Summary of the 3rd European Sustainable Phosphorus Conference (ESPC3) Helsinki, 11-13 June 2018

ESPC3 a success

The 3rd European Sustainable Phosphorus Conference (*ESPC3*), co-organised by Baltic Sea Action Group (*BSAG*) and ESPP, brought together nearly **300 participants from 30 countries**, significantly increased from *ESPC1* (Brussels 2013) and *ESPC2* (Berlin 2015).

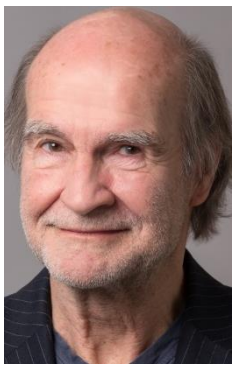
HELSINKI 11-13 June 2018 | ESPC3 | European Sustainable Phosphorus Conference

Highlights included input from the **European Commission** (DG Environment and DG Research), **Finland national government** (ministries of the Environment and Agriculture and Forestry). international organisations (**HELCOM**, **Rhine Commission**), company and nutrient management success stories.

Sessions included: **success stories** from companies recycling or managing nutrients and watershed management, links to **carbon and climate change**, nutrient **circular economy**, **livestock** production, ecological nutrient **restoration**, **nutrient recovery** technologies and **policy tools** for sustainable use of nutrients.

ESPC3 outcomes (presentation slides and posters) online at www.phosphorusplatform.eu/ESPC3

The BSAG conference organising team for ESPC3 and the conference moderator Sonya van Renssen



Ludwig Hermann, European Sustainable Phosphorus Platform (ESPP) President, opened the ESPC3 conference by summarising achievements in phosphorus (P) sustainability in Europe since ESPC1 (2013). These include addition of phosphate rock and white phosphorus (P_4) to the EU list of Critical Raw Materials, the EU Circular Economy package and Fertilisers Regulation proposal, initiatives on recycled products in the Nitrates Directive and digestate in REACH, R&D projects, national phosphorus recycling legislation in Germany and Switzerland and HELCOM Recommendations. The ESPC conferences are a key part of ESPP's functioning by smart cooperation and dialogue.

R&D needs for nutrient management

An active discussion addressed proposals for including nutrients in the **next EU R&D funding programme, Horizon Europe**, which will follow on from the current Horizon 2020 programme.

With UN-Environment support, the "**Global call for a science initiative on phosphorus**" was *launched*.

Please participate by signing this Call at *www.opfglobal.com*

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Phosphorus a priority at every level

For Helsinki: Jam Vapaavouri, Mayor of Helsinki, indicated that nutrient sustainability is integral to the City's objectives of circular economy and business opportunities. Helsinki Environment Services (HSY) is actively innovative in sewage nutrient removal and recovery (see site visit summary below). He welcomed ESPC3 to Helsinki, underlining the importance of exchange and cooperation.

For Finland: **Jaana Husu-Kallo, Finland Ministry of Agriculture and Forestry**, indicated that Finland has the objective to process for recycling 50% of both sewage sludge and manure by 2025 and to become a world leader in nutrient recycling, in coherence with actions on recycling of manure, sustainable seafood protein production, river and marine nutrient protection plans. The objective is a systemic approach encompassing water, energy and nutrients.

For the Baltic: **Mathias Bergman, Baltic Sea Action Group**, emphasised that the Baltic Sea is in a critical state, near to death, because of nutrient inputs accumulated in its closed waters and in sediments. Important reductions of nutrient discharges have been achieved, but more needs to be done.

Recycling of nutrients is important, both for nutrient stewardship and to avoid that "removed" nutrients end up leaching into the Baltic sea from sludges or manures. Major positive restoration and recovery actions are being undertaken, and that the Baltic Sea could be a model for nutrient mitigation and restoration worldwide.

For Europe: **Karmenu Vella, European Commissioner for the Environment**, speaking from Brussels, also cited the Baltic sea as an example of impacts of nutrient losses, but noted that eutrophication is an issue across Europe. Watch video online *www.youtube.com/watch?v=ZqPSczxzECk* Nutrient losses are also a wasted opportunity, with potential for more efficient use and for job creation in recycling. Already, the EU has included phosphate rock and P_4 on the list of Critical Raw Materials and has engaged revision of the Fertilisers Regulation to facilitate the Nutrient Circular Economy. Further proposed actions include obligatory Farm Sustainability Tool for Nutrients proposed in the new CAP *proposal* (Common Agricultural Policy).

For North America: **Matt Scholz, Sustainable Phosphorus Alliance**, identified as drivers: algal blooms, regulation, public incentives, threats of litigation (e.g. actions proposing the classification of manure as 'Hazardous Waste'), regulatory livestock capacity limits and objectives of supermarkets and the food & beverage industry of supply chain sustainability.

The Sustainable Phosphorus Alliance main activities in North America are networking and information sharing.

The Alliance's **Biosolids and Manure Task Force** is working on a compendium and map of regulations (this information is essential to develop processing and transport) and on dialogue between manure and sewage biosolids industries. The Alliance is promoting research that connects field-test phosphorus data to watershed-

level phosphorus transport models through its Phosphorus Field-to-Watershed Modelling Workshop, to be held in Columbus, Ohio, in August.

The Alliance is also participating in **phosphorus sustainability metrics development** efforts on behalf of both retailers and utilities.

Global: Petteri Taalas, World Meteorological Organization (WMO), noted that phosphorus and nutrients are embedded in several of the *United Nations Sustainable Development Goals*, in particular #2 "Zero Hunger", #6 "Clean Water and Sanitation" and #12 "Responsible Consumption and Production", as well as being linked to climate change.

International cooperation

Tabea Stötter, International Commission for the Protection of the Rhine (ICPR), summarised nearly 70 years action from the ICPR's establishment in 1950 to today (see SCOPE Newsletter *n°46*). The Rhine is over 1 200 km long, providing drinking water to 30 million people, and has a catchment population of 60 million. The ICPR brings together 9 countries plus the EU. Total phosphorus in the river has been reduced, e.g. at the German-Dutch border from around 1 mgP/litre in the early 1970's to below 0.1 mgP/l today. Phosphorus emissions have been reduced by 1/3 to c. 16 ton P/year in 2014. **This reduction results mainly from improved sewage treatment, and some 80 billion euro have been invested in municipal wastewater treatment in the catchment since the 1970's.**

Phosphorus levels are still higher than targets at some monitoring points, especially in small affluent rivers and further action is particularly needed on non-point sources. Nitrate levels are also higher than targets in groundwater in many places, and higher than Netherlands objectives when the Rhine reaches the North Sea.

Tabea Stötter accounts the ICPR's success to its institutional framework (e.g. principle of trust), contacts with stakeholders and public pressure. Tomorrow's challenges include e.g. climate change, micropollutants, nitrates in drinking water and better engagement with farmers (nutrients and pesticides).

Dmitry Frank-Kamenetsky, HELCOM (Baltic Sea Marine Environment Protection Commission, 8 EU Member States, Russia and the EU), underlined that eutrophication remains today the main threat to the Baltic Sea and the whole of the Baltic Sea is today still eutrophied. **Both phosphorus and nitrogen (N) inputs have been reduced (almost -30% and -20% since the 1990's) but both still exceed targets** and none of the Baltic catchment countries is yet achieving its objectives for phosphorus emissions.

HELCOM is concerned that the c. 27 000 tP/y of **phosphorus transferred from municipal wastewater to sewage sludge, is often just removed but not recycled**, so risking losses back into surface waters. HELCOM Recommendation Rec 38-1 (2017) therefore specifies "maximum recycling or recovery of phosphorus" (see ESPP eNews *n°9*) and the 2018 HELCOM Ministerial Declaration *commits* to elaborating a "Regional Nutrient Recycling Strategy" by 2020.

The principal concern for phosphorus inputs is today agricultural losses to rivers in the Baltic catchment. HELCOM actions to address this are aimed at smart nutrient management including farm nutrient accounting and development and use of manure nutrient content standards.

HELCOM sees perspectives to reduce nutrient leakage also from upstream diffuse sources through coordinated management of river basins and strives to engage river basin management authorities to align reduction requirements.

European policies

Sirpa Pietikäinen, Member of the European Parliament (Finland), outlined windows in EU policy for phosphorus sustainability, underlining the **need for a paradigm shift away from resource consumption** and to take into account Planetary Boundaries. Sustainable finance and economy tools are essential to support this. Key EU actions currently under discussion are: the Fertilisers Regulation revision, which aims to increase recycling of nutrients and of organic materials (carbon sequestration) whilst ensuring low contaminant limits; the upcoming Research and Innovation programme Horizon Europe (see discussion below); the CAP *revision*, which proposes farm nutrient budgets but fails to engage a move to nutrient-lean farming. Cross-compliance (e.g. nutrient limitations, water quality, air emissions …) may be reinforced in the CAP revision but this remains to be defined.

Marco Bonetti, European Commission DG Environment, noted that although progress has been made to improve phosphorus management over recent decades, with a reduction in Europe's gross phosphorus balance and a general positive trend in river and lake phosphorus levels, but that **there are still very important challenges to address, concerning pollution hotspots, eutrophication and resource consumption**. Commission actions to follow up the EU Consultative Communication on Sustainable Use of Phosphorus (see SCOPE Newsletter *n°95*) include the addition of phosphate rock and phosphorus to the Critical Raw Materials list, the Fertilisers Regulation revision proposal, Horizon 2020 and LIFE project funding. Important dossiers currently underway include:

- **EU Fertilisers Regulation** and **STRUBIAS**
- **Water Framework Directive** – currently under evaluation
- New **Common Agricultural Policy (CAP)** proposal *published* 1st June 2018
- *Draft* EU Water Reuse Regulation
- New EU research and innovation funding programme (FP9 – **Horizon Europe**, see below)

Mr. Bonetti concluded that more efforts for a sustainable use of phosphorus are needed, with opportunities for improving efficiencies and for recycling. The EU plays an important role, by funding research, through regulation, notably via a number of Directives aimed at protecting water quality, and as a contracting party in international agreements. **Dialogue is essential with stakeholders, including farmers**, to ensure that closing the nutrient cycle is both sustainable and socially accepted.

Pavel Misiga, European Commission DG Research, reminded that the **7th European Environment Action Plan** states "*excessive nutrient releases continue to affect air and water quality and to have a negative impact on ecosystems*" and calls for "*a more holistic approach*" and joined-up policy making. EU policies on nutrients are fragmented, so missing opportunities for efficiency and circularity. Examples are the failure to address risk supply dependency in international trade policy, or the contradictions between Water Framework Directive quality objectives and the current Common Agricultural Policy. **The EU's R&D action aims to address this fragmentation**.

In particular, in **Horizon Europe**, which will follow on from Horizon 2020, "Food and Natural Resources" are merged into one Cluster. R&D should support EU policies. The proposed Horizon Europe "Missions" (see below) should engage stakeholders and Member States to further advance cross-sector challenges, with clear target impacts, and maybe nutrient sustainability could be one or part of such a "Mission".

Mr. Misiga notes that **a number of significant EU-funded R&D projects are now addressing nutrient sustainability**: ESPP has catalogued over 230 projects, see *www.phosphorusplatform.eu/R&D* Further large-scale demonstration of nutrient recycling should be included in projects for the 2019 "Water smart societies" call (see summary of R&D project calls at *www.phosphorusplatform.eu/scope-in-print/news/1710-eu-research-funding-calls-related-to-nutrients*).

Elisabeth Bömcke, Fertilizers Europe, underlined that mineral fertilisers represent 80% of the market value of all fertiliser and soil amendment products sold in Europe. Fertilizers Europe represents seventeen mineral fertiliser companies with 120 production sites in Europe and nearly 80 000 staff.

She expects phosphate fertiliser consumption to be stable over coming years in Europe (with a small drop in Western Europe balanced by growth in Eastern Europe) whilst yields and protein contents must continue to increase.

The fertiliser industry is actively engaged in promoting nutrient use efficiency to farmers, with precision farming tools, product developments and additives to ensure appropriate nutrient release and crop uptake, training and information. The food chain wants "environmentally friendly" production, and nutrient management is a key element of this. Nutrient recycling is part of this future, and the mineral fertiliser industry intends to be a key player.

Success stories

Ostara struvite recovery from sewage works

Andrea Gysin: Ostara operates as a fertiliser production business, with today 14 production units operating and 3 more coming soon, producing recovered struvite CrystalGreen phosphate fertiliser in bio-P sewage works across the world. The product is recognised as an EC Fertiliser under the existing Fertilisers Regulation 2003/2003 since 2010.

She identifies three factors for Ostara's success: the product purity (and so the sales value of the product), recovery technology suite enabling recovery of up to 50% of works inflow phosphorus and the business model (long term contract where Ostara takes the recovered struvite from the sewage works). Overall, success comes with the market for the recovered product, not from the recycling technology.

Veolia: a range of recycling routes

Marisa Cunha: Veolia recycles in France around 1.5 million tonnes/year (wet weight) of organic wastes to farmland, via compost and direct application containing around 4 500 t/y phosphorus.

Long term field trials (20 years, QualiAgro programme) with INRA show the agronomic value of both composts and manure and enabled Veolia to develop a set of tools for farmers to optimise use of these organic products, including SoilDiag (NIR - Near infra-red- soil analysis in-situ) and SoilAdvisor. This is an organic fertilisation decision support tool, which takes into account the crop, soil and climate and provides a nutrient plan for use of both organic and mineral fertilisers. Veolia has also developed the STRUVIA phosphorus recovery process (photo above; see SCOPE Newsletter *n°121*). Combination with biological phosphorus release aims to achieve recovery of at least 50% of sewage works inflow P (bio-acidification see SCOPE Newsletter *n°126*). Veolia is running various pilot projects concerning bio-acidification and tertiary phosphorus recovery within the Phos4You project (Interreg) and PhosForce (EIT Raw Materials.

Recycling organic wastes as compost

Tomasz Wojciechowski, GWDA Poland, presented the company's experience recycling urban organic wastes as compost in the city of Pila, Poland. Since 2012, green wastes, straw and sewage sludge are composted together. Around 60% of the 80 000 t/y compost produced is used in agriculture, with application dependent on climatic conditions. The compost contains around 1.3% organic carbon (C_{org}) and 0.8% phosphorus (P).

Growing media from pulp & paper organics

Hannamaija Fontell, Biolan Oy, and **Sanna Pulkkinen, Metsä Group**: Over 90% of side-streams from Metsä's paper and fibre production are recycled, over half to energy and <10% to soil products.

Biolan produces around 200 000 m^3/year of growing media at the company plant in Eura. Around half of this is from secondary materials inputs and the remainder from peat and other primary materials. Pulp & paper industry by-products have the advantage of supply throughout the year. Biolan uses today around 2000 t/y by-products from Metsä. Biolan's Istutusmulta growing media product obtained the Finland Gardening Product of the Year 2018 award, chosen by Finland's garden retailers. (*www.puutarhakauppiaat.fi/biolan-istutusmulta-on-vuoden-puutarhatuote-2018*). Istutusmulta growing media contains around 10 % pulp and paper by-products.

Fertilisers from animal by-products

Kristy Blakeborough-Wesson: SARIA manages in the UK around one million tonnes/year of secondary materials, of which around half are animal by-products (ABPs) which are rendered. Treatment routes depend on the level of sanitisation required for safety: via anaerobic digestion (ReFood, producing methane and digestate, used as fertiliser), processing for return to the human food chain or livestock feed (Sarval) or incineration (Secanim: high risk ABPs = Category 1). The process respects Animal By-Product Regulation and the Waste Incineration Directive requirements for safety (e.g. min. 850°C for 2 seconds, absence of cross contamination between input material and ash). The ash from the Secanim process has End-of-Waste status (UK Environment Agency) and is sold as a fertiliser and soil improver in the UK and Europe as Kalphos (20% P_2O_5, 4% K_2O, 1% SO_3, 25% NV neutralising value).

Recycling phosphorus in fire extinguishers

Marco Michelotti, ProPHOS Chemicals, summarised the company's innovation in recovery for recycling of nutrients in fire extinguishers, which must be emptied and refilled regularly (see detail in SCOPE Newsletter *n°123*). The PHOSave project was developed with Horizon2020 EU funding support and the process is now operational, recovering some 5 000 t/y of mono ammonium phosphate and ammonium sulphate from fire extinguishers to fertilisers. The chemicals are purified, micro-granulated and are now being tested for use as fertilisers. Exhausted fire extinguisher powders across Europe represent a potential of around 100 000 t/y of such recyclable nutrients.

Gypsum soil application to reduce P losses

Markku Ollikainen, University of Helsinki, presented results of the SAVE -project aiming at improving water quality of the Archipelago Sea by applying gypsum to fields. The pilot project covers field trials of 1559 ha at 55 sites in Finland demonstrating the effectiveness of gypsum in reducing the phosphorus load from agriculture to waters. The gypsum is a by-product from the fertiliser industry (Yara) and is low in heavy metals and safe to use on fields.. A 4 ton/ha application of gypsum using standard farm spreading equipment reduced phosphorus losses from fields by around one half at a cost of c. 70€/kg P mitigated, that is around a third of other phosphorus loss mitigation measures such as buffer strips. Soil analysis looked at impacts on factors such as soil pH and particle size. Sulphur content of the phosphogypsum was determined to not be a problem at the relevant application rates.

Organic by-products to improve soils

Juuso Joona, Soilfood Oy, Finland, presented experience since 2016 producing organic fertilizers and

soil improvers from forest industry and bio-energy sidestreams.

Today the company delivers products to around 10 000 ha of cropland, recycling over 260 t/y of phosphorus and sequestering net 14 000 t/y of CO_2. The company is currently field testing several novel products such as biochars from forestry sidestreams and is developing a soil improver based on paper industry fibres, which has shown in tests to reduce phosphorus losses from soils.

Calcium phosphate from sewage sludge ash

Yariv Cohen, EasyMining, summarised the company's Ash2Phos process to recover industrial-grade calcium phosphate from sewage sludge incineration ash.

Sewage sludge mono-incineration ash can contain 8 - 11% phosphorus. The process uses acid (by-products) then lime at ambient temperature and pressure to recover calcium phosphate, which can be input for production of animal feed or fertiliser, and iron and aluminium hydroxides which will be further processed to coagulants for P-removal in sewage works (see SCOPE Newsletter *n°125*).

After successful pilot tests, a 30 000 ton ash per year plant is planned in Sweden, currently pending authorisation to import sewage sludge incineration ash. The sludge ash used in the pilot trails was imported from Copenhagen (Biofos). The process generates an inert silicate rich fraction (approx. 50% w/w of input ash) which can be used as a raw material for the cement industry. Heavy metals are separated for disposal.

100 000t/y P-recovery from ash planned

Rob De Ruiter, Ecophos, explained that the company's new Dunkerque factory is now operational since

January 2018 for the line using low-grade phosphate rock (100 million € investment) and that the line using secondary ash materials is now planned.

The site is now the biggest DCP (Di Calcium Phosphate mainly for animal feed) production plant in the world: 220 000 ton DCP. As a by-product, sulphate gypsum is produced containing residual phosphate, which is sold as a soil improver. The second line which will take 100 000 t/y of sewage sludge incineration ash and other secondary materials as input, will produce phosphoric acid and include modules to remove contaminants (heavy metals, iron, aluminium, chloride). The permitting process for this second line has now been engaged, following the successful start-up of the low-grade rock installation.

Recovering nitrogen from anaerobic digestion

Thijs Wolbrink, Nijhuis Industries, presented the company's experience in recovering ammonia from anaerobic digesters (AD) and raw manure.

Active ammonia stripping in AD reduces nitrogen return to sewage works in digestate dewatering liquor (so reducing denitrification costs), enables the use of high nitrogen content inputs to AD (e.g. poultry litter) and lowers nitrogen content in manure (so increasing on-farm spreading capacity). Ammonia recovery also improves operation of reverse osmosis (RO), so enabling water recovery. Nijhuis has today >15 manure and digestate treatment installations worldwide, with some installations now operating for over 10 years. More than 2 million tonnes of manure and digestate is processed annually and transferred into recovered water and organic fertiliser.

Efficiency of chemical P-removal

Outi Grönfors, Kemira, reminded that chemical phosphorus removal (using iron or aluminium salts) is the most widespread system worldwide for nutrient abatement in municipal waste water treatment plants (around 90% of P-removal in Europe uses these chemicals) and can achieve very low discharge consents, down to 0.1 mgP/l when combined with appropriate tertiary filter systems.

Kemira is now developing phosphorus recovery by maximising phosphorus precipitation in a tertiary chemical P-removal and separation stage, by using smart pre-treatment upstream of secondary biological treatment (dosing low-levels of polymers to improve settling of organic sludge). This process is an energy efficient solution as it increases the biogas production by 20-30 % and reduces the aeration energy up to 25 %. Over 50 % of waste water treatment plant inflow phosphorus is recovered as phosphate salt (iron or aluminium), with very low heavy metal levels. The organic contaminants such as pharmaceuticals are non-detectable. Pot trials have demonstrated its effectiveness as a phosphate fertiliser for rye grass.

Research project presentations

- **Eko Harden (Miiro Jääskeläinen)**: Electrokinetic oxidation technology is being researched at Töölö Bay, Helsinki. The aim is to block internal loading of phosphorus to the Baltic, by sediment mud compaction and organic matter degradation and also to degrade organic pollutants in the sediment. The method induces electrolysis and compaction using pulsed low voltage electric field.

- **VTT Resource Recovery container:** containerised, transportable, plug-and-play installation for wastewater treatment from small settlements with varying flows and temperatures, combining physico-chemical treatment units. Up to 99% P and 97% N removal.

- **UpCycle (Jonathan Trent)**: OMEGA (Microalgae Cultivation Using Offshore Membrane Enclosures for Growing Algae) research project, see 2012 report *http://www.energy.ca.gov/2013publications/CEC-500-2013-143/CEC-500-2013-143.html*

- **Helsinki Region Environmental Services authority (HSY) Finland (Laura Rossi):** Phosphorus removal by tertiary chemical precipitation, followed by processing of the chemical sludge to recover phosphoric acid (see under Site Visits below).

- **NPHarvest, Aalto University (Anna Mikola):** the objective is to recover phosphorus and nitrogen from tertiary treatment sludge (see above). Small-scale pilots are underway in Helsinki (see site visits below). The nitrogen is recovered using a membrane reactor by diffusion, then reacted with sulfuric acid to form ammonium sulphate.

- **Linköping University (Geneviève Metson)**: mapping of digestate production potential if organic wastes go to biogas production compared to crop nutrient needs in Sweden. Only around half of digestate can be used in agriculture within 5 km of production. The tool can be used to optimise digestate transport, and so costs.

- **University of Amsterdam (Marissa de Boer)**: modelling sewage phosphorus flows and recycling potential in the Netherlands, showing that P-recovery from sewage works could cover over 160% of Netherlands mineral phosphate fertiliser consumption

- **Pasrea Oy (Jaakko Mäkelä):** experimental sheep stabling system where sheep deep litter manure (with bedding and wood chips) is composted on the animal shelter floor. Air is drained through the perforated floor, removing ammonia and heat from the composting deep litter which can then be stripped and recovered
- **ReNu2Farm project (Laura Schöll):** this InterReg *project* aims to pilot test recovery of nutrients from sewage sludge, food waste and manure and develop recycled fertilisers corresponding to farmers' requirements.

Parallel sessions conclusions

ESPC3's six parallel sessions included a range of presentations and discussion, leading to conclusions presented in plenary:

- **Phosphorus, carbon, nitrogen, climate and food security**
  Led by: **Helena Kahiluoto**, Lappeenranta University of Technology, Finland, and **Anders Nättorp**, FHNW, Switzerland.

  - Data is available on global phosphorus consumption, but models for future requirements vary, and data for phosphorus footprints is needed further work, in particular to take into account manure reuse in livestock/meat P footprint
  - Further work is needed on links between phosphorus, recycling of organic materials (biosolids, composts, digestates) and carbon soil sequestration

- **Nutrient circular economy ***
  Led by: **Lassi Linnanen** – Lappeenranta University of Technology, Finland and **Geneviève Metson**, Linköping University, Sweden

  - Roll-out and scale-up of nutrient recycling will require:
  - value of co-benefits and externalities in price
  - acceptance by consumers, industry, supermarkets
  - integration across different scales and sectors
  - linking to other societal goals, such as bio-energy and carbon sequestration

- **Nutrients in agriculture and livestock**
  Led by: **Oscar Schoumans**, Wageningen University & Research, Netherlands and **Kimo van Dijk**, ESPP

  - Focus on whole nutrition system: human diet and nutrient needs, crop and livestock production
  - Regional approaches with stakeholders are needed to close cycles
  - Integration of nutrient management into EU CAP is essential
  - Develop nutrient accounting, permitting and trading
  - Consider economic incentives, such as tax/reward for nutrient surplus/reduction

- **Technologies for nutrient recovery from waste waters**
  Led by: **Pertti Keskitalo**, Ramboll Global Water, Finland and **Paula Lindell**, Finnish Water Utilities Association

  - First priority is quality of sewage biosolids, and so control of contaminants at source
  - Sewage biosolids are a sustainable source of bio-energy and of soil carbon, as well as of nutrients
  - Nutrient recycling technologies are available: information is needed to enable selection of the most long-term sustainable options
  - Policies are available and should be implemented to provide an enabling frame and encourage nutrient recycling, but not be rigid

- **Policy tools for sustainable use of nutrients**
  Led by: **Beatrice Garske**, University of Rostock, **Martin Verbeek**, Twente Mineral Valley NL and **Chris Thornton**, ESPP

  - Need for better coherence between policies on nutrients, water, soil, climate, food (holistic policy approach covering different environmental challenges)
  - Force of international/multinational agreements

- Successful policy needs knowledge base, monitoring, enforcement, dialogue and economic incentives/competitiveness
- Innovative policy tools, e.g. "phosphorus rights"
- Links to good practice codes, food industry sustainable purchasing criteria and to the reform of CAP (Common Agricultural Policy)

- **Ecological nutrient restoration, nutrient recovery from sediments and run-off water**
  Led by: **John McGrath**, Queen's University Belfast and **Stephen Hinton**, Swedish Sustainable Economy Foundation (TSSEF)

  - We cannot rely on land-based measures only for restoration of water bodies: reduction of Internal loading (nutrients in sediments) is needed
  - Further research is needed to understand the biogeochemistry of legacy nutrient cycling in freshwater, marine and estuarine systems, in particular links and interactions with climate change scenarios
  - Environmental restoration by nutrient removal can use both natural systems (e.g. wetlands; harvest of zooplankton-consuming fish) or technological approaches (e.g. WETSUS, phosphorus removal from water, winner of Everglades Foundation challenge stage 1)
  - Sediment or organics removal or in situ physico-chemical treatments should be further investigated: ecological and biochemical impacts and fate of contaminants need further research and monitoring of long-term effects

** = full summary of indicated parallel session is available at www.phosphorusplatform.eu/ESPC3*

Discussion of a Nutrients Mission for FP9

A workshop session at ESPC3 discussed a possible "Mission" around nutrient sustainability for FP9 (Horizon Europe).

The European Commission *published* the draft FP9 outline programme on 7th June. This new Research & Innovation funding programme (2021-2028) will follow on from Horizon2020 with an *announced* budget of nearly 100 billion €. It is proposed to include in FP9 "**Missions**" (art. 5 of published Regulation) which will be horizontal, across the five "Challenges" (thematic R&D funding): Health, Inclusive and Secure Society, Digital & Industry, Climate - Energy & Mobility, Food & Natural Resources.

Discussion on the possible content of a "Mission" on nutrients showed suggested that this should have wide content, linking to the agriculture – food system and health, environmental impacts, economy and to societal questions (consumer behaviour and attitudes to waste).

The following were suggested to include in a "Mission" related to nutrient sustainability:

- Address nutrients overall, not just phosphorus
- Wide approach, through to nutrition – food – diet
  - whole food production cycle
  - "systemic" and sustainable food production
- Healthy food
- Eutrophication and nutrient losses/impacts
  - links to EU water and air policies
- Restoration of eutrophic lakes, sediments
- Concepts of nutrient flows, stocks
- Need for data and science to support policy
- Link to sanitation, source separation
- Food waste
- Address societal disconnect between waste producers and users: convince householders they can contribute to change, inform consumers both of eutrophication impacts and food links
- Price of food, farmers' income, transition of the agricultural system
- Water treatment costs
- Bio-economy
- Resource efficiency
- Economic tools - externalities
- EU dependency on imported resources / international dependency
- Spatial distribution of livestock production
- Animal welfare

Conference conclusions

A final panel discussion brought together **Ari Kangas (Finland Ministry of the Environment), Max Schulman (MTK, Finland farmer and forest owners organisation), Elisabeth Bömke (Fertilizers Europe), Marco Bonetti (European Commission DG Environment) and Kristiina Kiviharju (Valio).**

Key points from panellists and **conclusions of discussion** with conference participants were:

- Improving **nutrient use efficiency** and **reducing losses** to the environment are critical, including reducing excess nutrient inputs to agriculture
- Importance of links to **agronomy, soil health, microbiology and organic carbon**
- Need to move nutrient recovery and recycling **from R&D to demonstration and full-scale** implementation, to prove feasibility, but difficulty of achieving this
- Need for **new investment and funding models**: e.g. public/private, long-term contracts …
- **Policies need to be more joined-up** (water, air, food, agriculture …) e.g. current CAP revision
- New **policy tools** (pollution rights, emissions trading), costing of externalities and co-benefits in prices
- A range of **companies already successfully implement** nutrient management and recycling
- Nutrient sustainability means **SME initiatives, innovation and job creation**
- Need to ensure **quality and safety** of recycled nutrient products
- Importance of **acceptance** of recycled nutrient products by the whole agri-food chain, including consumer attitudes to acceptance of wastes
- Positive messages and **marketing** are needed, but sewage works or recycling technology suppliers are often not sales companies
- The **fertiliser industry** is ready to take things forward, but needs significant quantities
- **Manures** are largest and cleanest nutrient flows
- **Joint efforts** are required with all parties in the agri-food chain to implement viable solutions that are accepted by both farmers and consumers
- Consumer **information and labelling** are necessary for this, but must be positive and understandable
- **Traceability** is demanded by the food industry, essential for consumer confidence, and feasible with big data and mobile devices. This is a key challenge to address

Site visits

Helsinki HSY
P and N recovery innovation

Participants visited the **Helsinki Region Environmental Services Authority (HSY) Viikinmäki wastewater treatment plant**, which treats sewage from more than half of Helsinki metropolitan area's population (800 000 p.e.) and industrial effluents, with the additional challenge of mixed storm water from downtown Helsinki. To improve working conditions for the operators and improve functioning in winter time, the sewage works are mostly underground, in excavated caves.

The treatment process is chemical P-removal with ferrous sulphate (iron (II) sulphate) and biological nitrification and denitrification. The current process achieves effluent levels of 0.2 mgP/l and 4 mgN/l. In 2017 the annual load to the recipient was 20 tonnes phosphorous and 443 tonnes nitrogen. The digested, dewatered sludge is composted, and peat, sand and biotite (a silicate mineral) are added to produce 80 000 m^3 of lawn soil which is sold by HSY under the brand name Metsäpirtti.

HSY has developed and tested at small pilot scale the **RAVITA phosphorus recovery process** (see ESPP eNews *n°15*). Phosphorus is chemically post-precipitated then separated using disc filtration. The resulting chemical sludge undergoes dissolution and solvent/solvent processes. Phosphorus is recovered as phosphoric acid and precipitation metal salts can be recycled back to the post-precipitation step. A 1 000 p.e. pilot plant for phosphoric acid production is under design and will be constructed in 2018. The process aims to be scalable to fit different sizes and types of sewage treatment plants.

Aalto University also presented pilot tests of the **NPHarvest** process, developed with funding from the Finnish government RAKI and EU Regional Development Funding. The objective is to recover ammonia using membranes. This process could be combined with RAVITA and use the phosphoric acid to produce ammonium phosphate fertiliser.

Kemira
World leader in water chemicals

Kemira, with 4 700 staff worldwide, is a global chemicals company serving customers in water intensive industries. The company provides expertise, application know-how and chemicals for drinking water and waste water treatment. Kemira is the world market leader and the only company to offer all of the main coagulant and polymers used in chemical phosphorus removal and in improving sewage dewatering and purification. Most coagulant chemicals are manufactured with raw materials from industry by-products.

Participants visited the **Kemira Research Centre in Espoo**, where 160 staff work, which is one Kemira's three research centres worldwide.

The visitors saw the company's range of analytical equipment, servicing Kemira field staff and customers, pot trials of rye grass using recovered iron phosphate as fertiliser (see above) and the **Kemira "smart technology" centre**.

Kemira offers optimisation systems to waste water treatment plants for phosphorus removal including appropriate selection of chemical and polymer, definition of dosing points, real-time monitoring, dosing optimization and distant operation steering. The use of smart technology enables support to plants operation to constantly improve based on experience and knowledge in the monitoring data base, so enabling reductions in chemical consumption, lower sludge production and better dewatering, lower and more reliable phosphorus discharge levels and improved energy efficiency in secondary treatment.

Future trends identified by Kemira include post-precipitation of phosphorus (using iron or aluminium salts), to achieve low phosphorus discharge consents and enable phosphorus recovery, and the use of pre-precipitation polymers to reduce energy consumption in secondary treatment, reduce sludge generation and increase biogas production in anaerobic digestion of sludge.

Yara
Precision farming & fertilisers of the future

Participants visited the **Yara Kotkaniemi Research Station** near Helsinki, which is part of the worldwide Yara Research Network (Yara has 16 000 employees, operations in 50 countries, and sales to 150 countries). The region has special agricultural conditions: one of the shortest growing periods in Europe at 170 days; mainly clay soils; snow cover for around two months which allows no winter crops. This implies intense growth and nutrient use in June/July.

The participants visited three field sites. The first station focussed on Yara's mission in **circular economy** and presented field trials with mineral and recycled P fertilizers and the equipment for their application, underlining the importance of the product particle size.

The second field site introduced Yara **sensor technologies for precision farming**, especially the N-Tester, a hand held tool which enables quick and easy measurements to be taken in a growing crop, and the Soil Scout Solution with soil sensor technology.

The third field site was about experiments on **optimum (mineral) phosphorus fertilization**, where long term field experiments with different crops and different fertilization patterns show P deficiencies or optimum P supply. It was stated that in Finland the soil P content has decreased over recent years.

Yara's **soil nutrient status monitoring technologies** which contribute to measured crop nutrition were emphasised as an important part of precision farming in the future.

Posters and slides

The following posters listed below presented at ESPC3 and slides of talks in the six parallel sessions listed below, as well as slides of the plenary talks summarised in this Newsletter, are online: *www.phosphorusplatform.eu/ESPC3*

For reasons of space, only the lead author of each poster is cited here.

Parallel session:
Phosphorus, carbon, nitrogen, climate and food security

Paul Withers - Lancaster University UK - The role of phosphorus in the resilience and sustainability of the UK food system

Jari Liski - Finnish Meteorological Institute - Finnish Carbon Action pilot project

Janne Helin - Natural Resources Institute Finland (Luke) - Impacts of global food demand and income growth on phosphorus demand

Juha Helenius - University of Helsinki - Agroecological symbiosis: food system redesign for bioenergy and recycling

Parallel session:
Nutrient circular economy

Fabian Kraus - Kompetenzzentrum Wasser Berlin (KWB) - Comparative Life Cycle Assessment of phosphorus recovery from wastewater path and phosphate rock based fertilizer production

Renske Verhulst - Netherlands Nutrient Platform (NNP) - Transition agenda: a multi-stakeholder approach in the Netherlands

Mathias Bergman - Baltic Sea Action Group (BSAG) - Breakthrough for nutrient cycling business ecosystem

Gauthier Boels - Yara - Nutrient circular economy: fertilizer company integration in circular value chains

Parallel session: Nutrients in agriculture and livestock

Giuliana D'Imporzano - LIFE-DOP project - Nutrient management best practices in dairy production for Italian cheese

Sari Luostarinen - Natural Resources Institute Finland (Luke) - Tools to calculate manure quantity and quality and to plan regional manure nutrient recycling in Finland

Arno Rosemarin - Stockholm Environment Institute (SEI) - PEGaSus project Phosphorus efficiency in pigs and poultry: bridging the gaps in the phosphorus value chain

Erik Sindhöj - RISE Agrifood and Bioscience - Baltic experience of slurry acidification

Parallel session: Ecological nutrient restoration, nutrient recovery from sediments and run-off water

Leon Korving - Wetsus - Phosphorus removal from diluted sources such as agricultural run-off and sewage effluent

Esa Salminen - Vahanen Environment - Speeding up the ecological recovery of the Baltic Sea by engineering (EUTROPH 6)

Anne-Mari Ventelä - Pyhäjärvi-instituutti - Commercial fishery is removing efficiently phosphorus from Lake Säkylän Pyhäjärvi

Bengt Simonsson - Techmarket - Nutrient retrieval from top sediment: a circular economy framework

Linda Kumblad - Baltic Sea 2020 - Remediation of Björnöfjärden: a eutrophic bay in the Baltic Sea

Parallel session: Technologies for nutrient recovery from waste waters

Anders Finnson - Svenskt Vatten (Swedish Water & Wastewater Association) - Swedish strategy for recycling of wastewater resources and EU's waste and recycling hierarchy

Christian Kabbe - Isle Utilities - From discussion to implementation: the impact of nutrient recovery targets and legal obligations on practical implementation

Mindaugas Šilininkas - Pageldyniu Plantacija: - Nutrient from municipal water treatment sludge recycling into biomass in Lithuania: experience and prospects

Esa Nikunen - City of Helsinki - BEST project (Better Efficiency for Industrial Sewage Treatment)

Parallel session: Policy tools for sustainable use of nutrients

Arabel Amann - TU Vienna - Strategies towards a sustainable phosphorus management in Austria

Stefan Russel - European Environmental Foundation - Development, implementation and management of nutrient circular economy in Poland

Herman Walthaus - Netherlands Ministry of Infrastructure and Water Management - Towards a circular production of biomass and food in the Netherlands

Jessica Stubenrauch - Leipzig and Leibniz Science Campus Phosphorus Research Rostock - Sustainable Phosphorus Governance from a cross-national perspective

Posters:

Using Phospho-gypsum to Reclaim Saline-Sodic Soils in Sinai Peninsula, Egypt - Abdelmonem Amer - Faculty of Agriculture, Menoufia University

Decentralized Wastewater Treatment With Full Recource Recovery - Is it Worthwhile? - Mona Arnold - VTT Technical Research Centre of Finland Ltd

Clay soil structure improvement and lime filters – engineered solutions to control phosphorus leakage - Anne-Mari Aurola - Nordkalk Corporation

Development of a method to track the organic phosphate compound 'phytate' during wastewater treatment - Niall Bradshaw - University of Sheffield UK

Evaluation of soil microfungi as efficient plant growth-promoting organisms for P mobilization for Glycine max - Andrea Ceci - Sapienza University of Rome, Italy (not published)

Phosphorus Elimination and Recovery from Wastewater and Process Water with Reusable Nanocomposite Magnetic Particles - Asya Drenkova-Tuhtan - Tallinn University of Technology, University of Stuttgart

Czech Phosphorus Platform - first steps - Duras Jindrich - Povodí Vltavy, Státní Podnik

Closing the loop on phosphorus - Erik Elting - Nedmag BV, The Netherlands

Nutrient Recycle in Urban Platform - Leena Erälinna - Brahea Centre, University of Turku

Growth with organic side streams from agriculture – MOSKU - Hannamaija Fontell - Biolan Ltd

Sustainable Soil-P-Management in Environmental and Agricultural Law - Beatrice Garske - University of Rostock

Investigating the impacts of a dairy processing plant on a river catchment - Rupert Goddard - University of Plymouth

Flash mixing for struvite precipitation - laboratory scale case study - Noora Haatanen - South-Eastern Finland University of Applied Sciences

Nutrient recovery from wastewater by microalgae - Jussi Huotari - University of Helsinki

The impact of biochars prepared from brewery wastes on phosphorus availability and growth of maize - Ioanna Manolikaki and Evan Diamadopoulos - Technical University

of Crete, Chania

Pasrea composting system with heat and ammonia reclamation for animal shelters - Jaakko Mäkelä - Pasrea Oy

Demo plant – concept for nutrient recycling - Jani Isokääntä - SFTec Oy and Sakari Kiviniemi, Rakeistus Oy

Soil phosphorus saturation as a risk assessment of phosphorus loss from agricultural soils - Beata Jurga - The Institute of Soil Science and Plant Cultivation, State Research Institute IUNG-PIB

Fertilizer concentrate out of biogas plant residue - Eeva-Liisa Juvonen - Häme University of Applied Sciences (HAMK), Finland

Consumption of Estonian phosphorite - Kadriann Tamm - Laboratory of Inorganic Materials, Department of Materials and Environmental Technology, Tallinn University of Technology

From forest to field - Kauppila Raimo - Yara Suomi Oy, Finland

Inhibition of phytase activity by polyphenol-rich extracts from sorgum, in relation to phosphorus sustainability - Theofilos Kempapidis - University of Sheffield, UK

Palopuro Agroecological Symbiosis – integrating biogas production into nutrient recycling - Kari Koppelmäki - University of Helsinki

Innovations for Phosphate Recovery at Wetsus - Leon Korving - Wetsus

Understanding the soil-like behaviour of secondary P-source - a necessity prior to agricultural use - Vaclavkova Sarka - Institute of Chemical Process CAS, Czech Republic

Recycling Phosphorus from the Water-bodies into Plant Production: Sediment Fe/P Ratio Is the Key - Mina Kiani - University of Helsinki

Decentralized wastewater treatment with full resource recovery - is it worthwhile? - Hanna Kyllönen - VTT Technical Research Centre of Finland

Manure phosphorus surplus from fur animal production in Ostrobothnia, Finland - Johanna Laakso - Natural Resources Institute Finland

Feeds and soil improvers from vegetable by-products - Lehto Marja - Natural Resources Institute Finland

Farmers looking for more efficient use of poultry manure - Sari Luostarinen - Natural Resources Institute Finland

Phosphorus Vulnerability Index (PVI) as a tool for Phosphorus security - Madhuri Nanda - Teri School of Advanced studies

Improving phosphorus availability and reducing emissions through soil health – experiences from 24 test fields - Tuomas Mattila - Helsinki University Ruralia Institute

Recovery of concentrated fertilizer product from biogas plant reject water - Kristian Melin - VTT Finland

From field to forests: Financial and environmental benefits of recycled nutrients within sustainable plantation forestry - Mirja Mikkilä - Lappeenranta University of Technology

NPHARVEST – Solution for converting wastewater nutrients into eco-friendly fertilizer - Anna Mikola - Aalto University

Phosphorus new resources and limitations in Agriculture - Kakha Nadiradze - Association for Farmers Rights Defense, AFRD

Enhancement of nutrient recycling and phosphorus balancing by a local BioCycle (BioKierto) model - Jarkko Nummela - Häme University of Applied Sciences (HAMK), Finland

Switzerland - current status and outlook for the world-wide first national implementation of mineral phosphorus recovery - Anders Nättorp - School of Life Sciences, FHNW

New sustainable products from the solid side streams of the chemical pulp mills NSPPulp – Kimmo Rasa – LUKE Finland

Gypsum spreading on fields to reduce phosphorus runoff - Markku Ollikainen - University of Helsinki

PAKU – from municipal sludge to contaminant free fertilizer - Salmimies Riina - Endev Oy

RAVITA - Laura Rossi - Helsinki Region Environmental Services Authority (HSY)

Pyrolysis as a method for improved phosphorus recycling of fur animal manure - Minna Sarvi and Sari Luostarinen - Natural Resources Institute Finland

SYSTEMIC research project - Oscar Schoumans - Wageningen University

Baltic Sea Nodularia spumigena contributes to methylphosphonate degradation and methane liberation - Jonna Teikari - University of Helsinki

Nutrient neutral municipality - Sanna Tikander - Centre for Economic Development, Transport and the Environment (ELY) for Southwest Finland

Restoring nutrient cycles in food systems – a regional perspective - Bernou Van der Wiel - Rhine-Waal University of Applied Science

The content of phosphorus in the soil in the Czech Republic - Elizaveta Watzlová - Research Institute of Agricultural Engineering

Nutrient recovery with source separation of urine - environmental benefits and fertilizer potential - Eeva-Liisa Viskari - Tampere University of Applied Sciences

Probabilistic environmental risk assessment – comparing primary and secondary phosphate-fertilizer application (Example: Cadmium) - Malte Zamzow - Kompetenzzentrum Wasser Berlin

Optimizing the phosphorus cycle in the sugar beet production process - Ana. A Robles-Aguilar - Institute für Bio- und Geowissenschaften, IBG-2: Plant Sciences, Jülich, Germany