Manure** and agricultural P management systems
- **Transport pathways** for P from soil to water
- **Monitoring, modelling and communicating**
- Identifying **measures** to reduce P losses
- **Implementation** of measures

The conference underlined that the relations between reduced agricultural P use and water quality improvement are poorly understood, in particular because of **accumulated "legacy P"** in soils, accumulated phosphorus in surface water sediments in catchments, and concluded that more research is needed to understand P loss pathways, movements of phosphorus in catchment systems and water restoration limits.

Food prices

The need to balance society's demand for **cheap food** with the desire for clean water is noted. Global food prices fell 1% per year from 1990 to 2010 despite a quadrupling of the world population. The conference concluded the need to develop cost-effective nutrient recovery from manures and cost-beneficial recovered nutrient products.

A key challenge identified, related to the cost aspects, is the **concentration and intensification of livestock** production, resulting in a spatial disconnect from crop production and important regional phosphorus imbalances. Other overall challenges identified include the need to improve agricultural P-use efficiency and to integrate related costs into food prices.

For lasting reductions in agricultural phosphorus losses to be effective, **socio-economic drivers** must be addressed. Farmers cannot absorb the total costs of implementing nutrient loss remedial actions.

Nutrient management policies must consider the **impacts of climate change** on agriculture and focus on catchments, with adaptive, locally specific actions. For example, physical restoration of catchment headwaters can be effective in reducing nutrient loadings downstream, as well as in bringing wildlife benefits.

Nutrient management should prioritise vulnerable landscapes, in order to optimise remedial cost effectiveness. Data and modelling are necessary to identify these areas and to target actions. These models need to consider the time delay between actions and results, linked to soil and surface water sediment phosphorus storage, and interactions with organic carbon and nitrogen.

Adapting phosphorus management

Schoumans et al. underline that changes in phosphorus management are necessary to **improve P use efficiency** in fertilisers and in animal feeds. It is necessary to recover and recycle phosphorus in waste streams, and to limit soil erosion and phosphorus losses which will increase with climate change. The drivers for phosphorus stewardship are geopolitical instability of phosphate rock supplies and the very important environmental impacts of phosphorus losses (even if these losses only represent a small proportion of total phosphorus use). It is shown that to completely close the EU phosphorus it would be necessary to recycle all phosphorus from manure and wastewater. Options are today available to recover P from sewage works, but P recovery from manure is still in its infancy.

Withers et al. outline a strategic framework for phosphorus stewardship: **"5 R" = Re-align P inputs, Reduce P losses, Recycle P in bioresources, Recover P in wastes**, Redefine P in food systems. They examine phosphorus inefficiency in Europe's agriculture and society, and propose a "circular economy blueprint" for phosphorus to deliver a more competitive economy. Developing better knowledge of phosphorus flows and stakeholder dialogue are considered important to address barriers to change and to deliver results from technological and societal innovations.

Phosphorus availability in recycled P products

Stutter presents results for P concentrations, speciation and leaching risks (alongside other element concentrations) in seven **secondary materials suitable as soil P amendments**: Cambi process sludge, manure plus slaughterhouse waste anaerobic digestate, chicken manure, food waste compost, green compost, seaweed and wood biochar. Dry matter P levels varied from 0.02% to 2.1%; with high levels in the very specific Cambi process product (a combined nutrient removal process using high temperatures and pressures, operating on municipal sewage sludge in Scotland) and the manure + slaughterhouse digestate. The other products had <1% phosphorus. The extractability of the phosphorus (indicative of plant availability) was >80% for all the products except the wood biochar (25% only).

Bonvin et al. used isotope labelling methods to assess **plant uptake** (rye grass pot trials) from struvite and "NUF" (nitrified urine fertiliser). The NUF was produced from pure chemical solution (synthetic urine). In an acidic soil (pH 4.5) from Switzerland, plant uptake was comparable to ammonium nitrate (NH_4NO_3) and potassium phosphate (KH_2PO_4) solutions.

Agricultural phosphorus losses

Verheyen et al. assessed **dissolved phosphorus losses** from 3 headwater catchments in Belgium (0.3 – 2.7 km^2) with arable, pasture and forest land cover. Losses of dissolved P were eleven times greater in both of the farmed catchments than from forest. However, during the summer, even for the forest catchments dissolved P at times exceeded environmental thresholds.

Dodjic & Villa showed that high/resolution modelling predicted 72 – 96% of observed **overland flow and soil erosion** features in four arable catchments. The observed features covered small critical source zones representing only 0.4 – 2.6% of the total arable area. This shows that cost-effectiveness of management measures can be optimised by targeting these zones, subject to understanding the connectivity between them.

Messiga et al. analysed relationships between current **soil tested phosphorus levels** and history of phosphorus budget (inputs and offtakes) in fertilised grasslands (France, Switzerland, Finland and Canada). They found a linear relationship above a "deflection" point, but with no clear relationship at low phosphorus budgets. This points towards better identification of fertilisation levels appropriate to maintain grassland productivity whilst limiting phosphorus losses to surface waters.

Lehtoranta et al. looked at phosphorus release from **soil particles eroded from agricultural fields**, concluding that the release of soil-bound P is regulated by labile organic carbon in anaerobic, brackish environment. They suggest that the release of P from eroded soil back to water may vary between oligo- and eutrophic coastal systems and that this difference should be taken into consideration in eutrophication management.

Buffer zones and farm management practices

Collentine et al. assessed different strategies for using riparian **buffer zones** to reduce phosphorus losses, using the FryisSKZ web tool applied to data from the Svärta river agricultural catchment in Sweden. Only a few measures to reduce P losses are subsidized in Sweden to achieve EU Water Framework Directive water quality and Baltic Sea nutrient reduction objectives. Buffer zones along watercourses is the only measure which has been applied widely and is considered to primarily reduce erosion losses of particulate phosphorus. FryisSKZ is a public domain tool which summarises the cost-efficiency of buffer zones along lakes, rivers and ditches for the whole of Sweden, divided into nearly 13 000 sub-catchments. The allocation of buffer zone area as a function of expected cost-effectiveness reduced P-losses by 90% (relative to the no buffers scenario), compared to only a 30% reduction for a uniform 6m buffer zone in all areas, and also reduced programme costs by 32%.

Smith et al. tested different **management practices** at the field scale in the Lake Erie basin. Practices eligible for the USA Farm Bill conservation spending were assessed: no-tillage, rotational tillage (tillage only before planting maize), grassing waterways (buffer zones), and crop rotation (maize – soybean – wheat - oats compared to the standard regional maize – soybean rotation). Results differed for soluble and total phosphorus losses. For example, no-tillage decreased total P losses by nearly 70% but doubled soluble phosphorus losses. Grassed waterways also increased soluble and decreased total P losses. The modified crop rotation however reduced both soluble and total P losses by over 80%. The authors conclude that the Farm Bill measures tested could enable to achieve total phosphorus (TP) water quality goals, but that soluble P (SP) goals would require additional measures.

Phosphorus stewardship perspectives

Li et al. consider **phosphorus management challenges facing China today and perspectives to 2030**. High-grade phosphate rock reserves in China (>30% P_2O_5, reserves 231 million tonnes P, Yi unpublished data) represent only 25 years P supply at 2009 extraction rates. China is currently using phosphate fertiliser inefficiently (only c. 20% of applied P can be taken up by crops in the year of application), whilst agriculture accounts for the main part of phosphorus loads to many Chinese surface waters and eutrophication problems are present in many regions. Nonetheless, 15 – 92% of arable land has soil phosphorus below agronomic optimum levels (the critical fertility level is considered to be 20 mg Olsen P per kg soil for most crops, Li et al. 2011). Increasing concentration of livestock production in South East China is resulting in decreasing efficiency of manure P use in agriculture and P losses to the environment.

The authors recommend wider implementation of the "**Build-Up & Maintenance**" approach, based on soil phosphorus budgets (China National Soil Testing and Fertiliser Recommendation Programme 2005), modified to better exploit the crop / rhizosphere potential (soil – root zone), and the adoption of Good Management Practices to minimise phosphorus losses through soil erosion, runoff and leaching. Phosphorus inputs in animal feeds can be optimised and manure P-recycling developed. They underline the need for increased policy intervention on phosphorus management and financial support to farmers.

Iron sulphate P-removal in ditches

Uusitalo et al. present field testing in fifteen ditches in Finland of a system to dispense ferric sulphate ($Fe_2(SO_4)_3$) to reduce the eutrophication contribution potential of phosphorus-loaded arable ditch waters. The systems **reduced soluble phosphorus in the ditch water by 33% - 95%** (soluble P was on average c. 24% of total P in the ditch waters). The iron phosphate resulting from the ferric dosing had small particle size, and so was carried away from the dispensing systems and did not settle immediately downstream, therefore total phosphorus levels were not reduced. The authors suggest that the iron-reacted phosphorus would be less available for algae, so reducing eutrophication potential. SCOPE editors comment: this reduction might be only temporary if the iron phosphate is later released due to changing water or sediment chemistry or oxygen conditions. Costs were estimated at 14 – 430 Euros/kg soluble phosphorus reacted, with lower costs in ditches with higher soluble phosphorus concentrations. The authors stressed that the method is not a permanent solution, nor a widely applicable one, but may help as a first-aid measure to curb dissolved P loads originating from small critical source areas.

Kleinman et al. compared strategies for **reducing agricultural phosphorus losses in case studies** in the USA, UK, Sweden (within the Baltic Sea Action Plan). In the USA (Lake Eerie, Eucha-Spavinaw and Illinois river catchments) manure spreading limitations have affected cattle farmers negatively, but not chicken producers. In the UK, Northern Ireland and Sweden combinations of voluntary, regulatory and subsidy systems would benefit from a more comprehensive approach to phosphorus management and better data monitoring to support assessment of effectiveness. Iterative application of knowledge, field demonstrations to farmers and dissemination are identified as key to programme success.

AMBIO (Springer) Special Issue: Future agriculture with minimized phosphorus losses to waters, Volume 44, Issue 2 Supplement, March 2015
http://link.springer.com/journal/13280/44/2/suppl/page/1

Issue Editors: Lars Bergström lars.bergstrom@slu.se *Helena Aronsson* helena.aronsson@slu.se *Faruk Djodjic* faruk.djodjic@slu.se *Barbro Ulén* barbro.ulen@slu.se *Swedish University of Agricultural Sciences* http://www.slu.se/en/

Compost soil benefits
Soil restoration and contaminants

The mineral fraction of compost increases topsoil thickness, which can reduce contaminant accumulation or even in some cases lower contaminant levels, according to a recent publication by the German humus association, VHE, and the European Compost Network, ECN.

The authors carried out **desk-top modelling of compost impacts on topsoil thickness and contaminant levels**, based on compost and soil data, taking into account the non-organic (mineral) content of compost (determined by loss on ignition), estimated to be c. 62% dry matter DM in compost. This mineral content includes nutrients (on average 1.4% N, 0.7% P, 1.1% K, % DM) and carbonate (7.6 CaO %DM).

Increase in soil horizon

The mineral nutrients and carbonate content of compost were assumed to not accumulate in soil (take up by plants or dissolving), but **the remainder of the compost mineral content was assumed to accumulate** over the long term, so contributing to an increase in topsoil quantity. This stable mineral fraction also contributes towards soil structure.

The researchers used this basis to calculate the increase in the soil horizon (thickness) that would occur following long term compost application. They estimated that **the upper soil horizon would be increased by 3.6 cm** following regular compost use over 100 years at 10 tonnes DM/ha/year.

Contaminant concentrations

To assess impacts on contaminant concentrations, a typical compost **cadmium concentration** of 0.42 mg Cd / kg DM compost was considered. Due to increasing the depth of the upper soil horizon (i.e. soil build up) the concentration of contaminants from compost would be significantly lower compared with calculations based solely on the application of contaminants on their own. Similarly, at higher background soil contaminant concentrations (initial soil cadmium concentration of 1 mg Cd / kg DM soil), reductions in the soil concentrations of cadmium in the soil are possible due to the application of compost.

Dr Stefanie Siebert, ECN's Executive Director commented: "*This is in important conclusion, as it implies that long term compost applications will not result in ongoing increases in contaminant concentrations. A limit will always be reached, which is due to the diluting effect of the stable fraction. This study has the potential to influence the ongoing revision of the EU Fertilisers Regulation and development of European-wide end-of-waste criteria for compost*"

VHE / ahu study "Calculation of contaminant accumulation in soil due to long term compost application", March 2015
http://www.compostnetwork.info/wordpress/wp-content/uploads/2011/05/150309_Study_VHE_AHU_version_final_copyright.pdf

S. Lazar, S. Höke, ahu Wasser Boden Geomatik AG Germanytranslated by J. Gilbert, M. Kastler, published by European Compost Network and VHE Verbrand der Humus- und Erdenwirtschaft ingo@compostnetwork.info

Manures

Crop P uptake or P loss?

Three different manures were tested as phosphorus sources to crops in 9 month studies in an erosion field test plot in Mediterranean climate conditions.

15 plots, each of $42m^2$ and slope 9% at Castelo Branco, Portugal, were used for the trial, with 5 treatments, each in triplicate, randomised: no phosphorus fertiliser (control), mineral fertiliser, cattle manure, solid fraction of pig slurry, solid fraction of duck slurry. In all cases (except the control) phosphorus was applied at 50 kgP/ha, and in all cases (including the control) nitrogen was also applied at 40 kgN/ha. Ryegrass (*Lolium sp.*) **sown in November and grown for 9 months**

Analysis included: plant phosphorus uptake, plant biomass production, phosphorus in soil water and phosphorus in soil particles (both as lost in runoff water), bioavailable P in soil, and soil P desorption (that is, release of phosphorus from soil samples incubated for 3 months at 25°C after sample collection).

Low phosphorus losses

The experiments showed that **phosphorus losses in runoff water and erosion particles** were around 1% of the applied phosphorus. Erosion particles were very small (diameter < 2mm). Phosphorus uptake by the ryegrass ranged from 5% to 11% of applied phosphorus.

The **duck manure treatment showed the highest plant phosphorus uptake and plant biomass production**, and a significant increase in soil bioavailable phosphorus. These effects are considered by the authors to the consequence of calcium phosphates present in this manure, originating in animal feed supplements fed to the ducks.

Soil P desorption increased rapidly after fertiliser or manure application (within 2 weeks), showing that all the treatments had significant potential to release phosphorus from soil after crop harvest, or from soil particles lost through erosion, and so to potentially contribute to eutrophication.

C. Horta, P. Ribeiro, M. Batista, J-P. Carneiro., A. Duarte, Instituto Politécnico de Castelo Branco, Escola Superior Agrária, CERNAS, 6001-909 Castelo Branco, Portugal, carmoh@ipcb.pt
M. Roboredo, Universidade de Trás-os-Montes e Alto Douro, 5001-801Vila Real, Portugal. J. Torrent, Universidad de Córdoba, 14071 Córdoba, Spain. A. Sharpley, University of Arkansas, Dep. of Crop, Soil and Environ. Sci., Fayetteville, AR 72701

"Assessment of Bioavailability of P from Animal Manures", SPS 2014
http://sps2014.cirad.fr/content/download/4422/32460/version/1/file/Online_CHetal_Psummit2014.pdf *and "Animal manures applied to soil: Phosphorus bioavailability, losses to water and erosion"*
http://repositorio.ipcb.pt/bitstream/10400.11/2586/1/CH%20et%20al_Montpellier2014.pdf

Soil phosphorus

Appropriate soil P-tests for different soils/crops

Soil P testing is the starting point for correcting the phosphorus status of soils, and so applying fertiliser to crop needs whilst limiting risk of environmental losses. Numerous soil P testing methods, exist but their variable performance to predict plant response to applied P is well documented. The authors showed how two different types of test performed differently for rice and maize in tropical soils.

The rate of short-term P uptake by plants generally depends on the amount of P present in the soil solution (intensity), rather than the P present on the solid phase (quantity) and the P buffering capacity (PBC) of the soil. The PBC is the ability of the soil to resist changes in solution concentration, which is the link between intensity and quantity. Conventional soil P tests based on extraction in general relate to the P quantity and may extract P from pools not directly available for plant uptake. In contrast, the relatively new DGT (Diffusive Gradients in Thin films) technique mimics the physic-chemical uptake of P by plant root. As during plant uptake, the continuous removal of P from solution by the DGT lowers the concentration of P in the soil solution, which in turns promotes resupply from the solid phase (depending on quantity and PBC).

Phosphorus deficiency is an important limitation for crop production in tropical soils due to the high P fixing capacity of the weathered, acid soils. The aim of this work was to test the efficacy of the DGT method, relative to conventional soil P tests, to predict the growth response (yield) of two plant species (rice and maize) on different tropical soils.

In a glasshouse, maize (*Zea mays*) was grown for 4 weeks and rice (*Oryza sativa* L. Sebota 70 variety) for 7 weeks on 9 soils characterized by a low available P, but contrasting PBC (collected from Madagascar, Kenya and Vietnam). To each soil, 10-14 different phosphorus fertiliser doses (from deficient to adequate) were applied. Per pot, three seeds of maize or rice were planted and thinned to one seedling after 5 days. Plant above-ground dry matter and root specific surface area were analysed at the end of the experiment. The experiment was carried out in triplicate or duplicate.

DGT good at predicting the response to P fertilizer for maize

For maize, the results show that the DGT method and the $CaCl_2$ extractions (intensity measures) explained the growth response to applied P among the 9 different soils better than conventional test methods Olsen, Colwell, Bray-1, Mechlich-3, ammonium oxalate and resin extractions (quantity measures). Also, the critical DGT P concentration (to obtain 80 % of the maximum yield) was similar for all soil types and independent of soil properties, even of the PBC. For the conventional methods, the range of critical soil P test values is much larger, meaning that calibration would be needed for each soil separately before predictions of maize response to P fertilizer can be made.

DGT poorer predictor when plants are able to mobilize P from otherwise unavailable pools

In contrast with observations for maize, relative yields of rice were best predicted by the conventional soil P tests (quantity measures). The authors observed that **rice plants have a larger relative root surface and a lower P demand**, which makes them more P efficient than maize. This suggests, but not proves, that P availability for rice does not only depend on diffusion of P in soil as measured by DGT. Reactions in the rhizosphere (e.g root exudates mobilizing P), unaccounted for by DGT, might contribute to P uptake.

Selecting the appropriate soil P test for your soil-crop system

To conclude, results show that **DGT is a robust technique to predict the response of maize to applied P**. Similar results were observed for wheat, barley and tomato (Mason et al. 2010, McBeath et al. 2007, Menzies et al. 2005, Tandy et al. 2011). **However, for the tested genotype of upland rice, the DGT method is not the soil P test of choice**. The DGT method will not be able to account for mobilization of P from otherwise unavailable pools and thus DGT should not be used to predict yields for plant species or varieties able to do so. Nevertheless, 2D mapping based on DGT might be able visualize mobilization of P close to plant roots (Santner et al. 2012).

Six L, Smolders E, Merckx R. 2013. The performance of DGT versus conventional soil phosphorus tests in tropical soils—maize and rice responses to P application. Plant and Soil, 366, 49–66.* http://link.springer.com/article/10.1007/s11104-012-1375-4. *Department of Earth and Environmental Sciences, Division of Soil*

*and Water Management, KU Leuven, Kasteelpark Arenberg 20, 3001 Heverlee, Belgium. *six.laetitia@gmail.com*

See also:

Six L., Smolders E., Merckx, R. 2012. The performance of DGT versus conventional soil phosphorus tests in tropical soils—an isotope dilution study. Plant and soil, 359, 267-279.
http://link.springer.com/article/10.1007/s11104-012-1192-9#page-1

Mason S., McNeill A., McLaughlin MJ, Zhang H. 2010. Prediction of wheat response to an application of phosphorus under field conditions using diffusive gradients in thin-films (DGT) and extraction methods. Plant and Soil, 337, 243-258.

Environmental change

How soil acidification impacts phosphorus

A study using the acid gradient strip at the Rothamsted 150 year soil testing site gives indications about variations in forms of phosphorus present in soil as a result of acidification.

Due to liming practices, soil acidity is currently not a key problem in European agricultural soils; nevertheless it is a major concern to the productivity of agricultural ecosystems worldwide.

The unique **acid gradient strip** on a soil fertilization / exhaustion long-term experiment (Hoosfield) at **Rothamsted Research, Harpenden, UK** offers a singular opportunity to study a wide pH gradient in a single soil type that has been under uniform land use for 150 years (barley cultivation). The soil strip studied is c 2m wide and 200m long, with a pH gradient from 3.7 to 7.8. The authors analysed a range of soil parameters, in particular carbon, nitrogen and different organic forms of phosphorus present.

The soil was originally acidic, but pH was increased by addition of chalk in the nineteenth century. Since then, chalk has been applied but not to the whole field, resulting in some of the strip returning to acidic conditions.

Total soil phosphorus and total soil nitrogen vary little with the soil pH, at around 400 mgP/kg and 1gN/kg. Organic carbon levels in soil also varied little with pH, except below pH 4.2. Organic carbon levels were however negatively correlated to organic phosphorus levels.

Different phosphorus forms

Among the main findings, the authors reported that **inositol phosphates, DNA and phosphonates were preferentially accumulated under acidic conditions**. Possible causes to the observed behaviour were: a) metal chelation of inorganic phosphorus compounds; b) chemical interactions between organic phosphorus compounds and clay surfaces; c) pH dependency of soil phosphatase enzymes; d) Phosphatases inactivation by sorption; e) differential abundance of organisms that synthesize phosphatases.

The **acid pHs strongly limited barley growth and therefore the P extraction and cycling**; therefore the observed results are not just a function of soil chemical factors, but were most likely were also a function of the complex interactions and mass balances associated with the different plant growth and survival across the studied acid strip.

This study brings new insights about the **effect of long term soil acidification on the abundance of different forms of soil phosphorus**. The issues involved are transversal to soil P fertilizer application and management strategies in agricultural soils.

"Isolating the influence of pH on the amounts and forms of soil organic phosphorus", European Journal of Soil Science, April 2013, 64, 249–259
http://onlinelibrary.wiley.com/doi/10.1111/ejss.12026/abstract

B. Turner, Smithsonian Tropical Research Institute, Apartado 0843-03092, Balboa, Ancon, Republic of Panama & M. Blackwell, Rothamsted Research, North Wyke, Okehampton, Devon EX20 2SB, UK TurnerBL@si.edu

Blog

http://www.phosphorusplatform.eu/blog.html

Nutrient Platforms

Europe: ***www.phosphorusplatform.eu***

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

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

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

North America Partnership on Phosphorus Sustainability NAPPS ***https://sustainablep.asu.edu***

SYMPHOS 2015
Sustainable agriculture and foods

18th to 20th of May 2015, Marrakesh

SYMPHOS : International Symposium on Innovation and Technology in the Phosphate Industry. Organised by the OCP Group, this technological and scientific event focuses on innovation, technology and current trends in processes to upgrade phosphates and derivatives, as well as research and development prospects in the phosphate sector.

Following the success of the two previous events held in 2011 and 2013, Symphos 2015 will be the place to be for major international players in the phosphates and phosphate derivatives industry. A wide range of scientific subjects, phosphate innovations and the use of advanced technology for sustainable agriculture will be discussed during Symphos 2015. Renowned international experts will take part of this event to contribute to, and to benefit from its various programmes. It is also an opportunity for these experts to share the results of their researches, and of their different projects. There will be also debate sessions organised by a high-level international and technical committee.

Symphos will be also open to biotechnology, fertilizers of tomorrow and to "slow & - controlled releases". As well as a forum to share ideas and to discuss sustainable development topics including water & energy management, industry-related challenges, and the development of innovative processes and sustainable agriculture.

Sustainable agriculture

Through the organisation of this event for the third time, OCP, the world leader of the phosphate industry, reaffirms its commitment to the promotion of technical and industrial innovation for sustainable agriculture.

The International Symposium on Innovation and Technology in the Phosphate Industry (SYMPHOS) is a once every 2 years event and a global benchmark dedicated to key players in the phosphates and phosphate derivatives industry. This technological and scientific event is a platform for sharing ideas on innovation, technology, current trends in terms of processes for upgrading phosphates and derivatives, research, and development prospects for the phosphate sector. Initiated in 2011 and repeated in 2013, SYMPHOS has been attended by over 1,900 industrial stakeholders, manufacturers, equipment suppliers and researchers from 43 countries, who come together to share their experiences, discover the latest innovations and discuss their thoughts on the future of the phosphate industry. Held every two years, this committee works to enrich and diversify the event's scientific and technical content in connection with the phosphate industry.

OCP: world leader

The OCP Group is a global leader in the phosphates and derivatives market, including fertilisers, and has been a major player on the international market since 1920. The Group has exclusive access to Morocco's phosphate reserves, the largest reserves in the world according to the USGS. The Group is also a "leading low-cost" producer of phosphate and has become a key player throughout the entire phosphate value chain. The Group employs nearly 23,000 staff and achieved a turnover of US$5.5 billion in 2013. *http://www.ocpgroup.ma/*

Contacts: Aziz Moqadem. Landline: +212 522 924-436. a.moqadem@ocpgroup.ma
Khalid Zahoui. Landline: +212 522 924-730 khalid.zahoui@ocpgroup.ma
www.symphos.com

Upcoming events

- 12-17 April 2015, Vienna, Austria, **European Geosciences Union: P soil biochemistry, P across boundaries, P-recovery** *www.egu2015.eu*
- 16-17 April, Rennes, France, **BioRefine meeting on organic fertilisers, composts and digestates** *http://www.aile.asso.fr/index.php/rencontres-franco-belges-entre-regions-productrices-de-fertilisants-issus-delevage*
- 17-18 April, Axel, Netherlands, **ManureEcoMine** pilot plant visit and presentation *www.manureecomine.eu*
- 22 April, Canberra Australia & Copenhagen Denmark, OECD, FE[2]W, **Feeding more than nine billion by 2050 – challenges and opportunities** *https://crawford.anu.edu.au/sites/default/files/events/attachments/2015-03/draft_program_canberra_-_feeding_more_than_9_billion_by_2050_0.pdf*
- 29th April, London 9h30 - 16h30, Royal Society of Chemistry: **UK Nutrient Platform** meeting of stakeholders *http://www.phosphorusplatform.eu/images/UK_Nutrient_Platform_29-4-2015_save-the-date.pdf*
- 1 May – 31 Oct. **Expo2015** Feeding the planet, energy for life, Milano *http://en.expo2015.org/*
- 3-7 May 2015, Barcelona, SETAC Livestock Environmental Assessment and Performance (LEAP) Partnership session, **challenges for global modelling of N & P in agriculture supply chains** *http://barcelona.setac.eu/home/?contentid=767&pr_id=766*
- 6-8 May, Kajaszo, Hungary, Brdo pri Lukovici, Slovenia, Budapest, Hungary, **REFERTIL Agri Workshop** and open days *http://www.refertil.info/events*
- 26-29 May, Erfurt, Germany, ReUseWaste, FertiPlus, IneMad and Biorefine meetings and FIRe workshop: **Innovative strategies to improve the recycling of energy, nutrients and organic matter from waste materials** *http://www.reusewaste.eu/events/register/*
- 18-20 May 2015, Marrakesh, Morocco: **SYMPHOS** *www.symphos.com*
- 18-21 May, Gdansk, Poland, **IWA Nutrient Removal and Recovery Conferences** *http://www.iwahq.org/2jw/events/iwa-events/2015/nrr2015.html*
- 18-22 May 2015, Washington DC, **Phosphorus Research Coordination Network (P-RCN)** *https://sustainablep.asu.edu/*
- 19 May, Washington DC, **NAPPs stakeholder event**. Programme at *https://sustainablep.asu.edu/events*
- 3-5 June 2015, York, England, **RBB-11 11th International Conference on Renewable Resources & Biorefineries** *http://www.rrbconference.com/*
- 6 June 2015, Leeds, England, **Food Waste Reduction** (AqueEnviro) *http://www.aquaenviro.co.uk/view-product/A-New-Opportunity-for-Food-Waste-Reduction*
- 15-16 June, Skellefteå, Sweden, **LIFE+ conference Resource Recovery and Water Protection** *http://www.outotec.com/en/About-us/Calendar-of-events/Life-Conference-Resource-recovery-and-water-protection/*
- 17-19 June, Prague: **ARGUS FMB East Europe Fertiliser Conference** *http://www.argusmedia.com/Events/Past-Argus-Events/Europe/2014/Fert-East-Euro/Home*
- 24-25 June, Stuttgart, Germany, P-recovery **P-ROC pilot plant** visit & conference (in German) *http://www.prueck-dwa-bw.de/programm_und_vortraege/*
- 24 June, Brussels, ECN (European Compost Network) policy workshop: compost & digestate in the Circular Economy *www.compostnetwork.info*
- 19-22 August, Tampere, Finland: **Global Dry Toilet Conference** *www.huussi.net/en*
- 30 Aug – 2 Sept, Ghent, Belgium, Bridging towards the chemical industry1[st] **IWA Resource Recovery Conference** *http://www.iwarr2015.org/*
- 17-18 September 2015 Toledo, Castilla-La Mancha Gastronomy School, Spain **REFERTIL International Conference** *http://www.refertil.info*
- 1-2 October, Vienna University of Technology, "**Mining the Technosphere**: Potentials and Challenges, Drivers and Barriers" *helmut.rechberger@tuwien.ac.at*
- 11-14 October 2015, Ithaca, New York, USA, 2[nd] International Conference on **Global Food Security** *www.globalfoodsecurityconference.com*
- 18-19 November, Minneapolis, **SERA-17** promoting promote innovative solutions to minimize phosphorus losses from agriculture *http://www.cvent.com/events/2015-sera-17-meeting/event-summary-4eb969f0be224a25821b4372c54c34a5.aspx*
- 2-4 Dec 2015, Ghent, Belgium, **ManuResource II** (manure valorisation) *http://www.manuresource2015.org/*
- 12-16 Sept 2016 Rostock, Germany, **8[th] International Phosphorus Workshop (IPW8),** Phosphorus 2020 – Challenge for synthesis agriculture & ecosystems *http://www.wissenschaftscampus-rostock.de/*