European Sustainable Phosphorus Platform

SCOPE NEWSLETTER

Sustainable phosphorus policies

Germany
German Phosphorus Platform launched

The German Phosphorus Platform (DPP) was officially launched in Berlin with >60 participants including ministries, business, technology companies, scientists.

Policy
German Federal Council presses for P-stewardship

The Bundesrat has voted a motion calling for national and EU policies on phosphorus, including agricultural reuse and recycling from sewage sludge.

In depth report
Sustainable Phosphorus Use in Europe

The European Commission 7th Science for Environment Policy Report looks at scientific knowledge and policy development on phosphorus stewardship.

Canada
Discussions on P management framework

Discussions for a new framework for phosphorus management in Canada.

Composts and digestates
EU End-of-Waste and Ecolabel criteria

The EU is currently developing European End-of-Waste EoW criteria for composts and digestates as well as revising the Ecolabel criteria for Soil Improvers and Growing Media.

Phosphorus uses and flows

Phosphorus in food
European Food Safety Authority (EFSA)

EFSA has published two documents assessing available information concerning health effects of diet P levels.

Phosphorus recycling

Sweden
P flows, agriculture, cadmium and P-recycling

Thesis assesses P flows, fertiliser efficiencies of iron and aluminium phosphates, P-recycling, cadmium contamination and life cycle analysis (LCA).

Thames Water
UK's first full-scale sewage nutrient recovery unit

The Ostara nutrient recovery facility at Slough Sewage Works will produce 150 tonnes/year of Crystal Green® fertiliser.

Ekobalans
Struvite P-recovery operational in Helsingborg

Pilot P-recovery plant producing struvite, combined with potassium and waste recovered nitrogen to produce a balanced nutrient fertiliser.

Florida Wastewater Treatment Plants
Economic evaluation of struvite recovery

Options for mitigating deposit problems downstream of anaerobic digestion shows benefits of struvite recovery.

Ideas and input

Phosphorus Challenge
ipad App now available in iTunes Store

Nutrient management ideas challenge

EU consultation on phosphorus use

http://ec.europa.eu/environment/consultations/phosphorus_en.htm

(until 1st December 2013)

Agenda: dates 2013-2014

The partners of the European Sustainable Phosphorus Platform

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Sustainable phosphorus policies

Germany

German Phosphorus Platform launched

The German Phosphorus Platform (Deutsche Phosphor-Plattform DPP) was officially launched in Berlin on 15th November 2013. Prof. Rudolf Stauber (Fraunhofer IWKS) opened the meeting of more than 60 participants from 8 countries (AT, BE, CH, DE, DK, FR, NL, ZA) representing different sectors of science, policy, waste and water management, industry, technology and innovation.

The German Phosphorus Platform establishment follows insistent calls from various frontrunners, according to a **political agenda fixed last June at the German federal Ministers of the Environment** 80th conference (UMK) in Oberhof (Thuringia). The Ministers of the federal government and the 16 federal states agreed to the establishment of a national Phosphorus Platform and welcomed the initiative of Fraunhofer IWKS in Alzenau, strongly supported by the Bavarian ministry of the Environment, to host and administer the platform.

So, what a remarkable coincidence and emphasis of importance, to officially launch the German Phosphorus Platform at the same date, when the following 81th UMK was held in city of Erfurt.

An opening message, on behalf of the **Federal Minister of the Environment**, Dr. Peter Altmaier, was delivered by Prof. Gerhard Sextl, head of Fraunhofer ISC. Dr. Altmaier endorsed his patronage for the platform and recalled the importance of the limited and vital resource phosphorus. By establishing the German Phosphorus Platform, not only a political resolution has been executed, but also **an important milestone towards resource efficient** tackling the challenges in the case of phosphorus for the whole society has been set.

Just having arrived from the 81th UMK in Erfurt, **Bavarian Minister of Environment**, Dr. Marcel Huber, emphasized the necessity for political reaction to the "Phosphorus Challenge", and that the establishment of the German Phosphorus Platform is an important milestone to protect natural resources. The recovery of phosphorus is an **important issue for the Bavarian circular economy** and Bavaria intends to develop a phosphorus stewardship strategy. Dr. Huber invites the German federal government to foster the recovery and recycling of phosphorus by sending out clear signals like a reliable quota for P recovery from relevant waste streams and reasonable funding for transforming knowledge into innovation. Finally, he endorsed support for the new Platform's activities and invited all stakeholders to participate and wished all the best for a successful cooperation and business development.

Dr. Lorenz Kaiser, representing the Fraunhofer managing board, explained that the **hosting of the Platform by Fraunhofer IWKS** corresponds to the competence and the team in Alzenau. This was underlined by the two scientific representatives of Fraunhofer IWKS directly responsible for the platform's activities and administration. Prof. Armin Reller (IWKS) gave a detailed insight to the phosphorus topic as a global challenge and its strategic importance.

Prof. Stefan Gäth, appointed head of the German Phosphorus Platform, encouraged all interested stakeholders to participate, collaborate and innovate. The credo of the platform is not just to be an institution, it has to be recognized as everyone's platform. The acronym "DPP" stands not only for Deutsche, but also for Deine (your) Phosphor-Plattform.

The Objectives of the German Phosphorus Platform are:

- **Bring together** all interested stakeholders from industry, public and private organizations, knowledge institutions
- **Link knowledge and experience** for more efficient use of phosphorus, as well as recovery and supply of secondary phosphorus resources
- Development, exchange and **coordination of projects and concepts** to optimize recycling
- Establish an interactive information and monitoring **database of phosphorus flows**, to increase transparency and quality of data on P uses and losses along the value chain
- Address sectors and technologies to improve communication and **exchange of knowledge** between science, industry and policy
- **Raise public and political awareness** about the Phosphorus Challenge to foster a more efficient use of the vital resource phosphorus

Dr. Marcel Huber (Bavarian Minister the for Environment), Prof. Dr. Gerhard Sextl (Head Fraunhofer ISC), Prof. Dr. Stefan Gäth (Head of the German Phosporus Platform DPP)

The President of the European Sustainable Phosphorus Platform (ESPP), Arnoud Passenier, welcomed the establishment of **the third national phosphorus related platform in Europe**. He emphasized the importance of multi-stakeholder cooperation (triple helix: participate, collaborate, innovate) and the **involvement of companies wishing to innovate, and to invest in new sustainable technologies and markets**. Governmental and knowledge agencies can help to create the enabling environment for successful business cases which are a prerequisite to develop a market for the recycled products and to push our economies towards sustainability and resource efficiency – the circular economy.

To seal the willingness for close cooperation, representatives of **the three national platforms signed a Memorandum of Understanding** (MoU): Wouter de Buck (Netherlands Nutrient Platform), Dirk Halet (Vlaams Nutriëntenplatform) and Prof. Stefan Gäth (German Phosphorus Platform DPP). In this MoU the three platforms commit themselves to create cross-national business cases. The text is on the European Sustainable Phosphorus Platform website.

The Joint Declaration establishing the German Phosphorus Platform, signed by participants, can be downloaded at *www.deutsche-phosphor-plattform.de* Special thanks are also due to the following persons not mentioned above, whose contribution enabled the DPP launch: Michael Spitznagel (Bavarian Ministry of the Environment), Dr. Walter Schindler (Fraunhofer IWKS), Ms. Jasmin Raslan (Fraunhofer IWKS), Dr. Christian Kabbe (Berlin Centre of Competence for Water and coordinator of P-REX),

German Phosphorus Platform (DPP):
www.deutsche-phosphor-plattform.de
Contact: Prof. Stefan Gäth, head of the German Phosphorus Platform stefan.gaeth@isc.fraunhofer.de

Policy

German Federal Council presses for phosphorus stewardship

In response to the European Commission "consultation on sustainable use of phosphorus", the German Federal Council (Bundesrat) voted on 20th September 2013 a response welcoming European action on phosphorus, calling for European policies on phosphorus recycling, and instructing Germany's federal administration to take measures to ensure reuse of phosphorus in agriculture and recycling of phosphorus from sewage sludge and sludge incineration ashes.

The resolution emphasises that phosphorus is essential for life and for modern agriculture, and therefore that efficient use and minimisation of phosphorus losses are important. The use of mineral phosphate resources should avoid environmental risks, and in particular EU fertiliser regulation should fix cadmium limits and assess possible limits for uranium. **Phosphate recycling to agricultural land must also avoid environmental risks**.

The Federal Council calls on Europe to launch strong measures to develop phosphorus recovery from both waste water and other wastes, on the basis of a European phosphorus recycling strategy.

The resolution voted specifically **instructs the German federal administration to develop measures to ensure the reuse of phosphorus in agriculture and the recovery and recycling of phosphorus** from sewage sludge and sewage sludge incineration ashes.

Possible content of a P-recycling ordinance

Claus-Gerhard Bergs of the German Federal Environment Ministry presented at the VDI (Association of German Engineers) conference, 6-7 November 2013, possible ideas for measures which could be included in a "**Phosphate recovery decree**". This is both in response to the German Federal Council resolution, and is part of ongoing German development of phosphorus stewardship policy, within for example the **ProgRess national resources efficiency programme**.

A P-recycling decree could require:

- **Nutrient recovery in all sewage works where biosolids are not acceptable for use as fertiliser on land** according to the German sewage sludge ordinance specifications
- Nutrient recovery in all sewage works **where the sludge contains more than 12gP/kg dry matter** (c. 30 g P_2O_5) and **where the sludge is going to incineration**
- Nutrient recovery from all sewage sludge ash from **mono-incineration** (that is, incineration of sewage sludge only, not mixed with other waste)
- **Sewage sludges should not be mixed with other wastes**, except with wastes having a high phosphorus content (eg. animal wastes)
- **Delay for implementation**: at least ten years
- Rules to be implemented by **decree**

Dr Bergs noted that **the proportion of phosphorus being recycled to land in Germany is currently around 50%, through agricultural use of sewage biosolids and other application on soil**, although it is not certain that phosphorus in sewage sludges is always plant available. This proportion will fall from 2015, when new German requirements concerning heavy metal limits in biosolids used in agriculture will come into force (ordinance for fertilizer).

He also presented **proposals to further tighten German regulations on sewage sludge quality**, covering both heavy metals and organic contaminants (PCB, dioxin equivalent, AOX, BaP, PFC). It is proposed, for example to limit dioxins to 30 ng/kgTS, which is the level already required under German fertiliser regulations (compared to 100 ng under the current German sewage sludge decree). The objective is to enable safe reuse of sewage biosolids and to ensure public confidence.

"News of the German sewage sludge decree and proposals for a phosphorus recycling decree", Dr C-G. Bergs, BMU (German Federal Environment Ministry), presentation at the VDI (Verein Deutscher Ingenieure- Association of German Engineers) technical conference on sewage sludge treatment (Dortmund, Germany, 6th - 7th November 2013).

In depth report

Sustainable Phosphorus Use in Europe

The European Commission's 7th Science for Environment Policy 'In-depth Report' addresses "Sustainable Phosphorus Use". The EU is estimated to waste 1.25 million tonnes of phosphorus annually, resulting in considerable negative environmental impacts through eutrophication.

At the same time, although the magnitude of phosphorus rock reserves is uncertain, geopolitical concentration of supply is expected.

The challenges of phosphorus stewardship and the need to provide support to policy decision makers are today recognised by the scientific community: > **164 000 scientific publications concerning phosphorus have been published since 1970**, with a number of recent special issues in journals, see below.

However, **only recently has science begun to address the question of phosphorus as a non-renewable resource**, previous publications concentrated on phosphorus as a useful nutrient or as a problematic pollutant.

Scientific journals special issues on phosphorus:

- Phosphorus biotechnology (**Current Opinion in biotechnology**, 2012), see SCOPE Newsletter n° 98
- **Procedia Engineering** (SYMPHOS 2012, phosphate industry technology 2012) *http://www.sciencedirect.com/science/journal/18777058/46/supp/C*
- **Plant and Soil** (12/2011), see SCOPE Newsletter n° 87
- **Chemosphere** (Phosphorus Cycle, 8/2011), see SCOPE Newsletter n° 83
- **Science of the Total Environment** (landscape sources of nutrients, 2005), see SCOPE Newsletter n° 62

The objective of this Science for Environment Policy "In-depth Report" is to give an overview of existing research from the perspectives of a **DPSIR framework (Drives, Pressures, State, Impacts, Responses**), including possible policy interventions, and to highlight research gaps. The contents and views included in this report are based on independent, peer-reviewed research and do not necessarily reflect the position of the European Commission.

Drivers of phosphorus demand

An overarching driver of phosphorus consumption, the report suggests, is the **increase in world population**. This is accompanied by a worldwide trend towards **concentration of population in urban areas**, and particularly in mega-cities. This results in a corresponding geographical concentration of phosphorus waste, with urine being the largest single source of phosphorus in cities and representing a "P hot spot".

Intensification of farming is also identified as important, as geographical concentration of livestock production results in manure phosphorus no longer being recycled back to farmland. It is estimated that only around 50% of the manure from the world's 65 billion farm animals is today returned to fields (Gilbert, 2009)

Increasing meat content in global diets also drive increasing phosphorus consumption in fertilisers and animal feeds. Vegetarian diets contain around 0.8 gP/day compared to around 1.6 gP/day for meat eaters (Cordell 2009).

The possible **development of bioenergy crops** could also accentuate phosphorus demand, in particular palm oil, soya beans, cereals, sugar cane and maize.

Overall, in Western Europe, mineral phosphate fertiliser use is now stabilised and not increasing. However, **consumption of fertiliser in developing countries is increasing** and is expected to continue to do so for coming decades.

Geographical distribution of phosphate rock reserves

Europe is largely dependent on imported phosphorus for food production, and only Finland has some phosphate rock reserves. Worldwide, 85-90% of phosphate reserves are located in just five countries: Morocco, China, Algeria, Syria and Jordan (Jasinki, 2013). The report suggests that this uneven distribution of resources could lead to **volatility of prices**. This may be accentuated by vertical integration, as mining countries and companies bring rock processing and fertiliser and chemical production close to the mine.

The report also anticipates that **the quality of mined phosphate rock will decrease over time**, as the best reserves are consumed, resulting in lower contents of phosphorus and higher contents of contaminants such as cadmium, and so higher processing costs. Energy consumption, greenhouse gas emissions and waste generation from phosphate mining and processing are discussed. The discussion of levels of phosphorus reserves and resources is developed. This is detailed in this Newsletter n° 98.

Phosphorus flows

The report presents **phosphorus flow data** for the world level (global flows), from national studies in Sweden (see this SCOPE Newsletter), Netherlands (SCOPE 97), UK (food production and consumption, Cooper & Carliell-Marquet), Finland (energy system and forestry), and Japan (SCOPE 83), from French regions (SCOPE 93), and cities in China (SCOPE 83) and Sweden (SCOPE 93). Preliminary results of a phosphorus flow assessment for the European Union (EU27, 2005) are presented.

The current estimated figures for EU27 (van Dijk *et al.*, in preparation) show an **import into the EU of 2.7 million tonnes P/year**, of which 56% in mineral fertiliser, 24% in imported crops and food, 16% in imported animal feed and additives and 5% in non-

food materials. Within the system, some 930 000 tP go to human consumption. Losses from soils by leaching and runoff are estimated at c. 160 000 tP/year. Exports total only 590 000 tP, indicating a **total net annual import into the EU of over 2 millions tonnes P/year**.

Phosphorus stewardship

A range of **different possible responses** to improve phosphorus sustainability are summarised, including reducing mining losses, addressing agricultural phosphorus efficiency and efficiency in the food chain, recovery and reuse or recycling of phosphorus from waste streams.

In agriculture, efficiency of phosphorus use can be improved and phosphorus losses to surface waters reduced by a number of measures:

- **Better use of phosphorus on land**: avoiding excess phosphorus loadings, e.g. from manures, and ensuring that phosphorus application is adapted to crop productivity potential
- **Reducing soil erosion**, because phosphorus is lost to surface waters when soil particles are lost through erosion. Possible measures include reduced tillage, returning crop residues to land, using buffers of vegetation to hold run-off, management of drainage, using wetlands to capture runoff
- **Enhancing soil quality or ensuring appropriate soil moisture**, which enable increased phosphorus uptake by plants
- **Optimising use of both inorganic and organic fertilisers**, including appropriate dosing, timing, placement
- **Improving crop phosphorus uptake** through technical progress such as crop selection (cultivating crops which are more phosphorus efficient), crop breeding, symbiosis with root and soil fungi, growing crops with low levels of phytic acid (so that more of the phosphorus in the plant is available to humans and non-ruminant animals)
- **Reducing phosphorus levels in livestock diets**, by adjusting more closely to needs (as a function of growth phases, for example) or by using phytase enzymes to improve the availability and uptake of phosphorus in feeds
- **Better use of manures**: animal manures could supply up to 50% of agricultural phosphorus needs in Western Europe (Smil, 2000), but only if the manure reaches crop growing fields. This implies either moving back from today's increasingly intensive and geographically concentrated livestock production, or developing systems to process manures so that they can be stored and transported

Wastage and loss of food along the supply chain and in the home can also reduce phosphorus consumption, proportional to the upstream phosphorus use necessary to produce the food. Where waste is inevitable, the phosphorus can be recovered and reused.

Closing the loop

The report identifies sewage (mixed or source separated), animal manure, crop residues, animal carcasses and slaughterhouse waste and food waste as offering **significant potential for phosphorus recovery and recycling**. Human sewage (urine and faeces) represents around 14% of lost phosphorus worldwide, and corresponds to c. 22% of global annual phosphorus demand (Milhelcic *et al.*, 2011).

In the EU27 (2010) around 40% of sewage biosolids are currently applied to land (so that the phosphorus is recycled, subject to appropriate spreading management), 30% incinerated, and the remaining 30% either goes to landfill or other destinations (van Dijk *et al.*, 2013).

A range of **phosphorus recovery and recycling options** are summarised: small-scale decentralised (ecological sanitation), biological uptake, chemical precipitation, adsorption to different materials such as industrial or food production by-products, ion exchange, recovery of phosphorus from biosolids incineration ashes, wastewater fed aquaculture.

It is underlined that **no single approach will be appropriate and that an integrated response is needed**, depending on local situations, and addressing all areas of phosphorus stewardship coherently.

The authors conclude that the market price of phosphorus alone is unlikely to drive phosphorus stewardship or recycling, and that economic and policy tools need to be developed to ensure that costs of environmental impacts (such as eutrophication) are taken into account and penalise inappropriate phosphorus use.

It is important that a stable policy framework is defined so that operators can invest in phosphorus stewardship with confidence, based on regulatory

framework or incentives which will be stable over the lifetime of investments.

European Commission Science for Environment Policy "In-depth Report: Sustainable Phosphorus Use", Issue 7, October 2013
http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR7.pdf#

Previous phosphorus related "Science for Environment Policy" news alerts:

How much phosphorus pollution makes lakes unsafe for recreation?
http://ec.europa.eu/environment/integration/research/newsalert/pdf/333na3.pdf

More dynamic indicators needed to measure phosphorus's availability
http://ec.europa.eu/environment/integration/research/newsalert/pdf/323na1.pdf

Different recycling approaches may be needed for urban phosphorus
http://ec.europa.eu/environment/integration/research/newsalert/pdf/319na3.pdf

Canada

Discussions on phosphorus management framework

At a webinar on 18th March 2013, the Canadian Council of Ministers of the Environment in collaboration with agricultural organizations, hosted a webinar of Canadian and world experts to discuss a new framework for phosphorus management in Canada. Some 174 participants included municipalities, provinces, federal agencies, academics and companies.

The aim of the webinar was to:

- **raise awareness** of need for circular phosphorus management as a key policy driver to those managing phosphorous;
- determine **key areas for further work and collaboration** for governments, academia and industry to move forward in a co-ordinated manner for phosphorus management; and
- identify **key strategic actions** required to move forward on phosphorous recovery, recycling and conservation to ensure management of phosphorous for sustainable food production.

Experts in the various facets of phosphorus management provided an **overview of the state of knowledge** in various areas, including: resource supply, nutrient management- food security- energy linkage, nutrient recycling and recovery from solid bio-wastes, manures and wastewater, nutrient markets, innovative technologies and nutrient use efficiency:

Phosphorus Challenge: Don Mavinic, University of British Columbia, presented the phosphorus challenge. Phosphorus is essential for life and non-substitutable: the human body contains around 1 ½ kg of phosphorus. P is crucial for the world's food supply, but 80% of P mined from phosphate rock never reaches consumed human food. P losses to the environment cause eutrophication problems (e.g. Lake Winnipeg). World phosphate rock reserves are highly concentrated in Morocco and China, posing issues of geopolitical dependency. Struvite (magnesium ammonium phosphate) precipitation is a solution to recover and recycle phosphorus

Sustainable upcycling: **Anthony Boone, Ostara**, presented Ostara's Pearl® process for phosphorus recovery in sewage works, as struvite. Struvite is produced, an environmentally-friendly fertiliser which releases phosphorus slowly according to crop needs. Advantages for sewage works include improved operating reliability and nutrient removal performance (meeting discharge limits) and reduced P content in biosolids.

Supply and demand for phosphorus: **Tom Bruulsema, IPNI (International Plant Nutrition Institute)** emphasized that phosphorus is a non-renewable, non-substitutable resource. Although world demand has increased by a factor of 4x over the last 60 years and is expected to continue to increase in coming decades, reserves of phosphate rock are expected to last another 100 – 400 years. Different regions in Canada show different phosphorus status in soils and have different phosphorus requirements that reflect livestock and crop selection and productivity, climatic influences, historical and future demand for food, feed, fuel and fiber. . Presentation online at *http://nane.ipni.net/article/NANE-3069*

Phosphorus stewardship: Chris Thornton, reporting from the first **European Sustainable Phosphorus Conference**, indicated that there are a number of different drivers for improving phosphorus management, including raw materials risk (dependency, price variability), the development of biofuels, synergy with energy recovery from biowastes, pollution limitation.

Key issues for phosphorus stewardship identified in Europe include quality standards for recycled phosphates, local stakeholder involvement and local solutions, and potential for employment.

Benefits of recycling phosphorus in biosolids: Don Hilborn and Christine Brown OMAF / MAF (Ontario Ministry of Agriculture and Food / Ministry of Rural Affairs) explained the benefits of recycling phosphorus from non-farm resources to farmland. Municipal greenbin materials and biosolids add nutrients and organic matter to soils. Anaerobic digestion to produce biogas is expanding rapidly in Ontario. Anaerobic digestion enables considerable levels of pathogen reduction before the digestate is applied as fertilizer and a soil amendment. By combining different source materials and treatments farmers and municipalities can add value to improve nutrient balance, resource utilization and processing logistics.

Recovery and restoration

Renewable biomass energy: Vivek Voora, IISD Water Innovation Centre, Winnipeg, presented the Netley-Libau Nutrient-Bioenergy project. Harvested cattails (*Typha* spp.) are used to capture and remove phosphorus from the Lake Winnipeg watershed, and the harvested biomass used as a novel renewable feedstock to produce heat, power, and high value bioproducts. Cattails as they grow sequester CO_2 and accumulate nutrients (P, N, K) which can be recovered in ash post-combustion. . Cattail is transformed into fuel products such as pellets, cubes, and briquettes, which can be used in biomass boilers. The boiler ash is recovered and land applied for soil conditioning and fertiliser. IISD is currently pursuing commercial scale applications for phosphorus capture and bioenergy. Project lead is Dr. Richard Gossnans, more information online at *http://www.iisd.org/wic/research/wetlands/netleylibau.asp*

Catalyst agri-innovation society: Chris Bush, Agricultural Centre of Excellence in Sustainability, explained the need for a holistic approach to nutrient, water and energy management in agriculture. Recycling of both phosphorus and nitrogen represent opportunities. Independent, cross-sectoral research is needed, and the Canadian Council of Ministers of the Environment can facilitate this through networking and information exchange.

On-farm technologies to enhance nutrient use efficiency for food, feed, fibre, fuel: Ian McDonald, OMAF / MAF (Ontario Ministry of Agriculture and Food / Ministry of Rural Affairs) show cased how agronomics, economics, environment and social behaviour combine to motive successful solutions to management nutrients as a resource on farms. Sustainable options must manage risk that is ever changing in these biological systems. Precision technology equipment together with production response research and detailed soil mapping developments allow site specific recipes that make the most of resource inputs while producing economic farm outputs that minimize environmental impact.

Moving forward

The discussion explored a number of phosphorus management issues, including economic issues of full life cycle phosphorus management and how they might work together with researchers, federal/municipal partners to develop strategies to support circular phosphorus management for long term food security.

The webinar confirmed the **interest in Canada in phosphorus stewardship**. Specific Canada perspectives identified include know-how in P-recovery technologies, bioenergy and agricultural systems, and particular regional phosphorus situations, depending on agricultural phosphorus balance or sensitive ecosystems (such as the Great Lakes).

CCME is now considering potential work on phosphorous recovery.

Discussions to explore research/information sharing and large scale technology transfer with European Union and US potential partners, including agriculture dairy and swine, are planned in 2014.

Other Canadian Research Initiatives

Nutrient recovery has been identified as one of top priorities in the Canadian National Research Agenda for Wastewater and Biosolids:
http://www.cwn-rce.ca/assets/resources/pdf/national-research-agenda-municipal-ww-biosolids-final-report.pdf

The Canadian Water Network has funded two research projects, as below:
http://www.cwn-rce.ca/news/research-funding-announcement-2013/

- **"Integrated Sorption Technologies for Recovery of Nitrogen and Phosphorous from Anaerobic Membrane Bioreactor Permeates**," led by Dr. Wayne Parker at University of Waterloo, will receive $132,000 from CWN from 2013-2015. This project will evaluate and develop adsorptive technologies for recovering nitrogen and phosphorous from treated municipal wastewaters.

- "**Options for Improved Nutrient Removal and Recovery from Municipal Wastewater in the Canadian Context**," led by Dr. Jan Oleszkiewicz at the University of Manitoba, will receive $100,000 from CWN from 2013-2015. This project will explore operational and design limitations of existing primary and secondary treatment plants to identify cost-effective process upgrades for lowering N_2O emissions as well as existing and emerging processes for phosphorus recovery and re-use.

Environment Canada through the Lake Winnipeg Stewardship Fund is funding research projects to **reduce phosphorus loading** to Lake Winnipeg, some of which include phosphorus recovery, as below:

- "**Cattail and novel biomass: nutrient capture and reclamation turning a waste/pollution stream into an input for a sustainable Manitoba Bioeconomy**", led by Richard Grosshans at IISD, will receive $180,000 from EC from 2013-2016. This project will demonstrate pilot-scale harvesting of wetland (i.e. cattail) biomass from nutrient-rich areas upstream in the Lake Winnipeg watershed to directly reduce nutrient loading to Lake Winnipeg. Harvested biomass will be utilized for multiple bioproducts, and phosphorus recovery evaluated from ash, biochar, and pre-processing nutrient extraction

Copies of the webinar slides are available from Laura Crawford at laura.crawford@ccme.ca

Composts and digestates

EU End-of-Waste and Ecolabel criteria

The EU is currently developing European End-of-Waste EoW criteria "biodegradable waste subject to biological treatments", that is principally composts and digestates.

It is proposed that **member states will continue to be able to implement specific national criteria**, for example to cover a wider range of input materials that are outside the scope of the proposed EU End-of-Waste criteria, in order to adapt to local situations (but such national criteria would not have mutual recognition in other member states).

The EU is also in the process of updating the European Flower Ecolabel criteria for Soil Improvers and Growing Media.

The proposed End-of-Waste criteria for composts and digestates cover **production from a range of input wastes**: green wastes from parks and gardens, separated household food and bio-wastes, agricultural and forestry crop wastes, food processing industry and catering wastes, manure, animal by-products (subject to relevant legislation).

End-of-Waste criteria (as defined by the EU Waste Framework Directive 2008/98/EC) **enable a waste, through processing, to change status to become a product**, thus becoming no longer subject to waste management regulations, and no longer subject to producer-responsibility and traceability obligations.

This requires that:

- There exists a **market** for the product
- It fulfils requirements for **specific purposes** and uses
- Uses **do not lead to adverse environmental or health effects**

Also, although the JRC document provides data on the market value of compost and digestates, no specifications for the market or applications are included in the EoW criteria proposals, and it is indicated that there are a **wide range of uses**.

The proposed End-of-Waste criteria proposed for compost and digestate include:

- **organic content** of 15%
- **pathogens**
- presence of viable **weed seeds**
- **macroscopic impurities** (e.g. plastics, metals, glass)
- **heavy metals** (Cd, Cr, Cu, Hg, Ni, Pb, Zn)
- **persistent organic contaminants** (sum of 16 polycyclic aromatic hydrocarbons)
- **biological stability**

The **stability criteria** are questioned by stakeholders because this is difficult to measure and there is no standard.

Authorised levels of **zinc and copper** have been increased somewhat from previous criteria proposals, because these metals are micronutrients necessary for plants and are quite widely deficient for plant growth, also they are widely present in many biosolids.

No specific limits are currently proposed for pharmaceuticals or hormones.

The End-of-Waste criteria specify processing parameters for composting and anaerobic digestion, but **do not define limits or parameters for local emissions from processing sites**, despite the fact that inappropriately designed or managed composting installations can pose significant local nuisance odours and pollutant emissions. Requirements to require HACCP (Hazard Analysis and Critical Control Point) and to respect a processing quality management system could reduce such problems.

Narrow European scope - excluding sewage sludge

The latest proposal for criteria (JRC, EU Commission Joint Research Centre, draft final report 7/2013) opts for an option of "***Narrow scope excluding certain input materials***", considered to be a compromise solution:

- ensuring **highest possible consumer and public confidence**, by excluding from input materials with a negative image, in particular sewage biosolids
- by **reducing the scope of the proposed *European* End-of-Waste criteria** to composting and anaerobic digestion, these materials are NOT excluded from other treatments
- offering subsidiarity, by **enabling member states to adopt *national* EoW criteria** which can accept other input materials.

The scope of the European EoW criteria is thus proposed as:

> *"hygienised and stabilized compost and digestate materials obtained through a biological waste treatment process exclusively using non contaminated input materials from the separate collection of bio-waste, as well as from biodegradable residues from agriculture (including manure), forestry, fishery and horticulture, or any such previously composted or digested material. … 'Bio-waste' is defined according to Article 3(4) of the Waste Framework Directive 2008/98/EC as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants."*

In particular, in a significant change from previous criteria proposals (August 2012), **sewage sludge biosolids, and paper industry sludges are excluded** (see pages 111 and 148), **as is the organic fraction obtained by sorting of mixed municipal wastes**. The latter is considered appropriate in order to encourage separate collection of biodegradable municipal wastes.

The exclusion 'on principle' of sewage sludges is a reversal of the JRC's earlier conclusion that there was no scientific reason to exclude these, however it was is supported by some stakeholders, because of concerns about pathogens or contaminants. However, it can be considered contradictory to the objectives of making waste waters into a resource, and of optimising the recycling of phosphorus, nitrogen and organic carbon in waste waters. **Agricultural reuse routes need to be maintained** for appropriately treated sewage biosolids (stabilised, sanitised), subject to ensuring levels of organic contaminants (pharmaceuticals, hormones) which do not pose risks.

The criteria proposed are based on some 120 samples of composts carried out in 2011. However, **1/3 of these samples were taken in France, where national End-of-Waste criteria are currently in place for composts**, in which sewage sludge input is authorised.

European and national End-of-Waste criteria

The exclusion of certain biosolids as input materials for compost and digestate would apply to the European End-of-Waste criteria, but it is proposed that **member states would under subsidiarity be able to develop (or maintain existing) national EoW criteria for composts or digestates** which DO authorise the input of sewage sludges, but these would not benefit from mutual recognition in other member states

The current proposals are thus likely to result in a **superposition** of European End-of-Waste criteria for composts and digestates using a limited range of input wastes with national criteria in some cases authorising a wider range of inputs (eg. current French compost End-of-Waste criteria which authorise the input of sewage biosolids). This would pose questions for example:

- If a product is produced according to locally applicable End-of-Waste criteria (in the country in which it is manufactured), it **cannot then be exported as a product** (only as a waste) to other countries (for example, where no national criteria are defined)
- In this case, **what information is included** with the product to specify parameters for which the product would not be eligible for European End-of-Waste criteria, in order to enable farmers and consumers to choose or not the product with full information?

Phosphate recycling and nutrient content

The background report to the End-of-Waste (EoW) criteria proposal **recognises the importance of biodegradable wastes in phosphorus stewardship and recycling**, indicating in \$2.8.1.7 that the reuse of phosphorus in such wastes has positive environmental effects and in \$2.4.1 that agricultural phosphorus requirements can often be covered by compost application. The report indicates in \$2.5.6 that **phosphorus in compost could substitute c. 10% of mineral fertiliser use** (Germany), but it is not clear that this would remain true with the narrow scope of the EoW criteria proposed (exclusion of sewage biosolids).

The phosphorus recycling value of composts and digestates is recognised also through the proposal to indicate levels of nutrients (N, P, K, Mg) as a possible quality criteria (p. 122). However, it is then proposed to only include organic matter content (and not nutrient content, p. 123).

It would seem appropriate, as a minimum, to require that information concerning nutrient content be communicated with the product. This should be presented as the fertiliser replacement value, to enable farmers to provide nutrients according to crop needs, and to respect fertilisation management plans to limit environmental losses, and as increasingly required under local implementation of environmental legislation (eg. for both nitrogen and phosphorus under the Nitrates Directive, and under the Water Framework Directive …).

There has been discussion as to whether labelling should include some indication of the **plant availability of the nutrients**, but this poses questions as to how to define and measure this.

European Ecolabel for soil amendments

The EU is also currently **updating criteria for the EU "Flower" Ecolabel for Soil Improvers and Growing Media**. As for the proposed End-of-Waste criteria above, the use of sewage sludge is proposed to be excluded.

Manures would be authorised as components for Ecolabeled products, under certain conditions if composted or treated by anaerobic digestion. The acceptance of manures treated for example by drying and pelletisation and of biochars is not clear.

The environmental and consumer associations EEB and BEUC have proposed to specify in the new Ecolabel criteria that minerals used be either partly or completely sourced from recycled sources. This would be a positive step to promote recycled phosphates. The European Sustainable Phosphorus Platform is supporting this proposal and has submitted comments (see on *www.phosphorusplatform.org*)

End-of-Waste criteria proposal: (JRC, EU Commission Joint Research Centre, draft final report 7/2013) "Technical report for End-of-Waste EoW criteria for biodegradable waste subject to biological treatments"
http://susproc.jrc.ec.europa.eu/activities/waste/documents/IPTS%20EoW%20Biodegradable%20waste%20Draft%20Final%20Report.pdf

European Compost Network summary and position on the proposed criteria:
http://www.compostnetwork.info/wordpress/wp-content/uploads/2011/06/131004_ECN-NEWS_03_2013.pdf

EU Ecolabel for Soil Improvers and Growing Media, criteria update process: http://susproc.jrc.ec.europa.eu/soilimprovers/

European Sustainable Phosphorus Platform comments on EU Ecolabel for Soil Improvers and Growing Media www.phosphorusplatform.org *under "Downloads"*

Phosphorus uses and flows

Phosphorus in food

European Food Safety Authority (EFSA)

EFSA has published two documents assessing available scientific information concerning health effects of diet phosphorus levels

A minimum of phosphorus in human diets is essential for health, because the body needs phosphorus (P) for bones, teeth, DNA, energy metabolism and many other functions. The recommended daily requirement for health for phosphorus is 1gP/day[1]. However, today in Europe, dietary P intake is around 1.3 – 2.7 g P/day[2] of which around 0.15gP/day[3] is estimated to come from food additive phosphates used to ensure processing of the foodstuff, stabilize flavour and colour or help to ensure food safety (bacteria free preservation)[3].

EFSA (European Food Safety Agency) has published two documents concerning the possible association between increased **diet phosphorus levels** and health risks. The first concludes that there is no proof that increased blood phosphorus levels cause an increased in cardiovascular disease (CVD), risk, and that there is no evidence that increased diet phosphorus intake leads to increased blood phosphorus levels. The second analyses available scientific information on the health impacts of diet phosphorus. Over 10 000 published papers were initially identified, and 21 were analysed as relevant.

The 19-page assessment of possible health risks associated with diet phosphorus levels (EFSA Journal 2013;11(11):3444) is presented as **an assessment of one publication (Ritz et al. 2012), which is a review presenting a selection of population studies** relating blood phosphorus levels to cardio-vascular disease occurrence, presenting in vitro evidence of mechanisms whereby increased phosphorus levels could contribute to CVD mechanisms, and suggesting that dietary phosphorus intake from food additive phosphates could therefore pose health risks.

The EFSA assessment notes that the Ritz publication does not appear to be a comprehensive review of relevant literature, and relies mainly on studies selected to support the hypothesis put forward. The principal studies presented in this publication are analysed by EFSA (Tonelli et al. 2005, Dhingra et al. 2007) as well as other relevant studies (Foley et al. 2008, Lopez et al. 2013, Slinin et al. 2011, Onufrak et al. 2009) concluding that although a number of studies do suggest a statistical correlation between increased blood phosphorus levels and CVD risks, other studies do not show such a correlation, and that there is no evidence of a causal relationship. That is, **there is no proof that blood phosphorus levels cause cardio-vascular disease**, as both could be related to other factors (other health or diet factors, lifestyle …).

No evidence that diet P intake leads to increased blood P levels

Furthermore, EFSA assesses a number of studies (Bell et al. 1977, Antoniucci et al. 2006, Foley et al. 2008, de Boer et al 2009) **concluding that there is no evidence that increased dietary phosphorus intake leads to increased blood phosphorus levels**, and so also no evidence that increased dietary phosphorus intake is related to increased CVD risk. Indeed, it is known that when dietary uptake of phosphorus increases the body reacts to regulate blood phosphorus levels, so that blood phosphorus is brought back to normal levels within a few hours, in particular by increased excretion of phosphorus into urine by the kidneys. Patients with impaired kidney function on the other hand, do show adverse health effects from dietary phosphorus, because they cannot regulate body levels.

EFSA concludes that although a number of studies do show that, in people with normal kidney function, **there is a statistical correlation between blood phosphorus levels and risk of cardiovascular disease**, it is not possible to conclude that the former is the cause of the latter, and also that **other studies do not show such a correlation**.

EFSA further concludes that studies investigating **links between dietary phosphorus intake and blood phosphorus levels are inconclusive**, so that it is not possible to ascertain whether the increased cardiovascular disease risk is attributable to dietary phosphorus intake.

It is also noted that all the large epidemiological studies presented were carried out in the USA, and that results may not be relevant to other populations, e.g. in Europe.

Food phosphates will be for re-evaluated by EFSA by end-2018 as part of the Agency's already defined

work programme, and the Agency calls for all relevant information to be submitted, collected and evaluated, in particular information concerning the usage levels of phosphate additives in foods.

EFSA literature review: summary of knowledge on health impacts of dietary phosphorus

The second document published by EFSA (European Food Safety Agency) is a literature review report (contracted by EFSA to Pallas health research and consultancy, The Netherlands) **assessing scientific information available today concerning the health impacts of dietary phosphorus levels**. The report concludes that blood phosphorus levels are correlated to cardiovascular disease, but that there is no evidence that diet phosphorus levels are linked either to cancer or to increased blood phosphorus levels.

Over 10 000 studies since 1990 were identified by literature data base searches, from which 400 were identified as potentially interesting and were analysed. Animal studies and data were not considered, only human data. **This was reduced to only 20 studies considered to provide potentially useful data concerning the health impacts of dietary phosphorus**. The references of these 20 studies as published produced one further study, making a total of 21.

Five of these studies compare diet phosphorus levels to occurrence of different types of cancer (4 prostate / bladder cancer, 1 colorectal cancer). **4 out of these 5 studies showed no association between diet phosphorus levels and cancer occurrence**.

Six other studies compare diet phosphorus levels to other health outcomes (bone = 4, hypertension = 1, muscle mass = 1). **No conclusive evidence of links was found**.

Six studies compare blood phosphorus levels (NOT diet phosphorus levels) to cardiovascular disease (CVD) or symptoms of CVD. In this case, this report concludes, there was evidence of a link.

The report notes that a number of the studies identified (within the 21 studies) have limitations such as confounding factors (eg. other food micronutrients), subject selection bias (smokers, health workers), small cohorts or short follow-up times.

The report notes however that the studies indicate that **higher dietary phosphorus intakes result in higher phosphorus excretion by the kidneys, whilst blood phosphorus levels remain stable**: changes in phosphorus intake did not affect serum phosphorus or serum calcium concentration.

1 = Council for Responsible Nutrition, 2013 Vitamin and Mineral Recommendations, http://www.crnusa.org/about_recs.html *(based on US Food and Drug Administration data)*

2 = Flynn A, Hirvonen T, Mensink GBM, Ocke MC, Serra-Majem L, Stos K, Szponar L, Tetens I, Turrini A, Fletcher R, Wildemann T (2009) Intake of selected nutrients from foods, from fortification and from supplements in various European countries. Food and Nutrition Research 53:20-20. doi:10.3402/fnr.v53i0.2038

3 = estimate by the Phosphoric Acid & Phosphates Producers Association of 25 000 tonnes P/year in food additives for EU25 in 2006 http://www.cefic.org/Documents/Other/13-04-2007-Food-Phosphates-brochure-final.pdf

"Assessment of one published review on health risks associated with phosphate additives in food", European Food Safety Authority, EFSA Journal 2013;11(11):3444, November 2013 http://www.efsa.europa.eu/fr/efsajournal/pub/3444.htm

"Literature search and review related to specific preparatory work in the establishment of Dietary Reference Values for Phosphorus, Sodium and Chloride", European Food Safety Authority, External Scientific Report, Supporting Publications 2013:EN-502 (388 pages) http://www.efsa.europa.eu/de/supporting/doc/502e.pdf

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Phosphorus recycling

Sweden

Phosphorus flows, agriculture, cadmium and P-recycling

Kersti Linderholm's thesis and four published papers look at phosphorus use and flows in Sweden's agriculture and food, looking in particular at the need for and efficiency of phosphate fertilisation for agricultural production, including testing the fertiliser efficiency of iron and aluminium phosphates. Pot and field trials looked at plant P availability and mycorrhizal root development. Cadmium flows are also summarized.

The 4th published paper (Life cycle analysis of phosphorus alternatives for Swedish agriculture) has already been summarised in SCOPE Newsletter n° 88.

The **phosphorus flow analysis** (material or substance flow analysis MFA or SFA) looks at P-flows into and out of Sweden's agriculture and food system, as well as phosphorus in wastewater and waste flows. Internal flows within the national agriculture – food – waste/water system were not calculated, other than accumulation of phosphorus in agricultural soils.

P flow analysis: Sweden not self-sufficient

The paper published in **AMBIO 2012** concludes that **Swedish farmland has a net annual import of 4.1 kgP/ha/year**, corresponding to the level of imports of mineral and other fertilisers (the calculation includes arable and cropland surfaces). The accumulation of phosphorus surplus in farmland is concentrated on farms with > 0.6 animal units/ha.

Sweden's imports of animal feeds (fodder and mineral feed supplements) and human foods exceed fertiliser imports (totaling 14 100 tonnes P/year; equivalent to 4.6 kgP/ha/year). **Imports of phosphorus in human foods and animal feeds is increasing**, whilst at the same time imports of fertilisers have been declining over recent years, probably corresponding to decreasing agricultural production in Sweden and correspondingly decreasing national self-sufficiency in food production.

Phosphorus inputs to municipal wastewater treatment plants (other than from human food via urine and faeces) were estimated at 0.52 gP/person/day, compared to generally accepted figures of 1.5 – 2 gP/person/day in diet, suggesting significant input from other sources.

The paper concludes that Sweden could probably maintain current agricultural production without importing fertilisers **if manure phosphorus was used better**, but that if Sweden wished to become self-sufficient in food production then import of phosphate fertiliser would be necessary.

Fertiliser field tests

The **VATTEN 2003** paper presents results of 3-year field tests in Sweden, at a site with low phosphorus-status soil, using oats (1994) and barley (1995, 1996), assessing the phosphate fertiliser value of mixed waste incineration ash, **sewage sludges from works operating chemical precipitation nutrient removal using iron chloride, aluminium or calcium** ((AVR aluminium 8.2%, iron 1% weight, calcium as slaked lime), sludge from biological treatment of pulp and paper industry waste, compared to readily soluble mineral phosphate fertiliser (calcium phosphate) and a control (no phosphate fertiliser). Tests were carried out on 8 x 40 (320 m^2) plots, repeated in three blocks, for three years.

All plots received nitrogen and potassium fertiliser, dosed to ensure adequate supply of these elements and the same level of dosage based on the total N and K content of the different products. Half of the treatment plots also received lime, to compensate lime present in the lime precipitated sludge and ash. Parameters measured were grain yield, straw yield, P, K and N concentrations in grain and in straw.

In the first year (relatively dry), oat grain yields were on average 2200 kg dry matter/ha in the limed experimental plots, and 1900 in the non-limed plots, with the highest yield in the limed plot receiving mineral fertiliser (2600). These yields were compared to usual yields in the region of 3200 kgDM/ha for oats, indicating yield limited by climatic conditions. In this year, the authors note visible effects on biomass yield, **higher with the mineral fertiliser than with all other treatments.** Also, in this year, **plants showed symptoms of phosphorus deficiency in the control and sewage sludge (iron, aluminum, lime) plots**.

In the second and third years, barley grain yields showed no significant differences between any of the fertiliser treatments, including no significant differences from the control plots, with average yields in limed plots of around 3300 and 5200 kgDM/ha, compared to usual yields of 3000 kgDM/ha. For these years there were significant differences in some parameters for at least one year (P and K content in grains, straw production, N, P and K content in straw) between limed and unlimed plots, but not between different fertiliser treatments.

The authors conclude that successful phosphorus fertilisation is a question of maintaining the soil phosphorus status so it can supply the crop requirements when conditions are optimal. Phosphorus supply is a question that must be considered on a long-term basis. However, **under dry conditions readily plant-available phosphorus in fertiliser showed to be important for crop productivity**. Mineral fertiliser provides such readily available phosphorus, whereas in

this study the other products tested do not (iron, aluminium and calcium containing sludges, ash products, biological sludge from pulp and paper industry waste). No significant differences in productivity were shown between any of the fertiliser treatments and no significant difference to the no-phosphate addition control in years with adequate rain so that **this study alone does not provide directly any information about long-term availability of phosphorus in the different ash/biosolids products tested**.

Root and root fungus development

In a further paper, plant root development and arbuscular mycorrhiza (fungus on roots) were examined in ryegrass grown in pot trials using soil from the different experimental field plots above, taken the year afterwards (the soils had thus been treated four years before the pot trial with mineral fertiliser, ash, biological sludge from pulp and paper industry waste, iron- aluminium- or calcium- sewage sludge, or control). In some of the pots mineral phosphorus fertiliser was dosed again.

The root length and the fungus development were lower in the pots which received mineral P fertiliser and longest in the pots which received iron containing sewage sludge in the field then no mineral fertiliser in the pots. The authors deduce that **sewage sludges do not inhibit root fungus development**.

A further field experiment using clover, compared nitrogen and potassium fertiliser (NK) to iron-containing sewage sludge + NK to control (no treatment with mineral P fertiliser for comparison). Harvests were taken in years 2 and 3 after application. In this case, **the two treatments with NK fertiliser showed significantly higher dry matter production than the control**, but the iron-containing sewage sludge + NK only showed very slightly higher production than NK fertiliser only (and it cannot be deduced whether this was due to phosphorus, to additional nitrogen and potassium in the sludge, or to other elements).

The author has also published a report, including a literature review, for The Swedish Water & Wastewater Association, concerning long-term plant availability of phosphorus in sewage sludges.

Svenskt Vatten Utveckling report 2011-16 "Fosfor och dess växttillgänglighet i slam – en litteraturstudie"(phosphorus in sewage sludges) http://vav.griffel.net/filer/Rapport_2011-16

"Flows to Swedish food chain, fertilizer value, effect on mycorrhiza and environmental impact of reuse", Doctoral Thesis n° 2012:84, Faculty of Landscape Planning, Horticulture and Agricultural Science, Swedish University of Agricultural Sciences http://pub.epsilon.slu.se/9166/

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"Phosphorus Flows to and from Swedish Agriculture and Food Chain", AMBIO 2012, http://link.springer.com/article/10.1007%2Fs13280-012-0294-1

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"Plant availability of phosphorus in ash, calcium phosphate and different types of sewage sludge", Vatten 59, pages 161-167, 2003

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P-recovery from sewage

Thames Water launches UK's first full-scale nutrient recovery unit

Thames Water has partnered with Ostara Nutrient Recovery Technologies to launch the UK's first full-scale nutrient recovery facility, at Slough sewage treatment plant, recovering nitrogen and phosphorus as a high-added value fertiliser, marketed by Ostara under the brand name Crystal Green®, which will be supplied to farmers, golf courses and gardeners.

The UK £2 million investment plant is expected to **save Thames Water around UK £200 000 per year in operating costs**, by reducing chemical costs and avoiding nuisance struvite deposits blocking pipes and valves. The reactor thus effectively transforms a major operating cost for the sewage works - phosphate compound (struvite) deposits in pipes causing blockages - into **an economic advantage and an ecological benefit through phosphorus recycling**.

The Thames Water nutrient recovery facility was unveiled on 6th November 2013 by **Piers Clark, Thames Water Commercial Director**, **Philip Abrary, President and CEO of Ostara**, and **Tony Juniper, Friends of the Earth environmental campaigner and author**.

National media, local councillors, Thames Water staff, and the European Sustainable Phosphorus Platform participated and the **event obtained wide media coverage** including the BBC, ITV, Sky News, Daily Mail, Independent, Guardian, BBC Radio 4 and local press and media.

Ostara's nutrient recovery process will avoid problem deposits in pipes and valves

The nutrient recovery facility is treating digested sludge dewatering centrate covering the full capacity of the sewage works (**270 000-person equivalents**) and recovering **150 tonnes of Crystal Green fertiliser per year**. The production of struvite may increase in the future as improvements in the sewage works biological phosphorus removal operating process will mean that more soluble phosphorus reaches the struvite reactor. **Currently, the Ostara system recovers around 10% of the total phosphorus** entering the sewage works.

The nutrient recovery facility consists of a fluid-bed reactor where magnesium is added to the centrate under strictly controlled conditions, including pH adjustment if necessary, with a recycling pump to ensure upflow and mixing. The precipitated struvite settles to the bottom of the reactor where it is periodically drawn out, water is separated off, dried with warm air then sieved to sort by **pellet size, from 1 to 2.4 mm diameter pellets for different fertiliser applications.**

Sustainable Farming

The nutrient recovery technology has been welcomed by the UK's organic farming association. **Peter Melchett, policy director at the Soil Association**:

"*With the world's affordable mineable reserves of phosphorous set to start running out in the next 20 to 30 years, this new technology could offer a solution to securing global food supplies over the coming decades. Without fertilisation from phosphorous, wheat crop yields will fall by more than half. Meanwhile, as the planet's population is predicted to hit nine billion by 2050, demand for food will increase. Sustainable alternative sources of phosphorous, like this reactor at Slough sewage works, are vital if we are to keep pace with this demand*".

Ostara state that Crystal Green® fertiliser provides magnesium, ammonium (nitrogen) and phosphate to plants in a single plant-activated granule (5-28-0 +10%Mg). Unlike conventional water-soluble fertilisers, it is citrate-soluble, **releasing nutrients to the plant only when the roots ask for it, over 6 – 9 months**. Because of this, Crystal Green provides season-long nutrient availability to plants and reduces the risk of leaching and runoff to the environment while protecting sensitive regional waterways.

Piers Clark, Philip Abrary and Tony Juniper unveil the struvite reactor and participants visit the facility

Advantages for water customers and farmers

Piers Clark, Thames Water's Commercial Director, explains that the Crystal Green is:

"cleaner than anything else on the market, and greener, too – without the level of contaminants traditional fertiliser contains like heavy metals content. There's no odour either. To farmers this is long-lasting Viagra for crops: phosphorous-rich fertiliser they cannot buy elsewhere. The secret is in its slow nutrient release, making it one of the most efficient fertilisers of its kind in the world".

Dr Clark also underlined the advantages for Thames Water customers:

"With this new facility, we expect to save up to £200,000 a year. Until now that money was spent on chemical dosing to clear the struvite from blocking pipes. The savings and operational costs can only benefit consumers".

The Ostara Pearl® Nutrient Recovery unit at Thames Water's Slough sewage works

Ostara developments worldwide

Recently, Ostara announced a major project in partnership with Black and Veatch to construct a nutrient recovery facility for the Metropolitan Water Reclamation District of Greater Chicago at the city's Stickney wastewater treatment plant, in Cicero, Illinois.

The Stickney plant is **the largest wastewater treatment plant in the world, serving 2.2 million people**. By 2015, the nutrient recovery facility should be producing **10 000 to 15 000 tonnes of Crystal Green recovered phosphate product per year**.

In August 2013, Ostara officially launched its first Canadian nutrient recovery facility, in the province of Saskatchewan. The **Saskatoon Wastewater Treatment Plant** will recover around 300 tonnes of Crystal Green per year, that is **40% of the sewage works inflow phosphorus and 5% of the inflow nitrogen**, through the first commercial implementation of Ostara's WASSTRIP® process which transfers up to 40% more phosphorus from the sludge treatment stream to a soluble form in the nutrient reactor liquor stream (and so available for recovery).

The company has also recently announced a partnership with Grontmij, SH+E and the Dutch Waterboard Vallei & Veluwe to install a nutrient recovery facility for a **state-of-the-art project at Amersfoort in the Netherlands**, with anticipated production of approximately 700 tonnes of Crystal Green per year.

This will bring the total number of Ostara nutrient recovery facilities operating worldwide to nine, including existing plants: Slough (UK), Saskatoon (Saskatchewan), Nine Springs (Madison, Wisconsin), Nansemond – Hampton Roads (Suffolk, Virginia), York, (Pennsylvania), Durham-Tigard near Portland (Oregon), Rock Creek, near Portland, (Oregon), see SCOPE Newsletter n° 77.

See also: SCOPE Newsletter n° 76 (Slough Ostara project announcement), n° 57 and 41 (struvite pilot plant constructed by Thames Water themselves at Slough sewage works in 2000-2001)

Video (ITV News, 2 mins) at http://www.ostara.com/sloughUK

Thames Water P-recovery video (2 mins) http://bit.ly/1ggAkJ5

BBC "The world's insatiable hunger for phosphorus" and "New Slough reactor turns sewage into fertiliser" http://www.bbc.co.uk/news/business-24823266 *and* http://www.bbc.co.uk/news/uk-england-24824681

Ostara developments: http://www.ostara.com/news/news-releases

Thames Water "Fertiliser from sewage saving the planet - and cash": http://www.thameswater.co.uk/media/press-releases/17393.htm

Ekobalans

Pilot struvite P-recovery plant operational

Ekobalans Felix AB inaugurated in January 2013 a 6 m^3/h pilot struvite recovery plant at Öresundsverket NSVA municipal sewage works, Helsingborg, Sweden, currently producing around 50 tonnes of struvite per year. The struvite is then combined with potassium salts and nitrogen (from ammonium sulphate recovered from coke furnace gas) to produce a balanced NPK fertiliser.

Öresundsverket treats wastewater from 150 000 population equivalent, some 56 000 m^3 per day, from the city of Hesingborg. The sewage works operates **biological nutrient removal with anaerobic sewage sludge digestion** for energy recovery.

NPK fertiliser

The P-recovery unit installed treats around one third of the total sludge digester effluent, after digestion and after dewatering. The struvite precipitation is a simple, low-cost process which produces microcrystals that are separated out using hydrocyclones. The **potential for a full-scale plant is around 160 tonnes struvite/per year**.

The struvite microcystals are then formulated (currently at a separate facility) into dry, regular granules in **combination with ammonium sulphate and potassium salts, to give a balanced NPK fertiliser adapted to agricultural use.** The pellets can be used in standard farm fertiliser spreading equipment.

The project plans, in the coming three years, to integrate the P-recovery process into a system which will include drying the digested sludge (to 90% dry solids) and **pyrolysis to produce gas for energy production (with cadmium, mercury removal).** It is planned to use the resulting biochar, from which heavy metals have been removed, as a fertiliser

The installation was developed after experimental work carried out under a Swedish Biogas project (Svenskt Gastekniskt Center, Fransson et al.) in 2010 investigating struvite precipitation from a range of digestates

Ekobalans presentation, Sustainable Nutrient Recycling, G. Thelin, IBBA Workshop 9th May 2013-09-05 http://sgc-konf.camero.se/ckfinder/userfiles/files/EkoBalans.pdf

L. Fransson, S. Loewgren, G. Thelin "Recycling of nutrients through struvite precipitation from digestion residues", Svenskt Gasteknisk Center report SGC 218-1102-7371, May 2010 (110 pages, in Swedish with English summary) https://www.etde.org/etdeweb/details_open.jsp?osti_id=985452

NSVA launches struvite P-recovery: http://www.mynewsdesk.com/se/nsva/pressreleases/plastroer-minskar-struvitbelaeggningar-hos-nsva-742002

Ekobalans www.ekobalans.se *contact* gunnar.thelin@ekobalans.se

Florida Wastewater Treatment Plants

Economic evaluation of struvite recovery

Possible solutions were evaluated to mitigate struvite deposit problems occurring downstream of anaerobic sludge digesters at two Florida wastewater treatment plants (not operating nutrient removal): struvite precipitation for phosphorus recovery, ferric dosing to the digester, ferric dosing to the digested sludge dewatering centrifuges.

Results were based on current experience of **ferric dosing**, modeling of **struvite precipitation** option and two 10-day pilot tests of a full-scale Ostara Pearl struvite recovery unit.

The two Florida wastewater treatment facilities studied were the Central District and South District Water Resource Recovery Facilities, Miami-Dade County, Florida.

Both plants use **pure-oxygen aerated activated sludge reactors followed by clarifiers** (with sludge recycling), with **two-stage mesophillic anaerobic digestion of excess sludge**. The plants treat average daily flows of 440 and 380 million litres/day. Neither plant has specific nutrient removal operating requirements.

Both plants have experienced for several years considerable **struvite deposit problems** in the anaerobic digesters, the digester centrate lines and dewatering centrifuges. The Central District plant doses ferric salts to the anaerobic digester effluent (centrifuge influent) to reduce struvite deposits and improve the solids removal rate in the centrifuge. The South District plant addresses the deposits by weekly preventive maintenance (eg. jetting out of lines).

Technical and economic evaluation

The study was carried out by **Hazen and Sawyer Engineers, P.C.** and operational staff at both plants. The evaluation was based on data from sludge and centrate analysis, 0.3 l batch tests to evaluate the ferric dose necessary, spreadsheet evaluation of struvite precipitation potential, plant operation modeling (BioWin), in-situ coupon testing of struvite accumulation (sample surfaces placed in liquor flows within the treatment works), imaging and chemical analysis of deposits formed on these coupons and on the full-scale testing of the Ostara Pearl struvite precipitation unit.

During the two 10-day Ostara plant tests, magnesium dosing and occasional, minor pH adjustment (using caustic soda) were necessary to achieve optimal phosphate recovery. The tests used a **full-scale Ostara plant** installed at the South District wastewater treatment works, treating the centrate of this works for 10 days and also for 10 days centrate shipped from the Central District works. The influent and effluent ammonia and phosphate concentrations for the Ostara unit were tested. In both runs, the Ostara unit was effective in removing phosphate from the centrate and produced a struvite fertiliser product conforming to specifications.

In the batch experiments, actual **ferric dosing** necessary to achieve complete struvite prevention was evaluated as the point of crossover between actual and theoretical phosphate concentrations, because the addition of ferric causes a drop in pH resulting in the dissolution of existing struvite crystals, so releasing additional soluble phosphate.

Struvite prevention

BioWin modeling based on the experimental data showed that for the Central District plant, the Ostara unit alone (without ferric dosing) would result in **lower treatment works phosphorus effluent levels** (0.8 compared to 1.1 mgP/l) but would only reduce in-works struvite deposits by 16%, whereas ferric dosing to the digester could reduce struvite deposits by 30%

At the South District plant, the Ostara unit alone would reduce only slightly the works effluent phosphorus (by 0.1 mgP/l) but would reduce in-works struvite deposits by 59%. At this plant, ferric dosing would reduce struvite deposits by only 41% or 49% and reduce works effluent P by 0.2 mgP/l.

Modeling showed a higher struvite deposit risk at the Central District plant, because of higher magnesium concentrations in the raw wastewater

Economic evaluation

Net present worth evaluations were calculated for both facilities for the different struvite control options: no ferric dosing, with ferric dosing, use of the Ostara process with capital purchase of the struvite recovery plant, use of the Ostara process with a 20-year fee-based option.

This economic evaluation suggests that implementing the Ostara unit for struvite recovery (with capital purchase) offers the best net present worth at both treatment plants, with continuation of existing ferric dosing in digester effluent fed to centrifuges at the Central District plant (necessary to prevent struvite deposits) and without ferric dosing at the South District plant.

"A Theoretical and Practical Evaluation of Struvite Control and Recovery", Water Environment Research, vol. 85, n° 8, pages 675-686, 2013 http://dx.doi.org/10.2175/106143012X13560205145253

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Ideas and input

Phosphorus Challenge
ipad App now available in iTunes Store

The Dutch Nutrient Platform has launched the first Phosphorus Challenge Ipad app, now available in iTunes Store.

The app is developed as part of the international media campaign to raise awareness in Europe for the phosphorus challenge and presents the facts about phosphorus and the available solutions. Business cases, animations, movies and documents are collected and bring the abstract and technical context of sustainable phosphorus management and its transition to life by means of stories and visuals.

In addition to this new App, last year the Netherlands Nutrient Platform launched five films (also now view in the App) in which the Phosphorus Challenge is explained, and was a co-organiser of the successful first European Sustainable Phosphorus conference in Brussels, see SCOPE Newsletter n°92.

The Netherlands Nutrient Platform is a cross-sectoral network of Dutch organizations which turn the international phosphate problem into an opportunity by jointly creating a market for recycled phosphate.

The ipad App is developed for the iPad and can be downloaded in the iTunes Store at https://itunes.apple.com/app/the-phosphorus-challenge/id727142252?mt=8

The first Phosphorus Challenge App is an initiative of the Dutch Nutrient Platform and its members.

European Union
Public consultation on phosphorus use

The European Commission public consultation on the sustainable use of phosphorus" is **open until 1st December 2013**.

All interested parties are invited to submit contributions: companies, organisations, scientists, experts.

Contributions can answer the 11 questions proposed by the European Commission in the consultation document (19 pages), setting out European issues around phosphorus use and proposing options to improve efficiency and reduce environmental impacts. Contributions can also address any other phosphorus related issues interested parties wish to raise.

The European Sustainable Phosphorus Platform's response to this consultation can be consulted at ***www.phosphorusplatform.eu*** under 'Downloads'

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

Innocentive challenging nutrients
Transformative strategies for reducing excess nutrients in waterways

Innocentive challenge for ideas for reducing nutrients in waterways at any stage of cycle. US$ 15 000 award. **Deadline 1 December 2013**

You are invited to submit ideas for an innovative approach to reduce nutrients in waterways, including a description of technical feasibility (general approach, technical advances), impact, novelty and distinction from other ideas, user adoption strategy.

https://www.innocentive.com/ar/challenge/9933112

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*The SCOPE Newsletter summarises news and publications concerning sustainable phosphorus management, with the aim of furthering debate and knowledge, and **does not represent an official position** of the European Sustainable Phosphorus Platform nor of its members.* ***To SUBSCRIBE*** ***www.phosphorusplatform.eu***

Nutrient Platforms

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

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

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

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

Agenda 2013 - 2014

- 3 December 2013, London: **End-o-Sludg : Sludge and phosphorus management in Europe, present and future (UK)**
  eoslondon@gyronllp.co.uk
- 3 December 2013, London: **ADBA National Conference "Can we afford not to recycle P?"** (UK Anaerobic Digestion and Biogas Association)
  http://adbiogas.co.uk/adba-national-conference-2013/
- 5-6 December 2013, Bruges:
  ManuResource 2013
  (manure management and valorisation)
  http://www.manuresource2013.org/registration
- 10 December, Brussels, **European Sustainable Phosphorus Platform steering committee**
  info@phosphorusplatform.eu
- 11 December 2013, Brussels: **End-o-Sludg : Sludge and phosphorus management in Europe, present and future (EU)**
  http://www.end-o-sludg.eu/es/wp-content/uploads/2013/09/EOS_Brussels.pdf
- 12-13 December, Cambridge, UK
  International Fertiliser Society conference: soil structure, manure, fertiliser P use
  www.fertiliser-society.org
- 6-10 January 2014, Phoenix Arizona
  2nd **Sustainable Phosphorus RCN** (US Research Coordination Network) meeting.
  http://sustainability.asu.edu/research/project.php?id=704
- 23 January, Rennes, France
  Phosph-OR 2014 (P-recycling meeting, see SCOPE Newsletter n°83)
  http://phosph-or2014.irstea.fr/
- 28-29 January 2014, Berlin (BAM) **Opportunities for P- Recovery from Wastewater**
  oliver.krueger@bam.de
- 20-14 February 2014, **Anaerobic Digestion Europe 2014** *www.adeurope2014.eu*
- 23-25 March 2014, Paris:
  Phosphates 2014 (CRU)
  The annual phosphate industry conference
  www.phosphatesconference.com
- 24-26 March 2014, Sofia, Bulgaria: **EWPC11 European Workshop on Phosphorus Chemistry**
  http://ewpc11-bg.org/index.php
- 1-4 April 2014, Amsterdam: **International Fertiliser Association Global Technical Symposium** *www.fertiliser.org*
- 4-6 June 2014, Valladolid, Spain: 10th International **Renewable Resources and Biorefineries** Conference (RBB)
  (5th June: Nutrient & Energy cycling)
  www.rrbconference.com
- 29 June – 3 July 2014, Dublin:
  20th International Conference on Phosphorus Chemistry
  www.icpc2014.ie
- 13-17 July 2014, Harbin, China:
  IWA Science Summit on Urban Water
  http://www.iwahq.org/28f/events/iwa-events/2014/urban-water.html
- 26-29 August 2014, Montpellier, France:
  5th Phosphorus in Soils and Plants symposium
  http://psp5-2014.cirad.fr/
- 1 - 3 Sept. 2014, Montpellier, France
  4th world **Sustainable Phosphorus Summit**
  http://SPS2014.cirad.fr
- 27 Sept. – 1 Oct. 2014, New Orleans
  WEFTEC2014 (Water Environment Federation)
  www.weftec.org
- 26-30 Oct 2014, Kathmandu, Nepal
  IWA: Global Challenges for Sustainable Wastewater Treatment and Resource Recovery
  http://iwa2014nepal.org
- 3rd-4th March 2015, Berlin: 2nd European Sustainable Phosphorus Conference
- 23-25 March 2015, Florida:
  Phosphates 2015 (CRU)
- 29 March – 3 April 2015, Australia. **Beneficiation of phosphates VII**
  http://www.engconf.org/conferences/environmental-technology/beneficiation-of-phosphates-vii/
- May 2015, Morocco: **SYMPHOS**
  www.symphos.com