

SCOPE NEWSLETTER

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ESPP defines statutes and actions

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New IWA Cluster brings together R&D, water industry and materials users to identify and develop technologies for resource recovery from waste waters.

Biofuel from algae
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Producing biofuels equivalent to US air travel would double agricultural phosphorus consumption unless nutrients are recycled

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Wastewater treatment was combined with vegetable production to recycle nutrients from fishery wastewater

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Bio-electrolytically generated high pH enables phosphate release

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Europe
Agricultural N and P balances

A comparison of N and P turnovers shows European imbalances and policy failures



2nd European Sustainable Phosphorus Conference
Berlin 5-6 March 2015

4th March "Circular approaches to phosphorus: from research to deployment", **Workshop organised by EU DG Research & Innovation, ESPP & P-REX**, registration necessary tomas.turecki@ec.europa.eu

5 -6th March – ESPC2
2nd European Sustainable Phosphorus Conference
Programme now online www.phosphorusplatform.eu
Registration: info@deutsche-phosphor-plattform.de

5 -6th March 17h30 German Phosphate Platform:
formal establishment, statutes, election of Board

To reserve stands at the ESPC2 conference:
1 500 €/ unit
(ESPP members benefit from one unit at 250 €)
info@phosphorusplatform.eu

The partners of the European Sustainable Phosphorus Platform



Platforms and policies

ESPP

European Platform defines statutes and actions

ESPP (European Sustainable Phosphorus Platform) was initiated at the 1st European Sustainable Phosphorus Conference (ESPC1, Brussels, March 2013). Since then, the Platform has taken forward a number of actions and activated its network, without a formal legal existence, giving time to better define its objectives. The Platform adopted statutes as a Belgium Not-for-Profit association on 2nd December 2014 and elected an initial Board.

Members are now invited to formally join the Platform. At the 2nd European Sustainable Phosphorus Conference (berlin 5-6 March 2015) the Platform's General Assembly (all paid Members) will elect a wider Board to take the Platform forward.

Actions to date

The 2nd December meeting (full minutes online at www.phosphorusplatform.eu see Downloads) summarised developments and **Platform actions since ESPP's initiation in March 2013**, including

- conclusions from EUC Sustainable Phosphorus Communication (SWD 2014)263, 1/8/2014, see SCOPE Newsletter 107)
- EUC Circular Economy Communication COM(2014)398, 2/7/14 (see SCOPE Newsletter 105).
- P added to EU "Critical Raw Materials" list 5/2014
- Sweden : sustainable P policy consultation
- Netherlands: struvite fertiliser legislation
- Denmark: recycling policy
- Baltic: nutrient recycling objectives
- Germany: P-recycling proposals, proposed sludge policy
- Switzerland: P-recycling regulatory consultation

ESPP actions and inputs have included

- ESPP input to EU Consultation on Sustainable Phosphorus (see SCOPE Newsletter n°95)
- European Economic and Social Committee Opinion on "Sustainable Use of Phosphorus"
<http://www.eesc.europa.eu/?i=portal.en.nat-opinions.30554>

- UK Parliamentary Office of Science and Technology briefing on phosphate resources (see SCOPE Newsletter n°107)
- ManuResource position on manure recycling and Nitrates Directive (see SCOPE Newsletter n°100)
- EU Fertilisers Regulation recast: (see SCOPE Newsletter n°104)
- REACH and "recovered" phosphates, REACH and digestate (see SCOPE Newsletter n°98)
- actions and input addressing R&D and Horizon 2020
- Biorefineries: BioRefine (see SCOPE Newsletter 103), Arbor (see SCOPE Newsletter 102), EU Commission meeting, Brittany (see SCOPE Newsletter 107)
- SCOPE Newsletter special "sustainable phosphorus society vision", published as SCOPE Newsletter 106
- Launch of P-REX "E-market" for recovered phosphate products on the ESPP website www.phosphorusplatform.eu
- Outreach and communications including participation in over 20 conferences and meetings, SCOPE Newsletter, ESPP Twitter @phosphorusfacts (used as a professional information channel), development of the website www.phosphorusplatform.eu (now managed by FHNW Switzerland)
- Coordination with **national phosphorus platforms**: Netherlands (2010), Flanders (2012), Germany (establishment of a not-for-profit association planned for 5/3/2015), France (meeting 7 July 2014, minutes on www.phosphorusplatform.eu), UK (meetings 24 September 2013 and 12 November 2014, with Biorefine), projects: Czech Republic, Norway, Spain ...

ESPP as a not-for-profit association

Establishment of ESPP as an independent legal structure will ensure clarity and transparency of governance and of finances, necessary for development of the Platform. Governance is guaranteed by the **new ESPP statutes** (consult on www.phosphorusplatform.eu under 'Platform' -> 'About Us') which specify the Platform's objectives, modes of action and decision making structures.

Platform decisions will be taken by the General Assembly, made up of all paying Platform

“**Members**”, in respect of Belgian legislation. A Board, including a President and other officers is elected by this General Assembly, from persons or organisations proposed by “Members”, to take forward the Platform’s actions. The “Secretariat” is the Platform’s paid staff or contractors, and is responsible to the President and Board.

The **European Platform’s actions are defined** as all those appropriate to the achievement of its objectives, including

- *promote through communications and awareness raising the general principles of phosphorus sustainability*
- *facilitate the definition of shared visions for phosphorus sustainability in Europe*
- *facilitate dialogue concerning proposals for policies, regulation and actions to further phosphorus sustainability in Europe*
- ...

In particular, the statutes state that “*The Board may define and validate positions, documents or communications to be published or made by ESPP, with the principle that positions should generally represent consensus of ESPP Members and Partners reached after consultation of all Members and Partners.*”

ESPP Objectives, as fixed by the new statutes:

- *to promote, facilitate, contribute to and/or implement phosphorus sustainability in Europe ... addressing the following issues:*
- *phosphorus as a non-renewable and critical resource for agriculture (food supply) and industry in Europe*
- *sustainable phosphate rock supply, mining and processing, including industrial applications*
- *phosphorus re-use, recovery and recycling in synergy with other nutrients/minerals and carbon/energy*
- *phosphorus use effectiveness and efficiency in agriculture (in crop and animal production) and the in the bio-economy (bio-energies and bio-materials production ...)*
- *sustainability and safety of the food chain, from farm to diet*”

Priority actions 2015

The meeting identified the following as priority actions for ESPP for 2015:

- Networking, access to expertise, experience: **structured data base of competence and experience** (if possible, use infrastructure already developed by an existing organisation), member webinars on thematic / technical questions, integrate with ESPP website “Opportunities” section
- **Awareness** (website / SCOPE Newsletter, social media <https://twitter.com/phosphorusfacts>, videos project – see in this Newsletter): communicating opportunities, innovation, success stories
- **Regulatory monitoring**: EU Commission thematic contacts
- **International (GPNM)**: objective launch of a global action on phosphorus at UNEP-GPA convention meeting 2016 (Global Programme of Action for the Protection of the Marine Environment from Land Based Activities)
- **ESPC2 Conference, Berlin, 5th-6th March 2015, and workshop 4th March on P-recycling R&D and implementation** (P-REX, DG Research)
- **Develop national platforms**, enlarge ESPP action to Baltic and Danube regions
- **EU Critical Raw Materials list**: develop P flows data and input to EU materials assessment process
- Stakeholder consultation on sustainable phosphorus **R&D priorities**

ESPP statutes: on www.phosphorusplatform.eu under Platform -> About Us
Full minutes of ESPP establishment meeting, Brussels, 2/12/2014
www.phosphorusplatform.eu under Downloads

Awareness & education SUSPHOS – ESPP videos project

The SUSPHOS (sustainable phosphorus R&D) network and ESPP (European Sustainable Phosphorus Platform) are planning to produce a series of short (2-3 minute) education (MOOC) – awareness videos on different aspects of phosphorus management, including environmental impacts, recycling, phosphorus and health.

These will update and complement the series of 5 videos produced in 2013 for the first European Sustainable Phosphorus Conference (ESPC1), and other videos available online by other organisations:



Existing phosphorus videos

- European Sustainable Phosphorus Conference (ESPC1) videos:
<https://www.youtube.com/user/PhosphorusPlatform/videos>
- The Phosphorus Challenge – general introduction (2'30")
<https://www.youtube.com/watch?v=Y17HqUsaoj8>
- Phosphorus and food security (2'30")
<https://www.youtube.com/watch?v=YXpnr9nmn4>
- Phosphorus and the environment (2'10")
<https://www.youtube.com/watch?v=iaYmj-4Z1dE&list=UUMid-39AIMT-3pzjoY58qiQ>
- Geopolitical consequences (2'10")
<https://www.youtube.com/watch?v=-QgwcQti0IQ>
- Netherlands Nutrient Platform presentation 2013 (2'30")
<https://www.youtube.com/watch?v=4Px6LYp-I0U>
- Understanding Phosphorus and its impact – interview of Vivek Voora, Lake Winnipeg, IISD International Institute for Sustainable Development (6'30")
<https://www.youtube.com/watch?v=KNSrG-k2KK0>
- Peak Phosphorus, Arno Rosemarin lecture, Stockholm Environment Institute (5'20")
<https://www.youtube.com/watch?v=HnNUMn1cQEA>
- Peak Phosphorus silent animation 2010 (1'25")
<https://www.youtube.com/watch?v=VHvsQXSEbQQ>
- 1st European Sustainable Phosphorus Conference (ESPC1) video (4'10")
<https://www.youtube.com/watch?v=2AuSj3CCqAM>
- The Phosphorus Problem and food chain sustainability, Netherlands National Think Tank 2012 (3'30")
<https://www.youtube.com/watch?v=RUO-34xLYg0>
- Flanders Nutrient Platform presentation (6')
<https://www.youtube.com/watch?v=1K-fTYUPTCc#t=43>
- Hidden Phosphorus – phosphorus food additives (8'30")
<https://www.youtube.com/watch?v=EDgUwGQXa2w>
- Arte documentary “Towards planetary famine – phosphorus scarcity” (50'45”), in French
<https://www.youtube.com/watch?v=sg6dAdaFC3w>
and in German
<https://www.youtube.com/watch?v=q7BSLOoUU90>
- P-REX phosphorus recovery from sewage
<http://vimeo.com/78539404>
- Aljazeera “Earthrise” recycling phosphorus (8')
<http://www.aljazeera.com/programmes/earthrise/2014121693225616272.html>
- Ostara Nutrient Recovery Technologies (4'0")
<https://www.youtube.com/watch?v=N7KH20F3lqc>

- NuReSys Nutrient Recovery Systems (5'40")
<https://www.youtube.com/watch?v=t0KK-olGirs>
- EcoPhos introduction to P life cycle (3'20")
<http://www.ecophos.com/#/en/ecological/>

SUSPHOS and ESPP aim to produce further **short videos in internet format** (2 – 4 minutes), combining animations, interviews and video footage, to update the existing ESPC1 videos and to address new questions and subjects around sustainable phosphorus management. The project is open to input from partners and stakeholders interested in contributing on particular subjects.

Proposed video series

The ideas below are a first selection, to be completed and adjusted as a function of stakeholder proposals:

Social aspects

- The phosphorus trilemma: global phosphorus equality

Status quo

- Where is phosphorus: overview of phosphorus cycles
- Phosphorus supply security, including geographic and industrial/political aspects
- P as a Critical Raw Material for the European Union

Food and diet

- How phosphorus supply is linked to food prices and food security, worldwide and in Europe
- P in diet, why we need it, but is too much a health risk ?

Livestock and animals

- P in animal feed: what goes in comes out (manure), precision feeding, use of phytase
- P-recovery from sewage

Agriculture

- Better use of fertiliser: sustainable intensification
- Reusing sewage biosolids to land: cycling organics and nutrients, why and why not ?

Phosphorus reuse, recovery and recycling

- from waste water treatment plants
- from manures
- from other sources
- different reuse routes, recycling technologies

Industrial chemistry

- White phosphorus, why industry needs it ?

Eutrophication

- P-removal in surface waters, how to address the Water Framework Directive objectives ?
- Eutrophication: causes, impacts, costs, prevention and restoration
- Challenges to remove and recycle phosphorus from lakes, rivers and drainage ditches (Highlands & Islands Enterprise https://interact.innovateuk.org/web/corporate/competition-display-page/-/asset_publisher/RqEt2AKmEBhi/content/phosphorus-and-priority-substances Everglades challenge <http://www.evergladesfoundation.org/grandchallenge/>)
- P in the Baltic: issues and actions

Success stories and examples

- P-recovery in action: success stories (P-recovery from sewage, recycling manure nutrients, restoring eutrophied lakes ...)
- ...

If you are interested in contributing, contact info@phosphorusplatform.eu

INI – International Nitrogen Initiative

Scientific support for sustainable nitrogen management

The International Nitrogen Initiative (INI) is a science-led platform addressing the anthropogenic nitrogen cycle and its environmental impacts, with the aim of providing recognised, objective, and agreed scientific information to support global decision-making and coordinated actions on sustainable nitrogen management.

Like phosphorus, nitrogen is a key element for plant growth, essential for food production. Yet the use of fertilizer and other compounds of chemically fixed nitrogen, along with cycling of manure and other biosolids, can lead to **different types of environmental damage**, as nitrogen “cascades” between environmental pools impacting air quality, water quality, soil, greenhouse effect and biodiversity.

INI (International Nitrogen Initiative) was established in 2003 as a joint SCOPE*/IGBP* project, without funding. INI operates globally, with activities organised in six regional centres: Europe, North America, Latin America, Africa, East Asia, South Asia. This overview focuses on the activities of INI Europe, the European centre of INI

* SCOPE = Scientific Committee On Problems of the Environment www.scopenvironment.org IGBP = International Geosphere-Biosphere Programme www.igbp.net

INI functions as a platform, facilitating cooperation and integration amongst researchers, and also between researchers - policy makers - practitioners. INI produces reports and other publications with the objective of strong and non-disputable scientific input to support policy decision making.

Synthesis of scientific data

INI supports **scientific and stakeholder exchange** through workshops and conferences, including the **6th International Nitrogen Conference**, held in Kampala, Uganda, November 2013. INI-Europe co-sponsored the **18th Nitrogen workshop** in Lisbon, July 2014. INI Europe also facilitates the organization of other scientific projects addressing nitrogen. For example, it was involved in establishing **COST action 729** “Assessing and managing nitrogen fluxes in the atmosphere-biosphere system in Europe”, the ESF network **NinE** (Nitrogen in Europe) and the EU funded projects **Nitro-Europe** and **ÉCLAIRE**.

INI Europe tasks include to inventory, review and synthesise scientific work on nitrogen management, nitrogen data and information (e.g. from EUROSTAT, OECD) and nitrogen-related activities (e.g. TFRN, the Task Force on Reactive Nitrogen operating under the UNECE Convention on Long-range Transboundary Air Pollution: www.clrtap-tfrn.org). TFRN operates under the Convention on Long Range Transboundary Air Pollution, and provides technical support of the possibilities and extent of emission reduction measures, specifically on ammonia. This Task Force also reaches out to cover wider issues that air pollution, with an Expert Panel on Nitrogen Budgets, an Expert Panel on Nitrogen and Food, and an expert group on N and climate. These mechanisms allow to bring scientific evidence developed by INI Europe directly into policy applications.

Scientific assessment reports

The most prominent output of INI Europe are its **scientific assessment reports** (available for download on the INI website www.initrogen.org), based on the combined strength of the INI network of experts.

The **European Nitrogen Assessment** (ENA), published by Cambridge University Press (Sutton et al. 2011) has become the **standard text on nitrogen related environmental issues in Europe** – covering sources, physical transformations, impacts, and the role of society in general with regard to nitrogen management.

Our Nutrient World: Together with the Global Partnership in Nutrient Management www.gpa.unep.org INI published “**Our Nutrient World**” (see SCOPE Newsletter n°96), a report promoting sustainable production and use of nutrients globally, putting food production in the centre of attention while suggesting options to minimize nitrogen related impacts. This report proposed the aspirational objective of -20% anthropogenic nutrient use by 2020 and outlined seven UNEP policy framework proposals.

Focal themes defined by INI Europe

1. **N budgets (pools and flows) and N pathways/emissions**, at different spatial levels
2. **Impacts** of N compounds in air and water on ecosystems and human health, including long-term cost-benefit analyses
3. **Effects of N on terrestrial ecosystems**, including interactions with air quality, climate change, agricultural productivity, carbon sequestration, biodiversity
4. **N inputs and effects on aquatic/marine ecosystems**, productivity and carbon sequestration, and of eutrophication, taking into account interaction with other drivers (phosphorus, P, and silica, Si)
5. N and P use and **food productivity**, looking at nutrient use efficiencies in food chains (NUE, PUE) and supply chain analysis
6. **Regional boundaries** for N and P use (extending the “planetary boundaries” question, see e.g. SCOPE Newsletter n° 103) in balancing food production, food security and adverse environmental impacts
7. **Improving N management and best practice:**

close the science-policy gap by coming up with practically useful proposals to improve nitrogen use efficiency (NUE) in different situations

Information: <http://www.initrogen.org/europe>

Contact: Wilfried Winiwarter, c/o Climate and Clean Air Commission, Austrian Academy of Sciences, Dr Ignaz Seipel-Platz 2, 1010 Wien, Austria. E-Mail: europe@initrogen.org.

The European centre of INI (INI-Europe) is now hosted by the Austrian Academy of Sciences, Climate and Clean Air Commission. Previously, it was operated at ECN in Petten, The Netherlands, and at CEH Edinburgh, UK. The steering board currently consists of Hans van Grinsven, Bruna Grizzetti, Kevin Hicks, Maren Voss, Wim de Vries, and Wilfried Winiwarter.

SUSPHOS - ICSPC

Phosphorus Chemistry for Sustainability

The 1st International Conference on Sustainable Phosphorus Chemistry, Florence, 4-5 December 2014, brought together scientists and companies using phosphorus compounds and developing new P chemistries to improve sustainability in sectors including catalysis (vital to improve energy and material efficiency in many chemical sectors, plastics and oil refining), fire safety, performance polymers and in energy and nutrient recycling from waste streams.



Industry participants were Magpie Polymers, Italmatch, Phos4Ever, Clariant, BASF, Solvay, Outotec, ICL, Chemconserve, Strem, Arkema and DSM.

The conference was organised by SusPhos, the EU (DG Research) funded network for Sustainable Phosphorus Chemistry. **SusPhos was launched in February 2013 and includes 12 graduate students and two postdocs** working on different aspects of phosphorus chemistry, societal acceptance and awareness.

Chris Sloopweg (VU University Amsterdam, the Netherlands), coordinator of SusPhos and organiser of ICSPC presented the “**Phosphorus Challenge**”

awareness video (see at www.phosphorusplatform.eu) during the opening ceremony and indicated that SusPhos and ESPP (European Sustainable Phosphorus Platform) are producing new video(s) on the sustainable use of phosphorus (see in this Newsletter).

The conference consisted of **eleven lectures by distinguished speakers from academia and industry** and offered a forum in Sustainable Phosphorus Chemistry to discuss the **latest developments in sustainable phosphorus building blocks and the application of phosphorus compounds in industry** covering, e.g., small molecule activation (P_4), P-based catalysis, metal phosphide nanoparticles, and P-based polymers, etc, etc...

Christopher Cummins (Massachusetts Institute of Technology) underlined the ‘cosmic scarcity’ of phosphorus, and how this is reflected in the **vital role of the element P in biological systems and life** as we know it (see *SCOPE Newsletter 109*). Furthermore, he discussed new approaches to P_2 building blocks that can lead to novel processes converting P_4 , via P_2 , to P_1 -chemicals without the use of toxic chlorine gas.

Jan Weigand (Technical University Dresden) outlined “green chemistry” objectives for chemical processes: **reduce the use of solvents and toxic reagents, improve atomic efficiency (process losses) and reduce the number of reaction steps** necessary. He underlined that phosphorus-based catalysts are key to achieving these objectives for a range of chemical productions and petrochemical refining processes and targeted the creation of a more sustainable P family tree (Sustainable Phosphorus Management, Springer, 2014).

Both speakers emphasised the **importance of white phosphorus (P_4) as a raw material** for different phosphorus chemicals for a wide range of industrial production processes, including sectors such as electronics, polymers and flame retardants for fire safety.

Sustainability challenges for phosphorus chemistry

Chris Thornton (European Sustainable Phosphorus Platform) explained how the Platform brings together companies, governments, researchers and stakeholders to **facilitate access to competence, experience and innovation in sustainable phosphorus management** and projects. Transfer of knowledge and technology

across sectors is important, because phosphorus sustainability involves very different sectors, such as agriculture, waste treatment, food products, chemicals ...

He suggested a number of **areas where new chemistries or transfer of chemical knowledge can support phosphorus sustainability**:

- Knowledge transfer between **medicine, limnology, agronomy, waste management** ...
- How can limnology science help **mobilise P in soils, release P from iron in sewage sludges** ?
- Inorganic / organic P interactions: new **organo-mineral recycled fertilisers**
- Transfer of **nano P chemistry** from medical applications to other sectors
- Understanding ionic balances (P, Ca, Mg, Na) in **P metabolism and health impacts** (kidney health, heart disease ...)
- Phosphate **precipitation chemistry**, from kidney stones to arteries, waste water treatment processes, P-recovery
- **Bioaccumulation, persistence and toxicity of new organic phosphorus chemicals**, e.g. flame retardant, lubricants, plastics additives
- Understanding **inorganic phosphates toxicity** results in REACH and implications for use safety
- P adsorption mechanisms on **bio-materials for P-recycling**
- **P-removal and recovery from dilute solutions** (surface waters, sediments, drainage ditches ...), e.g. US\$ 10 million Everglades Challenge (*SCOPE Newsletter 107*)
- Phosphorus (bio)chemistry for **improved crop/soil P-efficiency**
- **Halogen-free routes to green organic phosphorus chemicals**
- P-recovery and new P products in **bio-refineries**
- and many other opportunities ...

Improving catalysts

Guy Bertrand (USCD-CNRS, U.S. & France), Berth-Jan Deelman (Arkema B.V. Vlissingen, the Netherlands) and **Paul Pringle (University of Bristol, UK)** presented industrial developments and research investigations concerning **phosphorus-based ligands and catalysts** used in a range of industrial processes including major conversions I petrochemistry, use of carbenes in P chemistry,

producing tin compounds (e.g. used to reinforce bottles and ensure a longer reuse life), stabilising polymers used in many industrial and consumer products, sulphur-removal from fuels ... Such applications demonstrate the importance of phosphorus in non-fertilizer uses.

Nicolas Mézailles (CNRS, France) presented research aiming to improve production efficiency for the creation of **phosphorus compounds used in semiconductors, LEDs** (light emitting diodes), such as a range of unique metalphosphides M_xP_y . The use of nanoscale production techniques could potentially both avoid the need for chlorine chemistry to process white phosphorus to these materials, and produce new products with specific performance characteristics.

New phosphorus chemistries

Steven van Zutphen (Magpie Polymers, France) explained that how phosphorus behaves in specific organometallic complexes, is key to the chemistry of selective phosphonium-based ion exchange resins developed by the company and used for **capture and recycling of high-value elements, such as the platinum group metals**. Phosphorus chemistry enables the development of very varied, targeted functionalities for such resins.

Hansjörg Grützmacher (ETH Zurich, Switzerland) presented research into new classes of phosphorus containing building blocks, based on phosphorus (white phosphorus) and sodium, as precursors for a variety of **new organophosphorus compounds** that have, e.g., optoelectronic properties or can be used as P-based photoinitiators for polymer production.

Roland Krämer (BASF, Germany) presented the company's innovative research and development into **phosphorus-based, halogen-free flame retardant solutions**, for polymers used in applications such as electronics, transport, buildings, where fire safety is important. The most important question is the compatibility of the flame retardant with polymer processing and performance (electrical, mechanical, colour ...). Phosphorus flame retardants act both by reducing heat transfer in case of fire, generating a protective layer of char, and inhibiting the flame in the gas phase. In all cases, these reactions depend on the decomposition products of the specific polymer. BASF is developing a new micro-scale calorimeter to facilitate testing of phosphorus flame retardant – polymer combinations (smaller samples) and to give

better indications about char formation and heat release.

Ludwig Hermann (Outotec) explained that the company offers a range of technologies relevant to nutrient recycling from waste streams. The **Phosdryer® process** dries manures, sewage sludges or digestates with less than half of the energy needed by conventional dryers, so enabling dry fuel for downstream gasification and P-recovery from gasification residues. The concept has been developed for combining co-incineration, for instance in a cement plant, with P-recovery by separating the energy (product gas) and the nutrient flow. The dryer is a perfect fit to steam gasification. A first plant, processing sewage sludge and farmyard slurries, supported by the EU (LIFE+ and KIC InnoEnergy) will be inaugurated in Skellefteå, Sweden in coming months. Outotec also offers processes using either alkali or chlorine donors, with heat, to process sewage sludge incineration ashes and MBA (meat and bone ash) to remove heavy metals and produce a fertiliser product (plant available phosphorus). Other processes are also being developed to produce recycled fertiliser products from such ashes: Improved Hard (*SCOPE Newsletter 86*), Ecophos (*SCOPE Newsletter 104*), Recophos Germany (Inducarb, *SCOPE Newsletter 104*), or a white phosphorus furnace (as previously operated by Thermphos, *SCOPE Newsletter 87*).

SusPhos (Network for Sustainable Phosphorus Chemistry) and ICSPC (International Conference on Sustainable Phosphorus Chemistry) www.susphos.eu

European Sustainable Phosphorus Platform website, "Phosphorus Challenge" videos
https://www.youtube.com/user/PhosphorusPlatform/videos?view_as=public

Phosphorus reuse and recycling

Netherlands

Legislation recognised P-recovery

From the 1st of January 2015 it is legally authorised to use three types of recovered phosphates (struvite, magnesium phosphate and dicalcium phosphate DCP) as fertilisers in the Netherlands.

The legal recognition of recycled phosphates includes phosphates recovered from industrial or municipal or other wastewater (thus also including

agricultural wastewaters). The legislation covers struvite (magnesium ammonium phosphate) and dicalcium phosphate recovered from wastewaters, and magnesium phosphate produced by pasteurisation or drying of struvite. Struvite recovered from potato industry food processing wastewaters was already authorised as a fertiliser in the Netherlands.

Success of Netherlands Nutrient Platform

The Ministry of Economic Affairs has realized this improvement in the fertilizer law in cooperation with the Ministry of Infrastructure and Environment to **support the creation of a market for recycled phosphorus**.

This is a successful result of the **Dutch Nutrient Platform's action since 2011**, in particular the **Dutch Phosphate Value Chain Agreement** signed by more than 20 companies, knowledge institutes, NGO's, stakeholders and by the Netherlands Government <http://www.nutrientplatform.org>.

The recovered phosphates are allowed for use as a fertilizer only if the products do not exceed the **requirements for heavy metals and organic micro-pollutants** applicable for regular fertilizers.

It is also specified that the Ministry may define by decree treatments to ensure that phosphates recovered from sewage do not contain problematic pathogens.

Discussions are still underway as to whether the recovered phosphates used as fertilisers are legally considered to be a "waste" or a "product". The Ministry also indicates for struvite recovered from manures, nitrogen application is limited as for "processed manure" under the Nitrates Directive.

The published regulation also modifies the levels of phosphorus applicable to soils in the Netherlands under application of the **EU Nitrates Directive**: in the Netherlands the 4th Nitrates Directive Action Programme 2014-2015 limits phosphorus as well as nitrogen application, with the objective of achieving balanced fertilisation.

For more information (in Dutch) <http://zoek.officielebekendmakingen.nl/stb-2014-543.html>

The tables specifying limit levels for heavy metals and for organic contaminants in recovered and regular phosphates used as fertilisers in the Netherlands (Annex II, tables 1 and 4) are available here: http://wetten.overheid.nl/BWBR0019031/geldigheidsdatum_12-01-2015

IWA International Water Association Resource Recovery Cluster

The new IWA Resource Recovery Cluster brings together R&D, water industry and materials users to further improve the water quality by promoting economically and environmentally attractive concepts of resource recovery and to enable a bigger impact from the work of relevant IWA Specialist Groups on resource recovery.

The **International Water Association (IWA)** is a global network of water professionals, spanning the continuum between research and practice and covering all facets of the water cycle. Through IWA, members collaborate to promote the development and implementation of innovative and effective approaches to water management. The strength of IWA lies in the professional and geographic diversity of its membership – a global mosaic of member communities, including academic researchers and research centres, utilities, consultants, regulators, industrial water users and water equipment manufacturers. IWA members from each of these communities represent the leading edge in their fields of expertise; together they are building new frontiers in the research and implementation of water and wastewater treatment technologies, with the framework of the total water cycle.

The **strategic objectives of the resource recovery cluster** are:

- To **promote resource recovery from water and wastewater** by, e.g. identifying existing examples and exploring their potentials on extending to other places, outlining possible routes for resource recovery, assessing constraints and ensuring successful marketing strategies, etc.
- To **network on innovations** of resource recovery through conferences, meetings, working groups, publications, etc.
- To **promote links with complementary organizations** to find proper ways to build value chains where waste is converted to resources in a well-managed and beneficial way

Why resource recovery?

In various types of used water, from industrial or domestic sources, there **are valuable resources** such as energy (heat and organic matter); nutrients

(including nitrogen, phosphorous and other minerals); and there is particular value in the form of the matrix itself i.e. water. It has been calculated that for sewage (domestic used water) the potential value is in the order of €1.6 per m³ [Verstraete and Vlaeminck, 2011; Int J Sust Development and World Ecology 18: 253-264] and, since on average a person discharges some 50 m³ per year, this value represents some €80 per person equivalent (PE) per year. Of course these values are theoretical, as the resources need to be processed before use.

Resource recovery is also about **saving costs for utilities**. If used water, loaded with pollutants, has to be cleaned by means of conventional technology, this imposes considerable costs. Over the past 100 years the treatment of used water has seen the development of a series of processes that have focused on 'dissipation' i.e. removal of unwanted elements. This has gradually increased the expenses incurred by used water treatment plants so that today it costs about €1 to treat 1 m³ of used domestic water or €50 per PE per year [Verstraete et al. 2009; Bioresour Techn 100: 5537-5545]. In other words, instead of recovering the €80 of value per PE per year that is discharged in the sewer, the utilities have to deal with a cost of about €50 per PE per year to make the water 'ready to be discharged back into nature'. Utilities are increasingly aware that there is a need to re-think the current technology, which has focused on making valuable resources 'disappear'. Such technology should be replaced by new technologies that make valuable resources effectively 're-appear' so that they can be collected, marketed and reused.

Also, the **current 'dissipative' technology** uses considerable energy (up to 1% of the total electricity use in industrialized countries [Caldwell 2009; Third Eur Water and Wastewater Conf]). Moreover, the organic matter present in used water is burned by biological oxidation to CO₂; and for many countries the residual amount of organic carbon, harvested as sludge, is also incinerated releasing CO₂. Changing mindsets to recover energy and nutrients will make a contribution towards **mitigating climate change**.

A further reason for focusing on resource recovery is to **strengthen the cyclical economy**. For example, recovering precipitated carbonates from water softening or iron oxides from drinking water production and upgrading them to be used in other industrial processes, such as the glass industry, can prevent landfill.

Demand orientation

Recovery must be oriented towards **the demand side**. The Cluster will explore the market interface willing to work with recovered products as alternatives to newly made or freshly mined products. A key issue will be the dimensions of scale because industry and agriculture rely heavily on competitive prices and efficient delivery as well as stringent quality characteristics, whereas resource recovery is relatively small scale

A major element of resource recovery from water and water systems relates to the **overall acceptability to the public**, regulatory frameworks and economies of scale. There is a need for widespread communication to educate and inform key audiences about used resources. This will facilitate the use of recycled resources and enhance cooperation between various sectors within agriculture and industry in order to secure the future of resource recycling.

Resource Recovery Cluster actions 2015

Following the success of the organization of several Cluster workshops, the development of a best practice tool and the preparation of a resource recovery compendium report (open access to be online soon), the key activities of the Cluster in 2015 will be:

- Active involvement in the World Water Forum in April 2015 in Daegu, South Korea. A Book with 5 white papers on various water aspects is being prepared, including one on resource recovery from water and used water. It is expected that issues related to **legislation and hazard assessment** of recovered products from water and used water systems will be prominent amongst participants and policy makers.
- The first IWA World Conference on Resource Recovery from 30 August to 2 September, 2015 in Ghent, Belgium. The theme of the conference is **'Bridging towards the chemical industry'**; the main aim of the meeting will be to create better 'pipelines' from water resources to industries. For more information visit www.iwarr2015.org

IWA Clusters: www.iwa-network.org Contact: Dr. Hong Li, Specialist Groups Manager hong.li@iwahq.org



Biofuel from algae

Nutrient and resource demands

Resource and nutrient demands for biofuel production from open-pond cultivated algae (*Chlorella sp.*) are estimated for different biofuel production technologies, and the potential to reduce N and P consumption by recycling is assessed.

In **Venteris et al. 2014**, US national-scale models of algae growth through open pond cultivation, are applied, with biomass to biofuel conversion efficiency estimated for hydrothermal liquefaction (HTL) and for lipid extraction (LE) biofuel recovery. Nutrient demands are estimated including considering post-fuel biomass recycling by anaerobic digestion (AD) or catalytic hydrothermal gasification (CHG). Scenarios producing 19 and 80 billion litres/year of biofuel are considered (the latter is approximately equivalent to US annual kerosene consumption for aircraft fuel).

The HTL extraction technology shows significantly lower resource consumption: for the 80 bn l/y scenario 6.7 million ha of land, 13.9 billion m³ of saline water and 11.3 billion m³ of fresh water. Without nutrient recycling, this scenario would require additional nitrogen inputs of c. 1.5x that currently used in US agriculture as mineral fertilisers, and additional phosphorus inputs of c. 1.06x current US agricultural P fertiliser use (total consumption for both would more than double).

Nutrient recycling

If nutrients are recycled in the biofuel production system (through GHG), additional **nutrient demand could be reduced to c. 44% for N and c. 36% for P** (of current mineral fertiliser consumption). Nitrogen consumption is one area where LE technology may retain an advantage, as additional N consumption could be reduced to only 15% of current demand. The authors consider that these demands (after recycling) could be fulfilled by nutrient recovery from animal manures.

The authors conclude that even for this relatively modest objective for biofuel production (via open-pond algae cultivation), **recycling of nutrients from post-fuel by-products and use of recovered nutrients from waste streams (manure) to feed the algal production would both be essential.**

Zhang et al. 2014 assess on-site nutrient recycling technologies for residues from biofuel production from algae. They consider anaerobic digestion (AD) and hydrothermal liquefaction (HTL), in both cases with the resulting digestate used to feed the biofuel algae production, as the best available energy plus nutrient recycling processes. They estimate that for 1 kg dry weight algae produced, 41g N and 4g P can be recovered via AD and 26g N and 7g P by HTL. The lower recycling rate from AD is because more of the phosphorus is in the solid fraction of the digestate and cannot therefore be fed to the biofuel algae production ponds (or it would block sunlight). However, more nutrients are recycled if the digestate is used as an agricultural soil amendment.

Alba et al. 2013 have shown that such biofuel production residues can be repeatedly recycled back into algal production, with no apparent toxicity but with a possible need to re-add certain micronutrients.

Potential of microalgae

Rösch et al. 2012 note that microalgae offer **five times higher solar energy fixing potential than terrestrial plant systems**, and could in theory produce 10 – 100 x more biofuel oil per hectare. However, such productivity requires high nutrient (N and P) inputs.

Using wastewaters as a nutrient source for microalgae cultivation is one important route to recycle nutrients and reduce “new” nutrient requirements for biofuel production, however this poses problems of contamination in high-performance algae cultures which aim to produce a single species in highly controlled conditions. Another route is to recycle the N and P present in the wastes when the algae are processed to extract biodiesel.

The authors note that **nutrient recycling can take place at different stages of the algae processing.** During harvesting, algae are separated by centrifuge and the separated water contains nutrients which are returned to the cultivation. In the stage of lipid separation, an oil free residue is produced (algal cell remains after lipid extraction), consisting mainly of carbohydrates and proteins. The biodiesel produced is treated to remove phospholipids (degumming). Three different possible routes for processing this by-product are considered: thermal gasification, anaerobic digestion, use as animal feeds. The modelling on these recycling paths indicate that the **production of one litre of biofuel from algae requires 0.23 – 1.55 kg N and 29 – 145 g P.**



Between 30 – 90% N and 48 – 93% P could be potentially recycled back to the algal production, with the highest nutrient recycling rates being achieved through hydrothermal gasification of residues after biofuel extraction. The technical feasibility and the possibility of heavy-metal accumulation when these residues are recycled need to be assessed.

“A national-scale comparison of resource and nutrient demands for algae based biofuel production by lipid extraction and hydrothermal liquefaction”, *Biomass and Bioenergy*, in print 2014 <http://dx.doi.org/10.1016/j.biombioe.2014.02.001>

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“A comparison of on-site nutrient and energy recycling technologies in algal oil production”, *Resources, Conservation and Recycling* 88 (2014) 13–20

<http://dx.doi.org/10.1016/j.resconrec.2014.04.011>

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“Recycling Nutrients in Algae Biorefinery”, *ChemSusChem* 2013, 6, 1330 – 1333, <http://dx.doi.org/10.1002/cssc.201200988>

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“Materials flow modeling of nutrient recycling in biodiesel production from microalgae”, *Bioresource Technology* 107 (2012) 191–199 <http://dx.doi.org/10.1016/j.biortech.2011.12.016>

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Aquaponics

Crop production for nutrient recycling

The potential of tomato, cucumber and aubergine plants to recycle nutrients from fish production wastewater was assessed in a recirculating aquaculture system (aquaponic RAS) in Switzerland. Specially designed trickling filters

were used to nitrify the fishery wastewater, in which the crop plants were grown. Up to 70% nitrogen recycling was achieved and up to 40% phosphorus.

Aquaponic (recirculating aquaculture) systems combine fish and plant cultivation in a cycling system, where **the plants can use the nutrients present in the fishery wastewater**. In this study, the fishery wastewater from a 2.5 m³ fish tank (producing Kenyan tilapia or Eurasian perch) was fed to special trickling filters containing light-expanded clay aggregate (LECA), in 30cm vegetable boxes, providing both a surface for biofilm growth and a cultivation medium for crop plants. Unlike in many fisheries, in this case the fish faeces were not separated, with the objective of recycling also the nutrients present in this waste. As a control, the same crops were grown in a hydroponic system (no solid substrate, using fertiliser nutrient solutions). Plant biomass and fruit production were monitored, as were nutrient budgets.

The crop-growing trickling filter system showed good performance for fishery wastewater treatment, achieving **water quality parameters comparable to a conventional bio-filter system**. Nitrification capacity was estimated as 0.26 kg fish feed/m³ LECA. N and P removal in the aquaponic trickling filter were 0.4 – 3.3 gN/m³/day and 0.08 – 0.43 gP/m³/day (per surface area = footprint of filter pots).

Nutrient recycling, calculated as the proportion of fish feed input nutrients recovered by harvesting above-ground vegetation (that is, not only in the fruit) was estimated at 9 – 70% N and 5 – 37% P, depending on the different crops.

The authors note that the nutrient removal is related to trickling filter volume, whereas the nutrient uptake by plants (so recycling rate) is related to footprint (surface exposed to sunlight). They conclude that the system was able to treat the fishery wastewater adequately and produce both fish and vegetables suitable for human consumption, and therefore that **nutrient recycling through crop production can be adapted to urban areas with limited available space**.

“Aquaponic Systems: Nutrient recycling from fish wastewater by vegetable production”, *Desalination* 246 (2009) 147–156 [doi:10.1016/j.desal.2008.03.048](https://doi.org/10.1016/j.desal.2008.03.048)

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Microbial electrolysis

Recovering P from iron phosphate

A lab-scale microbial electrolysis cell showed 95% phosphate release from iron phosphate (contained in digested sludge) when the near-neutral digestate in the cathode chamber was increased above c. pH 12 by application of electrical current (causing release of hydrogen gas, so depletion of H⁺ ions).

The microbial electrolysis cell tested consisted of a 0.04 litre cathode chamber and a stirred 2.5 litre anode chamber, separated by a Nafon™ proton-exchange membrane. The anode was equipped with several carbon fibre tissue electrodes. The cathode contained a platinum-sputtered vitreous carbon electrode.

Real sewage sludge digestate test

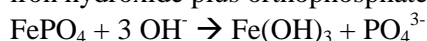
The anode chamber was filled with **artificial wastewater, based on *E. coli* K12**, and the cathode was filled with distilled water, to which **sewage sludge digestate** was added: 0.2 – 1.2 g of dried, milled (23µm) particles. For a first period (c 24 hours), under various applied voltages (0.2 – 6V) hydrogen gas was vented from the cathode chamber resulting in a pH increase in this chamber. In the following period (1-12 hours), again under applied voltages, phosphate was released into solution.

At time intervals, samples from the chamber solutions were centrifuged to remove solid particles, then **analysed for iron and phosphorus** using ICP-OES, so enabling assessment of release of iron and phosphate into solution.

Results showed **up to 95% solubilisation of phosphate from the iron phosphate present in the sewage sludge digestate** particles, after one hour at pH 12.3 or higher. This was confirmed by testing the cell using pure iron phosphate (85% mobilisation in 1 hour at pH > 12).

Iron phosphate solubilisation by hydroxyl substitution

The authors consider, based on pH change monitoring and modelling, that electrochemical reduction is not a significant mechanism in the phosphate mobilisation, which is considered to be principally due to **hydroxyl substitution** as follows, giving as products insoluble iron hydroxide plus orthophosphate:



The authors conclude that the release of phosphate from iron phosphate was **significantly faster in this microbial electrolysis cell than under microbial fuel cell conditions**, and that the low voltages applied generate a strong sustainable chemical base, reliably over time. They suggest that, subject to scale-up, the process has potential as an add-on for sewage works using iron salts for phosphorus removal to recover phosphate and hydrogen.

“Microbial electrolysis cell accelerates phosphate remobilisation from iron phosphate contained in sewage sludge”, Environ. Sci.: Processes Impacts, 17 (1), pages 90 – 97, 2015.

<http://pubs.rsc.org/en/content/articlelanding/2014/em/c4em00536h#!divAbstract>

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Europe

Agricultural N and P balances

OECD member countries are obliged to submit annual calculations of soil N and P balance, and more recently EUROSTAT has started estimating N and P balances at the NUTS-2 level (TAPAS 2007). These balances must be compared to soil P status, as net phosphorus application is justified if soil has low phosphorus as is the case in much of Central – Eastern Europe.

The authors show that N and P application levels in Europe are correlated to GDP and to population density, but **not to fertiliser requirement** (soil N and P status or expected crop yield). Furthermore, GDP is correlated to livestock density (and so to manure production). The amounts of manure and mineral fertiliser applied per hectare were +70% higher in the EU15 than in the EU12 ‘accession’ states, with particularly high levels in the Netherlands, Belgium, Luxemburg, Germany, Ireland and Denmark.

Soil phosphorus – negative correlation

The **proportion of land with high P-status** (good or very good soil P supply) is over 50% in Belgium, Norway, the Netherlands, Denmark, Ireland and Sweden. The proportion of land with high P-status is very much lower in the EU12 ‘accession’ states than in the EU15.



Comparison of soil P status to P fertiliser balance shows a negative correlation: that is, the opposite of agronomic logic – soils needing higher phosphorus application are overall actually receiving less, and, on the other side, soils with very good or excess P status, needing no mineral or organic P application at all, receive the highest amounts.

Cumulative balances and environmental impacts

Since the introduction of the **Nitrates Directive** (1991/676), total N surplus applied to land in the Netherlands, Belgium and Denmark has exceeded 2000 kg N/ha. As for phosphorus above, cumulative nitrogen balances are significantly lower in the EU12 ‘accession’ states. Comparison shows that the countries with higher cumulative N balances are those with high levels of groundwater nitrate pollution, and that those with lower cumulative N balances have lower nitrate pollution.

The authors conclude that **EU regulations are not achieving their objectives** as regards nutrient application and resulting pollution. They recommend:

Recommendations

For nitrogen fertilisation:

- Limiting nitrogen application to take into account manure nitrogen, both as applied in the same year and as accumulated from previous years
- Including soil N status and cumulative N balances in agro-environmental indicators

For phosphorus a “Phosphorus Directive” including:

- Application limits for P, taking into account crop P response
- Limiting P application to take into account phosphorus in manures applied during the year and accumulated over previous years
- Complete banning of phosphorus application over 50 kg P/ha/year
- Banning of P application to soils which already have excess P
- Including soil P status and cumulative P balances in agro-environmental indicators

For all fertiliser use

- Field testing of environmental impacts of fertiliser recommendations
- Definition of an OECD reporting method for

fertiliser balances, applicable to all EU member states

- Among the EU Member States, harmonization calculation methods for organic manure N and P contents and for their uptake over years, and of maximum permissible (plant uptake organic + total mineral) N doses, etc. This should be undertaken in their Nitrates Directive National Action Programs. This harmonization has been completed among the OECD countries on livestock and crop specific N and P contents (as part of land surface OECD N and P balance calculations)

Lastly, the authors note that a **major restructuring of livestock production across Europe is essential**, in that EU environment policies are not effective in reducing nutrient pollution if livestock density is market driven.

“Sustainable Agricultural NP Turnover in the 27 European Countries”, P. Csathó csatho.peter@agrar.mta.hu and L. Radimsky, in “Organic Fertilisation, Soil Quality and Human Health”, E. Lichtfouse (editor), 354 pages, Springer, 2012 <http://www.springer.com/life+sciences/agriculture/book/978-94-007-4112-6>

See also “Agriculture as a source of phosphorus causing eutrophication in Central and Eastern Europe”, P. Csathó et al., summarised in SCOPE Newsletter n°72.

See also publications concerning fertiliser recommendation system based on the correlations of Hungarian long-term field N-, P-, and K- fertilisation trials 1960 to 2000.

Németh, T. 2006. Application of the Bray-Mitscherlich equation approach for economically and environmentally sound fertilization of field crops in Hungary. *Communications in Soil Science and Plant Analysis*, 37: 2227-2247 <http://dx.doi.org/10.1080/00103620600817556>

Csathó, P., Árendás, T. and Németh, T. 1998. New, environmentally friendly fertiliser advisory system, based on the data set of the Hungarian long-term field trials set up between 1960 and 1995. *Communications in Soil Science and Plant Analysis*. 29. 2161-2174 http://link.springer.com/chapter/10.1007%2F978-94-017-3674-9_84

Csathó, P., Árendás, T., Fodor, N. and Németh, T. 2009. Evaluation of different fertilizer recommendation systems on various soils and crops in Hungary. *Communications in Soil Science and Plant Analysis*. 40: 1689-1711 <http://dx.doi.org/10.1080/00103620902895797>

Fodor, N., Csathó, P., Árendás, T., Radimsky, L. and Németh T. 2013. Crop nutrient status and NPK balances, obtained in the field trials, evaluating of different fertilizer recommendation systems on various soils and crops in Hungary. *Communications in Soil Science and Plant Analysis* 44 (5): 996-1010 <http://dx.doi.org/10.1080/00103624.2012.747611>



Agenda

- ❖ 15-16 Jan 2015, ETH Zurich, Switzerland: **P in Agriculture: where are we going** http://www.plantnutrition.ethz.ch/box_feeder/booklet_2p.pdf
 - ❖ 15 Jan, Ghent, Belgium, VCM: **Fertilisers from manure - rules for placing on market** (Dutch and French) www.vcm-mestverwerking.be/agenda
 - ❖ 21 Jan, Berlin, **International Green Week: Recycled Phosphate Marketing Event** www.gruenewoche.de/en
 - ❖ 13 Feb, Nürnberg, Germany, Biofach 2015: **Recycling phosphorus fertilisers - Should we change organic regulations?** www.biofach.de
 - ❖ 23-25 Feb, Istanbul, WEX Global 2015 “Water, Energy and the Zero Waste Society” <http://wex-global.com/event/>
 - ❖ 24 Feb 2015, Nottingham, UK, **Phosphorus removal from catchments** (AquaEnviro) <http://www.aquaenviro.co.uk/view-product/Phosphorus-Removal-from-Catchments--Technology-or-Source-Control>
 - ❖ 24 Feb 2015, **Loeben, Austria, RecoPhos thermal P-recovery pilot demonstration**, registration necessary <http://www.recophos.org/c/mid,1363,Events/> See SCOPE Newsletter n° 104 <http://www.phosphorusplatform.eu/scope-in-print/past-issues.html>
 - ❖ 2-3 March, Rostock, Germany, **Phosphorus Science Campus Rostock Symposium** <http://www.wissenschaftscampus-rostock.de/>
- ❖ 4th March, BAM Berlin, "Circular approaches to phosphorus: from research to deployment", **Workshop organised by EU DG Research & Innovation**, ESPP & P-REX, registration necessary tomas.turecki@ec.europa.eu
- ❖ 5-6 March 2015, Berlin: **2nd European Sustainable Phosphorus Conference** www.phosphorusplatform.eu
- ❖ 5th March, 17h30, Berlin, formal establishment as a not-for-profit association (eV) of the **German Phosphate Platform (DPP) official signature of statutes, election of Board**
- ❖ 23-25 Mar 2015, Tampa, Florida: **Phosphates 2015** (CRU) www.phosphatesconference.com
 - ❖ 29 March – 3 April 2015, Australia. **Beneficiation of phosphates VII** <http://www.engconf.org/conferences/mining-and-metallurgy/beneficiation-of-phosphates-vii/>
 - ❖ 31 Mar - 3 Apr, Seattle, International Conference on Livestock and Poultry Environmental Quality – **Waste to Worth** <http://water.okstate.edu/news-events/conferences/waste-to-worth-2015>
 - ❖ 12-17 April 2015, Vienna, Austria, **European Geosciences Union: P soil biochemistry, P across boundaries, P-recovery** www.egu2015.eu
 - ❖ 3-7 May 2015, Barcelona, SETAC Livestock Environmental Assessment and Performance (LEAP) Partnership session, **challenges for global modelling of N & P in agriculture supply chains** http://barcelona.setac.eu/home/?contentid=767&pr_id=766
 - ❖ 1 May – 31 Oct. **Expo2015** Feeding the planet, energy for life, Milano <http://en.expo2015.org/>
 - ❖ 18-20 May 2015, Marrakesh, Morocco: **SYMPHOS** www.symphos.com
 - ❖ 18-21 May, Gdansk, Poland, **IWA Nutrient Removal and Recovery Conferences** <http://www.iwahq.org/2jw/events/iwa-events/2015/nrr2015.html>
 - ❖ 18-22 May 2015, Washington DC, **Phosphorus Research Coordination Network (P-RCN)** <https://sustainablep.asu.edu/>
- ❖ 19 May, Washington DC **launch of the North America Partnership for Phosphorus Sustainability (NAPPS)** <https://sustainablep.asu.edu/>
- ❖ 30 Aug – 2 Sept, Ghent, Belgium, Bridging towards the chemical industry **1st IWA Resource Recovery Conference** <http://www.iwarr2015.org/>
 - ❖ 12-16 Sept., Rostock, Germany, **8th International Phosphorus Workshop (IPW8)**, Phosphorus 2020 – Challenge for synthesis agriculture & ecosystems <http://www.wissenschaftscampus-rostock.de/>
 - ❖ 1-2 October, Vienna University of Technology, **“Mining the Technosphere: Potentials and Challenges, Drivers and Barriers”** helmut.rechberger@tuwien.ac.at
 - ❖ 11-14 October 2015, Ithaca, New York, USA, **2nd International Conference on Global Food Security** www.globalfoodsecurityconference.com
 - ❖ 2-4 Dec 2015, Ghent, Belgium, **ManuResource II** (manure valorisation) <http://www.manuresource2015.org/>

Sustainable P Initiative blog

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