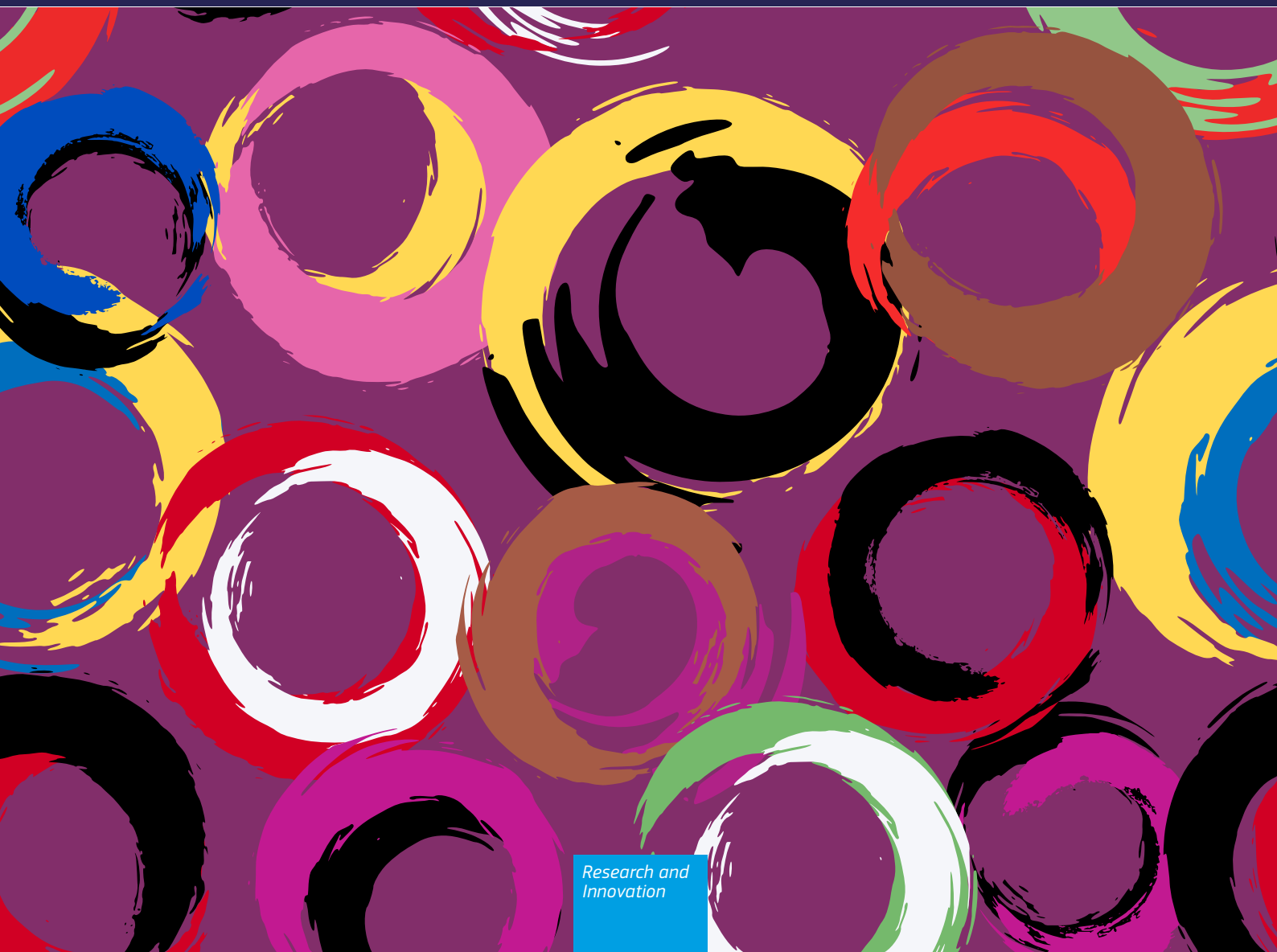
European Commission

Circular approaches to phosphorus:

from research to deployment



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2015 Directorate-General for Research and Innovation EN

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Executive Summary

The workshop "Circular approaches to phosphorus: from research to deployment" brought together 80 participants and 28 nutrient recycling research and demonstration projects funded by the EU (FP7, LIFE+, InterReg) as well as nationally funded projects and industry initiatives.

The projects presented have addressed sewage sludge reduction and recycling of nutrients from sludge by means of organo-mineral fertilisers, the content and fate of organic contaminants in sewage sludge after different treatments, and recovery of phosphorus from sewage sludge ashes. Demonstration of phosphorus recovery as struvite at a pre-industrial scale in municipal waste water treatment plant was also presented as well as a project emphasising more cross-sectoral and international networking in combination with piloting and demonstration of good practice techniques. Besides projects focusing on sewage sludge, others addressing nutrient recovery from livestock manure were presented as well.

Extensive assessment of a number of different routes and processes for phosphorus recovery from municipal sewage sludge and its reuse shows that some processes are already at a commercial production scale, e.g. struvite recovery or EcoPhos process using sludge ash. Numerous other approaches investigated by research institutes or industry are also promising.

The economic value of recovered phosphates as fertiliser does not cover recycling costs. In some cases, implementation is driven by operational cost savings (e.g. reduced waste disposal costs, P-removal chemical purchase and maintenance) or operational improvements in water treatment. Another way forward is to high added-value recovered phosphorus products such as pure phosphoric acid or white phosphorus P_4.

The workshop identified the following research and demonstration needs:
- phosphorus flow studies based on real monitoring data to identify points for P-recovery implementation
- social science (attitudes, acceptance, skills, choices) to accompany phosphorus recycling implementation
- actions covering the whole value-chain, from P-recovery to recycling
- detection, monitoring and risk assessment of organic contaminants in sewage sludge
- agronomy research into phosphorus use efficiency in farming practices and crop availability of recovered nutrient products
- support for the development of harmonised standards, regulations and product criteria
- full-scale demonstration in real environment
- frameworks for clustering of projects and networking

A strong message from participants is the need for policy support for phosphorus recycling and for the Nutrient Circular Economy. Also, regulatory barriers to market rollout were noted, with the message that coherent interpretation of existing relevant EU and national legislation is a precondition for widespread implementation.

The full workshop report below includes short summaries of presentations and discussions as well as one-page factsheets for projects and initiatives present. The inventory of nutrient recycling projects and initiatives developed through the workshop is now accessible and is maintained updated at www.phosphorusplatform.eu.

Introduction

This report constitutes a summary of presentations and discussions which took place at the workshop "Circular approaches to phosphorus : from research to deployment" held at the German Federal Institute for Materials Research and Testing (BAM), Berlin on 4 March 2015. The workshop was organised by the European Commission (DG Research & Innovation), the European Sustainable Phosphorus Platform (ESPP) and the P-REX project. It was attended by 80 participants representing 28 nutrient recycling research and demonstration projects funded by the EU (FP7, LIFE+, InterReg) as well as nationally funded projects and industry initiatives.

The workshop aimed to bring together research and demonstration projects on phosphorus recovery and recycling from across Europe, with industry practitioners and experts, to:

- enable contact between the different projects in order to exchange information, transfer experience and build synergies,
- take stock of research and demonstration projects and related networks dealing with phosphorus recovery and recycling,
- identify further research and demonstration needs to support development of the circular economy for nutrients,
- discuss implementation, identify obstacles and opportunities for moving from research to market rollout and societal uptake, including adapting to different local contexts.

The latter three aims determined the structure of the report below. Inputs coming from presentations made at the workshop are marked with endnotes providing a link with the list of presentations at the end. The presentations are available online at http://phosphorusplatform.eu/conference/espc2015.

1. Research and demonstration activities underway

The dominant sources from which phosphorus can be recovered include waste water and sewage sludge, livestock manures, food waste and biofuels production. The possibilities for nutrient recovery have been extensively studied especially in connection with the management of sewage sludge from waste water treatment. Currently, 50% of Europe's sewage biosolids are valorised on farmland, so recycling nitrogen, phosphorus and other nutrients and contributing to maintain soil organic carbon. Maintaining this reuse route is a priority for nutrient management, but requires attention to contaminants, in particular organic ones [1].

End-o-Sludg (www.end-o-sludg.eu), a recently completed FP7 project, took an overall approach to improving municipal sewage sludge management, looking at sludge reduction, solid-liquid separation by air flotation, recovery of biopolymers (BioPOL) and recycling of nutrients (P, N, carbon) by production of an organo-mineral fertiliser.

BioPOL is produced by milling the sewage sludge to break down cell structures and release biopolymers, then treated with alkali salt (NaOH). BioPOL was tested as a flocculant, and showed potential for replacing petro-chemical polymers in sludge treatment. This would enable use of a renewable product derived from the sewage itself for this process, and would avoid spreading of the petro-chemical polymer flocculants.

The organo-mineral fertiliser produced from treated sewage sludge showed good agricultural performance, with nutrient plant availability contributing to crop growth, as well as increasing soil carbon (positive for nutrient plant use, water retention and so drought resistance, and for soil structure thus reducing soil loss and erosion). Contaminant levels measured were considered not problematic. However, difficulties were encountered in producing pellets of the organo- mineral product with sufficient density and physical resistance for use with farmers' fertiliser spreading equipment [2].

Regarding the contaminants present in sewage sludge, the **ROUTES** project (FP7, www.eu-routes.org) studied organic contaminants in sewage sludges under different treatments (ultrasound, thermal at 135°C, anaerobic digestion) and in agricultural spreading. Organohalogens (EOX), detergent surfactants, polyaromatic hydrocarbons (PAH), PCBs and phthalates were analysed, as well as four pathogen families. The treatments considered reduced levels of these contaminants by 2 – 5 times. Sewage sludge has been used in agriculture over decades without any negative impacts. ROUTES project proved that usual sludge application rates to soil assure negligible ecological or toxicity risks. Detailed data is available in the presentation slides online at http://phosphorusplatform.eu/conference/espc2015 [3].

As an example of a demonstration project, a LIFE+ project **PHORWater** (www.phorwater.eu) was presented. This demonstration project pursues an integrated nutrient management model and phosphorus recovery as struvite at a pre-industrial scale (4.4 m^3, 3m height), implemented at the El Cidacos municipal wastewater treatment works, Calahorra, Spain (23 000 m^3/day, biological nutrient removal). Around 20-30% of the P entering the sludge line could be recovered by this technology. At present, some 70% of inflow phosphorus precipitates in the anaerobic sludge digesters.

The project involves modelling (using DESASS©) and rethinking of the treatment plant configuration, sludge / liquor management lines and recirculation paths in order to optimise phosphorus removal performance and phosphorus recovery for recycling [4].

Phosphorus recovery from sewage sludge ashes has been addressed by the **RecoPhos (thermal)** project (FP7, www.recophos.org). This technology for P-recovery from sewage sludge ashes or other P-containing dry wastes is based on the InduCarb furnace, heated to 1 300 °C using electrical induction, and producing elemental phosphorus (as a gas) and carbon monoxide (syngas, which can be used as a fuel). The pilot today is at a scale of 10 kg/h of dry waste input. Conditions inside the reactor enable iron to be mainly kept separate from phosphorus, so that iron-containing sewage sludge ashes can be used. The phosphorus produced was reacted to (high purity) phosphoric acid. At an industrial scale, it could also be maintained as white phosphorus (elemental P_4), a high-value industrial raw material.

The RecoPhos (thermal) consortium considers that the output slag could be granulated for use in the cement industry. Also, a pre-treatment step could be developed to use the reactor's waste heat for flash-drying of sewage sludge, which could be then fed directly into the reactor. To take this

project forward, a larger scale demonstration plant now needs to be built and operated (at least 100 kg/h input) [5].

Besides sewage sludge, ongoing projects address also phosphorus recovery from livestock manure and its subsequent reuse. **BioEcoSim** (FP7, www.bioecosim.eu) aims to recover a stabilised organic soil amendment product (biochar) and nutrient fertiliser products (P and N salts) from manures. The process involves acidification (sulphuric acid), solid/liquid separation, struvite precipitation and ammonia recovery, supercritical steam drying and pyrolysis of the organic fraction. The project includes construction and testing of a pilot plant (capacity 100 kg raw mass manure per hour) and assessment, including analysis of regulatory aspects of recovered product marketing [6].

Similarly to BioEcoSim, **ManureEcoMine** (FP7, www.manureecomine.ugent.be) focuses on livestock manure. The project is testing technologies to recover nutrients and energy from manures: pig manure (Netherlands) and cattle manure (Spain). It is using a combination of biological nutrient removal, anaerobic digestion, ammonia stripping and H_2S0_4 absorption, precipitation of struvite or potassium struvite (4 litres/hour lab scale reactor), production of an organic fertiliser product from manure solids and use of treated water for irrigation [7].

Finally, as an example of a broader approach, the **BioRefine** project, funded by the Interreg IVB programme (www.biorefine.eu) addresses the recycling of inorganic chemicals from agro- and bio-industrial waste streams. BioRefine puts a lot of emphasis on cross-sectoral and international networking where the actions include support for the establishment of regional nutrient platforms and dialogue between the different networks. The project also identifies nutrient recovery techniques from different waste streams which would be most suited for quantitative and qualitative nutrient requirements of the market. Good practice techniques are explored at pilot scale and in demonstrations. In this respect, BioRefine is working with industrial operators who are implementing struvite recovery from different waste streams, for example Aquafin at municipal wastewater treatment works in Leuven, Belgium. The project's work should result in new strategies for cross-sectoral resource recovery [8].

2. Further research and demonstration needs

Within the Seventh Framework Programme for Research and Technological Development (FP7), a number of calls offered support to projects addressing various aspects of phosphorus recovery and recycling. Research and demonstration projects in this area received over 21 million euros under FP7, with additional funding provided under the LIFE+ and InterReg programmes [9].

While much research has been done or is ongoing, the workshop identified the following R&D needs:

- Phosphorus flow studies based on real monitoring data (mass flows, characteristics), targeted to identify points for P-recovery implementation and phosphorus management
- Social science (attitudes, acceptance, choices) to accompany P-recycling implementation
- Focus on actions covering whole value-chains, from P-recovery to recycling of the phosphorus products, that is through to market and use
- Detection, monitoring & risk assessment of organic contaminants in sewage sludge and recovered nutrient products, in the field, the environment and throughout the food chain
- Agronomy research into phosphorus use efficiency in crops and farming practices to reduce P-losses, including demonstration, outreach and training for farmers
- Long-term agronomy research into crop availability of recycled nutrient products, long-term field trials assessing soil – organics – recycled nutrient interactions
- Support for full-scale demonstration projects, including monitoring and assessment in real environment to result in references to enable real market replication
- R&D to support development of harmonised standards, regulations, best available techniques and practices, and product criteria
- Frameworks for clustering of projects and networking, enabling synergies and experience transfer, reducing duplication and losses of know-how generated in single projects.

The need for clusters of projects, with a long time-horizon, was identified as important for research and demonstration in order to facilitate networking, to enhance impact of research on policy, to improve synergy and mutual learning and facilitate market uptake. The clustering and networking can also foster longer term approaches to nutrient circular economy than individual projects, facilitating continuity from research to spin-off market implementation. In this respect, the **BioRefine Cluster** provides a good example (www.biorefine.eu/cluster). It aims to ensure continuity and synergy of research into biorefining, by coordinating related research projects across Europe with industrial players. The critical mass of projects working together optimises impacts and transfer to implementation and facilitates interactions between research developments, policies and markets [8].

Horizon 2020, the EU research and innovation programme, continues to play an important role among the possible sources of research and innovation support. Funding opportunities for further efforts in the nutrient recycling domain can appear under Societal Challenges 2 and 5, and through the InnovFin initiative (www.eib.org/products/blending/innovfin)

Priorities for innovations in the water management to be supported under Horizon 2020 are identified by the European Innovation Partnership on Water (EIP Water, www.eip-water.eu) bringing together industry, government and research stakeholders. Among the EIP's priorities is waste water treatment, including recovery of resources. Nutrient recovery is specifically addressed by two action groups: ARREAU (www.eip-water.eu/ARREAU) and Anaerobic Membrane Bioreactor for Recovery of Energy and Resources (www.eip-water.eu/AnMBR).

Coordination of national research efforts in the water domain falls within the remit of the Joint Programming Initiative "Water challenges in a Changing World" (www.waterjpi.eu), which provides also research funding under its joint calls [9].

3. Barriers and opportunities for deployment

In terms of market readiness, the **P-REX** project (FP7, http://p-rex.eu/) assessed a number of different routes and processes for phosphorus recovery from municipal sewage sludge and its reuse, looking at a variety of technologies, their costs, risk assessment, legal framework and market potential. A key conclusion is the importance of producing recycled nutrient products which correspond to users' needs and requirements in aspects such as quality, physical characteristics, or logistics. Another essential success factor for implementation is the potential to meet the waste water treatment operators' requirements and needs. Full-scale applications successful to date all offer operational benefits for waste water treatment plants.

It is to be noted that some processes are already at the commercial production scale, e.g. processing manure to organic fertiliser, calcium silicate filter media for diffuse farm P-removal, struvite recovery or EcoPhos process using manure and sludge ash [10].

Identification and uptake of emerging technologies can be facilitated by processes such as the Technology Approval Group (TAG) supported by Isle Utilities (www.isleutilities.com). The TAG works with water utilities at the global level to assess new technologies, select and then carry through collaborative testing trials at water treatment plants. Criteria considered in the process include technology readiness, but emphasise market and implementation factors. An example of a technology that went through the TAG process is Bioptech's polonite, an innovative filter material that effectively removes phosphorus, bacteria and to some extent nitrogen from wastewater. Bioptech are now working on setting up a trial with a number of water utilities [11].

Phosphorus recovery solutions are often specifically adapted to local contexts, either because of local by-product streams rich in phosphorus or local potential users of recovered products. Processes using locally available materials for P-adsorption to produce a nutrient rich soil amendment (e.g. oyster shells, posidonia, orange skins, etc.) can have strong implementation potential in some regions only, necessitating appropriate approaches to industrial roll-out. Hence, within the EU framework, regional approaches are necessary, addressing specific local situations, for different waste streams, different potential users and logistics for recycled nutrient products (different crops, possible local industry users, storage and transport solutions, etc.). Some recycled phosphorus fertilisers may be more suitable to niche markets (organic farming, specific soils, perhaps outside of the EU) [1].

Discussions at the workshop underlined that policy is essential to support implementation of nutrient recycling at a wide scale, because the price of mineral fertilisers is relatively low compared to technology and logistics costs of recycling nutrients. Locally, nutrient recycling is driven by savings in waste disposal costs or improvements in water treatment operation, both pushed by regulation (waste disposal regulation, biosolids spreading limits, water treatment obligations). To invest, industry needs a clearly defined and reliable policy framework.

At the same time, complexity of existing regulation concerning recycling and reuse, and differing interpretations and implementation in different Member States, are a significant obstacle to developing a market for nutrient recovery technologies and for recycled nutrient products. Companies planning to market secondary phosphates or recycling technologies across the EU need a consistent interpretation of EU legislation. In this respect, clear end-of-waste criteria with EU-wide applicability for sludge and resources recovered from sludge and for biodegradable waste subject to biological treatment (compost/digestate) are needed.

As a priority, a revision of the EU Fertiliser Regulation is necessary to extend its scope to nutrients from secondary sources (e.g. recycled phosphates) and organic sources. At the same time, quality criteria should be set, especially regarding the thresholds for impurities. Such revision would facilitate the marketing of fertilisers containing recycled nutrients from secondary sources across the EU and improve the user confidence in their quality.

The P-REX project published the **P-REX policy brief** for decision makers (http://p-rex.eu/uploads/media/P-REX_Policy_Brief_final.pdf). In broad agreement with discussions at the workshop, the policy brief concludes that wide-spread implementation requires:

1. Realistic and reliable European phosphorus recovery targets
2. Obligation for national or regional action plans for phosphorus recovery
3. Clear guidelines stopping contradictory national interpretation of European legislation around recycling of phosphorus from waste, especially into fertilisers

4. National mechanisms for fair distribution of the cost of phosphorus recovery (e.g. fertilizer mixing quota, recovery obligations)
5. Financing of demonstration projects, because references are necessary for market penetration by innovative technologies and products [12].

The workshop concluded that research and demonstration projects should be closely coordinated with network actions (e.g. BioRefine, European Sustainable Phosphorus Platform, national/regional nutrient platforms) to ensure input into policy processes aiming at developing a nutrient circular economy by means of innovation.

Annex 1: List of presentations at the workshop

The presentations listed below are available online at:
http://phosphorusplatform.eu/conference/espc2015.html

[1] Christopher Thornton. European Sustainable Phosphorus Platform. www.phosphorusplatform.eu.

[2] Richard Clarke (United Utilities) and Ruben Sakrabani (Cranfield University). End-O-Sludg: Phosphorus Removal and Recovery.

[3] Giuseppe Mininni (CNR – Water Research Institute). Sludge preparation for agricultural use: results from the ROUTES project

[4] Laura Pastor Alcañiz (Depuración de Aguas del Mediterráneo). PHORWater: Integral management model for phosphorus recovery and reuse from urban wastewater.

[5] Harald Raupenstrauch (Montanuniversitaet Leoben). RecoPhos: Recovery of phosphorus from sewage sludge and sewage sludge ash.

[6] Jennifer Bilbao (Fraunhofer Institute for Interfacial Engineering and Biotechnology). BioEcoSIM: Valorisation of livestock manure into a range of stabilised soil improving materials for environmental and economic sustainability.

[7] Maël Ruscalleda (University of Girona). Phosphorus recovery from livestock manure for green fertilizers production: The ManureEcoMine project.

[8] Erik Meers (Ghent University). BIOREFINE: Innovative strategies for the recycling of inorganic chemicals from agro- and bio-industry waste streams.

[9] Tomáš Turecki (European Commission DG Research & Innovation). Funding opportunities under Horizon 2020.

[10] Christian Kabbe (Kompetenzzentrum Wasser Berlin). Fostering phosphorus recovery and recycling from sewage sludge: Opportunities for Europe.

[11] Suzanne Faber (Isle Utilities). Barriers to Technology Deployment & Isle's TAG Forum.

[12] Sirja Hukari and Anders Nättorp (University of Applied Sciences and Arts Northwestern Switzerland). The P-REX Policy Brief: Phosphorus recycling – now!

Annex 2: Flash presentations and posters

In addition to the speakers, a number of other nutrient recovery & recycling projects and networks presented posters (indicated by * below: these are online under the ESPC2 conference posters file www.phosphorusplatform.eu/conference/espc2015/47-espc2-highlights/586-espc2-posters.html) or made short summaries, so enabling information exchange and networking.

*Ludwig Hermann, Outotec, Finland: **DeBugger** (Demonstration of efficient Biomass Use for Generation of Green Energy and Recovery of Nutrients), funding EIT KIC InnoEnergy (www.kic-innoenergy.com/case-study/debugger/).

Oene Oenema, ALTERRA Wageningen University, Netherlands: **Fertiplus** (FP7, www.fertiplus.eu). Identifying and testing processing technologies to produce compost and biochar from municipal solid waste and farm wastes.

Kurt Möller, University of Hohenheim, Germany: **Improve-P** (ERA-NET Core Organic II, https://improve-p.uni-hohenheim.de), assessing phosphorus recycling in organic farming, taking into account potential for urban nutrient recycling and risk assessment of possible contaminants.

*Hong Li, International Water Association: **IWA Resources Recovery Cluster** (http://www.iwa-network.org/cluster/resource-recovery-from-water-cluster), brings together R&D, water industry and materials users to further improve water quality by promoting economically and environmentally attractive concepts of resource recovery. The first IWA Resource Recovery Conference will take place in Ghent, 30 August – 2 September www.iwarr2015.org.

*Carme Garcia i Belinchón, Cetaqua, Spain: **NECOVERY** (LIFE+, www.life-necovery.eu), rethinking the waste water treatment plant flow sheet of tomorrow to optimise energy (biogas) and nutrients recovery (P-recovery as struvite and N adsorption onto natural zeolites)

Oscar Schoumans, ALTERRA Wageningen University Netherlands: Manuvalor. Full scale pilot manure treatment plants, one under construction in the Netherlands (100 000 tonnes manure raw weight per year), one planned in Germany.

Manasis Mitrakas, Aristotle University, Thessaloniki, Greece: **PhoReSE** (ERDF funding, 2014-2015, www.phorese.gr): Phosphorus recovery from secondary effluents of municipal wastewater treatment plants. Pilot plant (300 m^3 per hour) to start-up soon, using ferric hydroxides to recover P as calcium phosphate.

Jennifer Bilbao, Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB), Germany: **PhosFarm** (FP7, www.phosfarm.eu). Using enzyme processes to recover phosphorus from agricultural residues by solubilising the phosphorus, followed by precipitation.

*Ylivainio Kari, Finland Natural Resources Institute (LUKE): **PROMISE** (Finland BONUS funding & Outotec, http://www.bonusportal.org/projects/innovation_projects/promise). P-recycling from mixed agricultural and municipal wastes to prevent Baltic Sea nutrient input and eutrophication, assessing possible impacts of contaminants (e.g. xenobiotics and pathogens in manures).

*Edward Someus, Terra Humana, Sweden: **REFERTIL** (FP7, www.refertil.info). Competitive manufacturing of ABC Animal Bone BioChar. A 10 000 tonnes output product/year industrial pilot plant is being finalised. The project has also developed a draft EU safety standards protocol for biochar, see http://www.refertil.info/biochar-policy.

Marissa de Boer, University of Amsterdam, Netherlands: **SusPhos** (FP7, www.susphos.eu). Sustainable industrial phosphorus chemistry network coordinating R&D public projects and within industry, market presentation of innovative applications. Recycling of phosphorus in industry is of growing interest, both as regards use of secondary phosphorus sources recovered from wastes and for recycling of P-containing chemicals such as catalysts or flame retardants.

Mirko Hänel, TTZ Bremerhaven, Germany: **SuWaNu** (FP7, http://suwanu.eu/). A network identifying and promoting technologies for wastewater treatment and agriculture resource recycling, with an emphasis on ensuring contaminant-safe routes for reuse of nutrient rich waste waters.

*José María Gómez Palacios, Biomasa Peninsular SA, Spain: **TL-BIOFER** (LIFE+, www.life-tlbiofer.eu). Developing the use of microalgae cultivation (TL = Twin Layer system) as a tertiary / nutrient removal stage for wastewater treatment to achieve EU Urban Waste Water Treatment Directive obligations. The biomass produced can be processed to produce an organic fertiliser product. The project is selecting efficient microalgae strains and is adapting laboratory pilot tests to full-scale external installation.

Mathieu Spérandio, INSA Toulouse: **VALORDIM** (follows Phosph'OR project, France BPI funding, 2014-2020, www.bpifrance.fr/content/download/131337/2292074/file/20140221%20Valodim%20-%20PSPC.pdf). Optimal valorisation of digestate with N, P & K recovery. The project will include an inventory of digestate characteristics, modullisation of nutrient recovery processes and drying as a function of different digestate properties, and tests with farmers' cooperatives of recovered struvite and organic pellets.

*Anders Norén, BiopTech, Sweden: the company's **Polonite**® (http://bioptech.se/). Reactive filter systems (a calcium silicate based material) have proved successful in removing phosphorus from farmland drainage and in individual household sewage treatment systems, with 4 000 installations sold to date. The used material can be spread to land to recycle the phosphorus. Industrial-scale pilot trials are currently underway at a UK sewage works and a Russian chicken farm.

Mette Dam Jensen, Krüger A/S, Denmark: **EDASK** (Denmark EPA funding, www.kruger.de). Development of an electrodialetic process for phosphorus recovery from sewage sludge incineration and other ashes.

Milena Bieg, BOKU, Austria: **Ferti-Mine** (Austria national funding FFG). Phosphorus and carbon recycling from sewage via pyrolysis, combustion, hydrothermal carbonisation and gasification.

Klara Westling, Swedish Environmental Research Institute: **R3Water** (FP7, http://r3water.eu/). Demonstration of innovative waste water treatment technologies for resource efficiency, reuse and recovery, including hydrothermal carbonisation.

Mathias Bergman, Baltic Sea Action Group: **BSAG** (www.bsag.fi). A non-profit foundation developing and promoting collaborative projects for protection and restoration of the Baltic Sea, where nutrient loss reduction and nutrient recycling are priorities.

John McGrath, Queen's University Belfast, UK: New project currently being launched (UK NERC funding) to test different technologies for phosphorus recovery in wastewater treatment plants in Northern Ireland.

Danielle Davelaar, **European Biomimicry Alliance** (www.biomimicryalliance.eu), Transnational network, promoting biomimicry approaches to closing the nutrient cycle.

Annex 3: Project factsheets

Acronym	**ARBOR**
Full name of the project	Accelerating Renewable Energies through valorisation of Biogenic Organic Raw Material
Summary of project objectives	ARBOR is an Interreg IVB NWE project with 13 partners from 6 European regions dealing with the development of technological solutions and regional strategy development for improved sustainable biomass utilisation. One of the actions is on nutrient recovery from digestates. An inventory is made of techniques (state of the art and those under development) for the valorisation of digestate and of its resulting end-products. Technical, economic and environmental data are collected. Possible end-products are physicochemically characterised. Plant availability and agricultural performance is investigated by means of lab incubation tests and field trials. A market analysis is executed by contacting agricultural users, chemical industry and fertiliser industry.
Project time frame	April 2011 – June 2015
Project website	www.arbornwe.eu
Lead partner/coordinator	Staffordshire University (United Kingdom)
Current members	– DLV Plant (The Netherlands) – FlandersBio (Belgium) – Ghent University (Belgium) – Inagro (Belgium) – Innova Energy (Belgium) – IZES (Germany) – LIST (Luxembourg) – POM West-Vlaanderen (Belgium) – Provincie Utrecht (The Netherlands) – Staffordshire University (United Kingdom) – Stoke-on-Trent City Council (United Kingdom) – University College Dublin (Ireland) – VCM (Belgium) – Wageningen University (The Netherlands)
Contact details (name and e-mail)	Viooltje Lebuf, lead Action on nutrient recovery: viooltje.lebuf@vcm-mestverwerking.be
Principal funder(s) or programme	EFRO – Interreg IV.B. The project is cofunded by local authorities from the United Kingdom, Flanders, Saarland, Luxemburg, the Netherlands, and Ireland

Acronym	**ARREAU**
Full name of the project	Accelerating Resource Recovery from the Water Cycle (EIP-Water Action Group ARREAU)
Summary of project objectives	ARREAU will develop market plans for viable and profitable value chains for resources from the water cycle. We will identify barriers and promoters for resource recovery and reuse. The outcomes will be used to develop frameworks that can be used to remove bottlenecks and enable successful resource recovery in Europe and beyond. Specific actions of ARREAU will be: – Review current European initiatives and best practices of resource recovery from the water cycle and value chains. – Identify success factors for viable and profitable value chains of recovered resources. – Identify barriers, constraints and requirements for implementation of value chains. – Develop market plans to exploit and commercialize opportunities for recovered resources and for the enabling technologies. – Define and implement an effective and well-targeted communication and dissemination strategy.
Project time frame	Established 2014
Project website	http://www.eip-water.eu/ARREAU
Lead partner/coordinator	Henry van Veldhuizen, KWR Water (The Netherlands)
Current members	Core team: – BWA Water (The Netherlands) – Energie En GrondstoffenFabriek (The Netherlands) – IVL Swedish Environmental Research Institute (Sweden) – KompetenzZentrum Wasser Berlin (Germany) – KWR Watercycle Research Institute (The Netherlands) – Reststoffenunie Waterleidingbedrijven (The Netherlands) More than 30 members from all over Europe (http://www.eip-water.eu/ARREAU)
Contact details (name and e-mail)	Theo van den Hoven, Secretariat: theo.van.den.hoven@kwrwater.nl
Principal funder(s) or programme	In kind contribution members

Acronym	**BioEcoSIM**
Full name of the project	An innovative bio-economy solution to valorise livestock manure into a range of stabilised soil improving materials for environmental sustainability and economic benefit for European agriculture
Summary of project objectives	This project targets to produce sustainable soil improving products that can be easily handled, transported, and applied. BioEcoSIM valorises livestock manure as an important example of valuable bio-waste into 1) pathogen-free, P-rich organic soil amendment, 2) slow releasing mineral fertilisers and 3) reclaimed water. The project combines three innovative technologies 1) superheated steam drying 2) precipitation unit of struvite and calcium phosphate and 3) selective separation and recovery of NH_3. Water reclaimed from manure will be utilised for livestock production and/or irrigation. The sustainability of this approach will be validated against standards ISO14040 and ISO14044. Implementation of the R&D results will help fulfil the need for economically viable and environmentally benign practices in European agriculture to move towards a more resource-efficient and circular economy.
Project time frame	October 2012 – September 2016
Project website	www.bioecosim.eu
Lead partner/coordinator	Sukhanes Laopeamthong, Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (Germany)
Project partners	– Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (Germany) – Stichting Dienst Landbouwkundig Onderzoek (The Netherlands) – Centre de Recerca i Innovació de Catalunya (Spain) – Universität Hohenheim (UHOH) (Germany) – Centro Technologico Agrario y Agroalimentario (Spain) – Acondicionamiento Tarrasense Associacion (Spain) – Gospodarstwo Rolne Jacek Śliwka (Poland) – Biocompostajes Españoles S.L. (Spain) – Dofco BV (The Netherlands) – YFlow Sistemas y Desarrollos SL (Spain) – Initial Projects Limited (United Kingdom) – Geltz Umwelttechnologie GmbH (Germany) – Agroenergie Hohenlohe GmbH (Germany) – ASB Grünland Helmut Aurenz GmbH (Germany) – Heckmann Maschinenbau und Verfahrenstechnik GmbH (Germany)
Contact details (name and e-mail)	Sukhanes Laopeamthong: sukhanes.laopeamthong@igb.fraunhofer.de
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N°308637

Acronym	**Biorefine**
Full name of the project	Bio-Refine: Recycling inorganic chemicals from agro- & bio-industrial waste streams
Summary of project objectives	– Provide a cross-sectoral and international network to share knowledge on the available nutrient resources in North-West Europe. – Deliver applied technological solutions for improved recycling of minerals. – Facilitate the removal of territorial disparities in legislation that hinder the development of a harmonised market of recycled minerals. – Stimulate market creation for secondary mineral resources – both from an end-user and producer perspective.
Project time frame	1 May 2011 – 31 December 2015
Project website	http://www.biorefine.eu/biorefine
Lead partner/coordinator	Prof. E. Meers and Prof. J. Buysse, Ghent University (Belgium)
Current members	Partners: – Ghent University (Belgium) – Gembloux Agro-Bio Tech, Université de Liège (Belgium) – Alterra Wageningen UR (The Netherlands) – Bauhaus-Universität Weimar (Germany) – University of Leeds (United Kingdom) – AILE (Association for Local Initiatives in the field of Energy and Environment) (France) – Waterleau Group (Belgium) Sub-partners: – Biogas-E (Belgium) – DLV InnoVision (Belgium) – Inagro (Belgium) – VCM (Flemish Coordination Centre for Manure Processing) (Belgium) – Vlaco (Flemish Compost Organisation) (Belgium) – LDAR (Laboratoire Départemental d'Analyses et de Recherche) (France) – Link2Energy (United Kingdom)
Contact details (name and e-mail)	Erik Meers, project manager: erik.meers@ugent.be Evi Michels, financial manager: evi.michels@ugent.be Eva Clymans, communication manager: eva.clymans@ugent.be
Principal funder(s) or programme	European Regional Development Funding through Interreg IV B NWE

Acronym	**Biorefine Cluster Europe**
Full name of the project	Biorefine Cluster Europe
Summary of project objectives	The Biorefine Cluster Europe interconnects projects and people within the domain of nutrient and energy cycling. As such, the cluster aims to contribute to a more sustainable resource management, both from an economic and ecologic perspective. The main goal is to increase interaction between member projects and consequently leverage their impact on stakeholders as well as on the development of policies, business and research projects. While the projects continue to operate autonomously, their association to the cluster increases their outreach by information exchange, interlinking working plans wherever mutually opportune and organizing joint events, publications, position papers, new proposals and the BioRefine Bulletin.
Project time frame	Established 2014 – launched from the Interreg IV B NWE Biorefine project (running from 2011 to 2015)
Project website	http://www.biorefine.eu/cluster
Lead partner/coordinator	Prof. E. Meers, Ghent University (Belgium)
Current members	Associated projects: – ARBOR – Biorefill – Biorefine – City Wise-Net – Co4Energy – Combine – Enerpedia – Fertiplus – GR3 – Graskracht – H2O-C2C – HP4Drying – Inemad – ManureEcoMine – NutriCycle – P-Rex – Refertil – ReNEW – ReUseWaste
Contact details (name and e-mail)	Erik Meers: erik.meers@ugent.be Eva Clymans: eva.clymans@ugent.be
Principal funder(s) or programme	European Regional Development Funding through Interreg IV B NWE

Acronym	**DeBugger**
Full name of the project	Demonstration of efficient Biomass Use for Generation of Green Energy and Recovery of Nutrients
Summary of project objectives	Efficient and safe exploitation of excrements is hampered by: a) high water content and b) pathogens and organic pollutants. Incineration or gasification destroy pathogens and concentrate nutrients in the residues. The project demonstrates technologies to yield energy and renewable fertilizers from waste flows that may have a combined technical energy potential of 3.5 million TJ and a phosphate recovery potential of 6 million tons (as P_2O_5) in Europe. The challenges are to close and manage the nutrient flows and to exploit the total energy potential of wet biomass waste.
Project time frame	1 January 2013 – 31 December 2015
Project website	www.outotec.com
Lead partner/coordinator	Outotec GmbH & Co KG (Germany)
Project partners	– Outotec Sweden AB (Sweden) – Stuttgart University (Germany)
Contact details (name and e-mail)	Ludwig Hermann: ludwig.hermann@outotec.com
Principal funder(s) or programme	EIT KIC InnoEnergy, LIFE+

Acronym	**EDASK**
Full name of the project	DK: ElektroDialytisk genanvendelse af slamASKe EN: ElectroDialytic recovery of sludge incineration ashes
Summary of project objectives	The EDASK project is aiming to develop a technology enabling continuous recovery of phosphorus bound in the incineration ash. The method is using just water and electricity, thanks to a new electro-dialysis technology. Moreover, the process is 'cleaning' the ashes of heavy metal impurities allowing the inorganics to be reused in the construction industry instead of going to landfill. The ongoing activity is demonstrating the technology in a pilot plant giving the necessary design figures for the technology to be upscaled in order to meet industrial volumes in a second phase. An expected business case and value chain will be developed.
Project time frame	January 2015 – January 2016
Project website	News will be provided at www.kruger.dk
Lead partner/coordinator	Krüger A/S (Denmark)
Project partners	– Krüger A/S (Denmark) – Technical University of Denmark - Department of Civil Engineering (Denmark) – BIOFOS (Denmark)
Contact details (name and e-mail)	Mette Dam Jensen: mdj@kruger.dk
Principal funder(s) or programme	Danish EPA MUDP 2014 (Environmental Technology Development and Demonstration Program, 2014)

Acronym	**END-O-SLUDG**
Full name of the project	Marketable sludge derivatives from sustainable processing of wastewater in a highly integrated treatment plant
Summary of project objectives	This project researches, develops and demonstrates a toolkit of novel processes together with market development for advanced sludge-based products and integration methodologies that can be applied to a range of wastewater treatment plants based on a typical municipal scenario.
Project time frame	January 2011 – December 2013
Project website	www.end-o-sludg.eu
Lead partner/coordinator	United Utilities (United Kingdom)
Project partners	– United Utilities Water PLC (United Kingdom) – Nijhuis Water Technology b.v. (The Netherlands) – WATERLEAU Global Water Technology nv (Belgium) – Teagasc - The Irish Agriculture and Food Development Authority (Ireland) – Hipsitec SA (Spain) – Chemical Engineering and Environmental Technology, Universidad de Oviedo (Spain) – COGERSA, Compañía para la Gestión de Residuos Sólidos en Asturias S.A. (Spain) – Natural Resources Department, Cranfield University (United Kingdom) – Crop and Environment Research Centre, Harper Adams University College (United Kingdom) – HGCA, The Agriculture and Horticulture Development Board (United Kingdom) – Carrs Agriculture Ltd (United Kingdom) – Sustainable Resource Solutions Ltd (United Kingdom) – Valsave Engineered Solutions Ltd (United Kingdom) – Demeter Technology Ltd (United Kingdom)
Contact details (name and e-mail)	Richard Clarke: richard.clarke@uuplc.co.uk
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N°265269 and contributions from partner organisations

Acronym	**ESPP**
Full name of the project	European Sustainable Phosphorus Platform
Summary of project objectives	ESPP is a not-for profit organisation bringing together industry, knowledge institutes and public establishments to promote and implement phosphorus sustainability in Europe: – Define and promote a vision for phosphorus sustainability in Europe – Develop collaborative actions, policies, business cases, value-chains – Address obstacles, propose solutions, in particular in EU regulations and policies – Identify and communicate opportunities Phosphorus sustainability requires dialogue, innovation and collaborative actions across society, and ESPP works with a wide range of sectors and stakeholders: farming, fertilisers and animal feed, chemicals and minerals, waste and water treatment, food processing, bio-resources, food safety and diet.
Project time frame	Established 2013
Project website	www.phosphorusplatform.eu
Lead partner/coordinator	Governance by a Board, elected annually by the Platform members
Current members	
Contact details (name and e-mail)	Chris Thornton, Secretariat: info@phosphorusplatform.eu
Principal funder(s) or programme	Financed by member fees

Acronym	**FERTI-MINE**
Full name of the project	From waste to fertilizer – phosphorus and carbon waste mining as nutrient recycling strategy for the future
Summary of project objectives	FERTI-MINE aims to recover phosphorus from waste materials in order to reduce the depletion of global rock phosphate resources. By applying different thermochemical conversion techniques (pyrolysis, combustion, gasification, hydrothermal carbonization) for carbonization as well as recovery of ash components, fertilizer products rich in phosphorus and organic carbon will be developed and assessed for their viability, ecological and economic impacts. This innovative strategy will help to close nutrient cycles, protect the diminishing phosphate resources and improve the fertility of agricultural soils.
Project time frame	1 September 2014 – 31 August 2018
Lead partner/coordinator	Universität für Bodenkultur – Institute für Verfahrens- und Energietechnik (Austria)
Project partners	– University of Natural Resources and Life Sciences Vienna- Institute for Soil Research (Austria) – University of Natural Resources and Life Sciences Vienna- Institute for Chemical and Energy Engineering (Austria) – AIT Austrian Institute of Technology - Health and Environment Department (Austria) – wpa Beratende Ingenieure GmbH (Austria)
Contact details (name and e-mail)	Univ. Prof. Dr. Christoph Pfeifer: christoph.pfeifer@boku.ac.at
Principal funder(s) or programme	The Austrian Research Promotion Agency (FFG)

Acronym	**FERTIPLUS**
Full name of the project	FERTIPLUS Reducing mineral fertilisers and agro-chemicals by recycling treated organic waste as compost and bio-char products
Summary of project objectives	FERTIPLUS will take up the challenge to identify innovative processing technologies and strategies to convert urban and farm organic waste to valuable and safe products for agriculture and allow industries to develop projects and provide adequate information on use and quality of the products.
Project time frame	December 2011 - November 2015
Project website	http://www.fertiplus.eu/Fertiplus/index.xhtml
Lead partner/coordinator	Peter Kuikman, Alterra Wageningen UR (The Netherlands)
Project partners	– Alterra Wageningen UR (The Netherlands) – Bauhaus-Universität Weimar (Germany) – VLAGEW (ILVO) (Belgium) – University of Leeds (United Kingdom) – Organic Waste Systems NV (Belgium) – Consejo Superior de Investigaciones Cientificas (Spain) – Consiglio per la Ricerca e la Sperimentazione in Agricoltura (Italy) – Idconsortium SL (Spain) – Stichting Energieonderzoek Centrum Nederland (The Netherlands) – Graphite Resources (Knightsbridge) Ltd. (United Kingdom) – Fundacion Para las Tecnologias Auxiliares de la Agricultura (Spain) – Proininso S.A. (Spain) – IRIS-Isontina Reti Integrate e Servizi (Italy) – Gestora de Residuos del Sur S.L. (Spain)
Contact details (name and e-mail)	Peter Kuikman: peter.kuikman@wur.nl
Principal funder(s) or programme	The project FERTIPLUS is co-funded by European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 289853

Acronym	**IMPROVE-P**
Full name of the project	IMproved Phosphorus Resource efficiency in Organic agriculture Via recycling and Enhanced biological mobilization
Summary of project objectives	Organic farming (OF) systems rely on the efficient use and recycling of available resources. There is an urgent need to improve the recycling of P from urban areas and the food industry, back to cropland. The IMPROVE-P project's overall goal is to design improved P recycling systems for OF. This includes enhanced P recycling using secondary P fertilizers as well as higher plant P use efficiency. For a holistic evaluation the project aims to develop tools to determine which alternative P fertilizers (APF) will minimize environmental damage. Optimum practices for OF will be identified using an integrated approach.
Project time frame	June 2013 – May 2017
Project website	https://improve-p.uni-hohenheim.de/
Lead partner/coordinator	Institute of Crop Science, University of Hohenheim (Germany)
Project partners	– Universität Hohenheim (Germany) – Forschungsinstitut für Biologischen Landbau (FiBL) (Switzerland) – Technische Hochschule Zürich (ETHZ) (Switzerland) – Bioforsk (Norway). – Universität für Bodenkultur (BOKU) (Austria) – Forschungsinstitut für Biologischen Landbau (Austria) – University of Newcastle (United Kingdom) – University of Copenhagen (Denmark)
Contact details (name and e-mail)	PD Dr. Kurt Möller: kurt.moeller@uni-hohenheim.de
Principal funder(s) or programme	Core organic II ERA-NET

Acronym	**IWARRC**
Full name of the project	International Water Association Resource Recovery Cluster
Summary of project objectives	– 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 build value chains where waste is converted to resources in a well-managed and beneficial way
Project time frame	2014 - 2018
Project website	http://www.iwa-network.org/clusters.php
Lead partner/coordinator	Dr. Hong Li, International Water Association (The Netherlands)
Contact details (name and e-mail)	Dr. Hong Li, International Water Association (The Netherlands): Hong.Li@iwahq.org
Principal funder(s) or programme	Topconsortia voor Kennis en Innovatie (TKI), till end of 2015; & International Water Association, till 2018

Acronym	**LIFE NECOVERY**
Full name of the project	LIFE NECOVERY – Nutrient and Energy ReCOVERY in wastewater treatment plants by pre-concentration and adsorption processes
Summary of project objectives	The main objective of the project is to demonstrate, by means of a prototype, the technical, economic and environmental feasibility of an innovative WWTP flowsheet based on an pre-concentration step at the inlet of the WWTP and focused on the recovery of nutrients and energy. The demonstration plant is based on the principle of high concentration ("pre-concentration" at the beginning of the flowsheet) to: – Recover much more primary sludge than conventional primary settling to maximize energy production – Recover nutrients from the pre-concentration effluent which contains only dissolved pollution, and also from the supernatant of the anaerobic digestion
Project time frame	July 2013 – December 2016
Project website	http://www.life-necovery.eu
Lead partner/coordinator	CETaqua, Water Technology Center (http://www.cetaqua.com) (Spain)
Project partners	– CETaqua, Water Technology Center (Spain) – AVECOM (http://avecom.be) (Belgium)
Contact details (name and e-mail)	Carme Garcia i Belinchón, Project Manager: cgarciab@cetaqua.com
Principal funder(s) or programme	EU LIFE+ Programme (LIFE12 ENV/ES/000332)

Acronym	**LIFE+ PHORWater**
Full name of the project	Integral Management Model for Phosphorus recovery and reuse from Urban Wastewater
Summary of project objectives	PHORWater project aims to decrease the environmental problem of phosphorus by reducing its discharges into waters and the associated eutrophication, obtaining an alternative source of this nutrient to reduce its mineral extraction and the problems linked to uncontrolled precipitation of struvite at wastewater treatment plants. The project will take place at El Cidacos WWTP (La Rioja, Spain) where the best configuration for enhanced biological phosphorus removal will be considered. A crystallization reactor will be developed and implemented at the optimal point of the sludge line for phosphorus recovery as struvite and its possible value as fertilizer will be evaluated.
Project time frame	September 2013 - September 2016
Project website	http://phorwater.eu/
Lead partner/coordinator	DAM – Depuración de Aguas del Mediterráneo (Spain)
Project partners	– DAM Depuración de Aguas del Mediterráneo (Spain) – Universitat de València (Spain) – CalAgua (Spain) – Université Claude Bernard Lyon I (France) – Laboratoire d'Automatique et de Génie des Procédés (France)
Contact details (name and e-mail)	Laura Pastor Alcañiz: laura.pastor@dam-aguas.es
Principal funder(s) or programme	EU LIFE+ Programme (LIFE12 ENV/ES/000441)

Acronym	**LIFE+ TL-BIOFER**
Full name of the project	TL-BIOFER. Nutrients and Regenerated Water Recycling in WWTPs Through Twin-Layer Microalgae Culture For Biofertilizers Production
Summary of project objectives	LIFE + TL-BIOFER aims to address the environmental problem of the compliance of the Directive 91/271/EEC on urban wastewater treatment for small and medium size WWTPs on sensitive areas by removal of Nitrogen and Phosphorus in-excess content, thanks to an innovative microalgae cultivation system in photobiorreactors (the Twin-Layer system, originally designed by UNIVERSITY of COLOGNE). A prototype is being designed by BIO-LOGICAL SOLUTIONS and a Pilot Plant will be set up at EMPROACSA "El Viso WWTP" in Córdoba (Spain) for 2 years tests. The project will also address the recycling in agriculture of the Phosphorus and Nitrogen as newly developed microalgae derived biofertilisers.
Project time frame	1 July 2014 – 30 June 2017
Project website	www.life-tlbiofer.eu
Lead partner/coordinator	Biomasa Peninsular S.A. (www.bpeninsular.com) (Spain)
Project partners	– Biomasa Peninsular S.A. (Spain) – University of Cologne (Germany) – EMPROACSA (Spain) – Bio-logical Solutions S.L. (Spain)
Contact details (name and e-mail)	Inmaculada González: igonzalez@bpeninsular.com
Principal funder(s) or programme	EU LIFE+ Programme (LIFE13 ENV/ES/000800)

Acronym	**ManureEcoMine**
Full name of the project	Green fertilizer upcycling from manure: Technological, economic and environmental sustainability demonstration
Summary of project objectives	ManureEcoMine proposes an integrated approach to the treatment and reuse of manure, by applying the principles of sustainability, resource recovery and energy efficiency. Technologies of proven efficacy in the wastewater treatment field (e.g. anaerobic digestion, ammonia stripping, struvite precipitation and partial nitritation/anammox) will be combined to demonstrate their technological and environmental potential at pilot scale. Moreover, the effects of the fertilizing properties and trace contaminants of recovered nutrients on plant growth and soil health will be established. Life cycle analyses will determine the concept sustainability, and identify the most environmentally friendly and effective reuse strategy, together with the boundaries of economic viability.
Project time frame	1 November 2013 – 31 October 2016
Project website	www.manureecomine.eu
Lead partner/coordinator	Ghent University (Belgium)
Project partners	– Ghent University (Belgium) – University of Girona, Laboratory of Chemical and Environmental Engineering (Spain) – University of Santiago de Compostela, Group of Environmental Engineering and Bioprocess (Spain) – University of Natural Resources and Life Sciences Vienna (Austria) – Forschungszentrum Jülich GmbH (Germany) – Colsen Adviesbureau voor Milieutechniek BV (The Netherlands) – Maatschap Van Alphen (The Netherlands) – Ahidra Agua y EnergÌa SL (Spain) – Baucells Alibes SA (Spain) – LVA Gmbh (Austria) – Peltracom NV (Belgium)
Contact details (name and e-mail)	Siegfried Vlaeminck: siegfried.vlaeminck@ugent.be Cristina Pintucci: cristina.pintucci@ugent.be Nico Boon: nico.boon@ugent.be
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 603744

Acronym	**PHORESE**
Full name of the project	Phosphorus recovery from secondary effluents of municipal wastewater treatment plants
Summary of project objectives	The objective of this project is the examination of phosphorous removal from a secondary effluent of a municipal WWTP aiming to its recovery as a precipitant that can be utilized as a fertilizer. The expected benefits from the project include the reduction of environmental impact from WWTPs and the confrontation to guidelines defining a low phosphorous content for the discharge of effluents to environmentally sensitive water bodies (1 mg/L);the development of a low cost process for P recovery that can be implemented in existing units at the 'end-of-pipe'; the utilization of phosphorous that is otherwise wasted, contributing to the conservation of mineral phosphorous that is currently exploited from limited reserves.
Project time frame	12 May 2014 – 31 July 2015
Project website	www.phorese.gr
Lead partner/coordinator	Aktor S.A. (Greece)
Project partners	– Aktor S.A. (Greece) – Laboratory Of General & Inorganic Chemical Technology, Division of Chemical Technology, Department of Chemistry, Faculty of Sciences, Aristotle University of Thessaloniki (A.U.Th.) (Greece) – Analytical Chemistry Laboratory, Department of Chemical Engineering, Aristotle University of Thessaloniki (A.U.Th.) (Greece)
Contact details (name and e-mail)	Dr. Panagiota-Aikaterini Palasantza: kpalasantza@aktor.gr Prof. Zouboulis Anastasios: zoubouli@chem.auth.gr Ass. Prof. Mitrakas Manasis: manasis@eng.auth.gr
Principal funder(s) or programme	European Regional Development Fund of the European Union and National Implementing Entity

Acronym	**PhosFarm**
Full name of the project	Process for sustainable phosphorus recovery from agricultural residues by enzymatic process to enable a service business for the benefit of European farm community
Summary of project objectives	PhosFarm addresses the needs of an increasing market for economically and environmentally sustainable phosphorus (P) recovery from agricultural residues. The European union is entirely dependent on imported phosphate rocks for the fertilizer production. To avoid this dependency, new technologies have been developed to recover inorganic P as phosphate salts. Agricultural residues are the most important source for P-recovery, but more than 40% of the P is present as refractory compounds (e.g. organic P, insoluble P). Thus, this share is not available for precipitation as P-salts. In this project a technology is being developed to recover both soluble and refractory P from agricultural residues.
Project time frame	September 2013 - August 2015
Project website	www.phosfarm.eu
Lead partner/coordinator	Dr. Jennifer Bilbao, Fraunhofer Gesellschaft zur Foerderung der Angewandten Forschung E.V. (Germany)
Project partners	– Fraunhofer Gesellschaft zur Foerderung der Angewandten Forschung E.V. (Germany) – Chiralvision BV (The Netherlands) – Geltz Umwelttechnologie GmbH (Germany) – Heckmann Machinenbau und Verfahrenstechnik GmbH (Germany) – Purines Almazan SL (Spain) – Agroenergie Hohenlohe GmbH (Germany) – ASB Grunland Helmut Aurenz GmbH (Germany) – Sevimed Almazan SL (Spain) – Vlaamse Instelling voor Technologisch Onderzoek VITO (Belgium) – Sveriges Lantbruksuniversitet SLU (Sweden)
Contact details (name and e-mail)	Dr. Jennifer Bilbao: jennifer.bilbao@igb.fraunhofer.de
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N°605771

Acronym	**P-REX**
Full name of the project	Sustainable sewage sludge management fostering phosphorus recovery and energy efficiency
Summary of project objectives	For the implementation to market, new technologies need to be proven capable and feasible. Within P-REX, novel and available technical solutions for phosphorus recovery and recycling will be demonstrated in full-scale. Their performance and feasibility are systematically assessed and validated, as well as the quality of obtained recycling products. Together with the analysis of the market barriers and the market potential for novel recycling technologies and their products, strategies and recommendations (policy brief) have been/ be developed for efficient and wide-spread phosphorus recovery and market penetration with regards to specific regional conditions, aiming to increase the European phosphorus recycling rate from municipal wastewater up to 80%. See P-REX movie here: http://vimeo.com/78539404
Project time frame	1 September 2012 - 31 August 2015
Project website	www.p-rex.eu http://e-market.phosphorusplatform.eu/
Lead partner/coordinator	Kompetenzzentrum Wasser Berlin gGmbH (Germany)
Project partners	– Kompetenzzentrum Wasser Berlin gGmbH (Germany) – Fachhochschule Nordwestschweiz (Switzerland) – BAM – Bundesanstalt für Materialforschung und -prüfung (Germany) – IASP - Institut für Agrar- und Stadtökologische Projekte an der Humboldt Universität zu Berlin (Germany) – Veolia Eau (France) – Outotec Oy (Finland) – Agro Plus Handelsunternehmen e.U. (Austria) – BSH Umweltservice AG (Switzerland) – INgitec GmbH (Germany) – LimCo International GmbH (Germany) – Proman Management GmbH (Austria) – ASIO, spol.s r.o. (Czech Republic) – Solintel M&P, S.L. (Spain) – P.C.S. Pollution Control Service GmbH (Germany) – PFI Planungsgemeinschaft GbR (Germany)
Contact details (name and e-mail)	Dr. Christian Kabbe: Christian.KABBE@kompetenz-wasser.de
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 308645

Acronym	**PROMISE**
Full name of the project	Phosphorus recycling of mixed substances
Summary of project objectives	Differently treated organic and recycled P fertilizers will be studied for their beneficial as well as harmful properties. PROMISE will convey backbone data on potentially hazardous contaminants and thereby further assess strategies for P fertilization that can acknowledge food safety and food security in the future. Mono-incineration together with successive processing is taken as one example of a possible way to ensure a full recovery of phosphorus in a safe fertilizer product.
Project time frame	1 April 2014 – 31 March 2017
Project website	http://www.mtt.fi/promise
Lead partner/coordinator	Natural Resources Institute Finland, Jokioinen – Coordinator Prof. Eila Turtola (eila.turtola@luke.fi) (Finland)
Project partners	– Natural Resources Institute Finland (Luke) (Finland) – Julius Kühn-Institut (Germany) – Outotec GmbH (Germany) – National Veterinary Institute (Sweden)
Contact details (name and e-mail)	Kari Ylivainio: kari.ylivainio@luke.fi
Principal funder(s) or programme	PROMISE receives funding from BONUS, the joint Baltic Sea research and development programme (Art 185), funded jointly from the European Union's Seventh Programme for research, technological development and demonstration and from Finnish Ministry of Agriculture and Forestry, PTJ – Projektträger Jülich Forschungszentrum Jülich and Vinnova.

Acronym	**RecoPhos (thermal)**
Full name of the project	Recovery of Phosphorus from Sewage Sludge and Sewage Sludge Ashes with the thermo-reductive RecoPhos-Process
Summary of project objectives	The main objective of the project is to develop a process that can safely extract phosphorus from sewage sludge ash. Next to the phosphorus, also all the other output materials (slag, metals) shall be obtained in a form and purity that will allow using them as raw materials in the industry. For experimental work a bench scale plant is to be designed and constructed. This comprises the planning and basic engineering of the reactors as well as of periphery like frequency converters, off-gas cleaning and automation technology. Finally, the basic design of a pilot scale plant is going to be realized.
Project time frame	1 March 2012 – 28 February 2015
Project website	www.recophos.org
Lead partner/coordinator	Montanuniversitaet Leoben – Chair of Thermal Processing Technology (Austria)
Project partners	– Montanuniversitaet Leoben (Austria) – Universitaet Stuttgart (Germany) – SGL Carbon GmbH (Germany) – MAL GmbH (Austria) – INERCO Ingeniería, Tecnología y Consultoría S.A. (Spain) – INSPYRO N.V. (Belgium) – Hariri Chemical Process Engineering (Switzerland) – M.I.T. – Metallurgy & Inorganic Technology (Austria) – Gesellschaft für Chemischen und Technischen Umweltschutz mbH (Germany)
Contact details (name and e-mail)	Univ. – Prof. Dipl.-Ing. Dr. techn. Harald Raupenstrauch: harald.raupenstrauch@unileoben.ac.at
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 282856

Acronym	**REFERTIL**
Full name of the project	Reducing mineral fertilisers and chemicals use in agriculture by recycling treated organic waste as compost and bio-char products
Summary of project objectives	The REFERTIL project is successfully combining applied science and advanced industrial engineering for market competitive compost and zero emission biochar technology and product developments. Added value, safe and economic "ABC" Animal Bone bioChar Phosphorus fertilizer nutrient is recovered with 30% high P_2O_5 concentration for horticultural/adsorbent applications. Beyond the key enabling technological/product development the REFERTIL project also provides a strong Fertiliser Regulation (Reg. EC No. 2003/2003) revision policy support in the fields of recovery of nutrients, recycled phosphorus, biochar/compost. In this context, improved compost/biochar quality and safety criteria/standards have been developed. Full industrial scale ABC Phosphorus recovery/recycling plant and market competitive industrial manufacturing installation is prepared.
Project time frame	1 October 2011 – 30 September 2015
Project website	http://www.refertil.info
Lead partner/coordinator	Edward Someus, TERRA HUMANA Clean Technology Development, Engineering and Manufacturing Ltd. (Hungary)
Project partners	– Terra Humana Ltd. (S&T coordinator and biochar knowledge center) (Hungary) – WUR - Stichting Dienst Landbouwkundig Onderzoek (DLO) / Plant Research International, Wageningen (The Netherlands) – Aarhus University (Denmark) – SEGES, The Knowledge Centre for Agriculture (Denmark) – University of Torino – Agroinnova (Italy) – Gottfried Wilhelm Leibniz Universität Hannover (Germany) – BGU Ltd (Spain) – WESSLING Hungary Environmental, Food safety, Health and Quality Service Ltd. (Hungary) – KOTO Lts. (Slovenia) – Municipality of Grugliasco, Torino (Italy) – Renetech Bioresources Ltd. (Ireland) – Profikomp Ltd. (Hungary)
Contact details (name and e-mail)	Edward Someus: biochar@3Ragrocarbon.com or edward.someus@gmail.com
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 289785

Acronym	**ROUTES**
Full name of the project	Novel processing routes for effective sewage sludge management
Summary of project objectives	The Routes project aimed to set up new technical solutions for solving typical problems of wastewater treatment plants of different capacities. Ten reference-scenarios (2 for small, 4 for medium and 4 for large plants) were compared with parallel new scenarios including new techniques and strategies under study. This comparison was carried out both from technical and environmental point of view. Quality of the sludge deriving from the investigated enhanced stabilization processes was assessed including heavy metals and organic micropollutant concentration, phytotoxicity and ecotoxicity. Specific attention was paid to the performance of the different enhanced stabilization processes on hygienization, including the possible re-growth of pathogens during sludge storage.
Project time frame	May 2011 – April 2014
Project website	www.eu-routes.org
Lead partner/coordinator	Consorzio Consiglio Nazionale delle Ricerche – Istituto di Ricerca Sulle Acque (Italy)
Project partners	– Consiglio Nazionale delle Ricerche-IRSA (Italy) – Consorzio Interuniversitario Nazionale "La Chimica per l'Ambiente" - INCA (Italy) – Università degli studi di Brescia (Italy) – EAWAG (Switzerland) – BFG (Germany) – Akademia Techniczno-Humanistyczna Wbielsku-Bialej (Poland) – Uniwersytet Przyrodniczy w Lublinie (Poland) – Universite de Reims Champagne-Ardenne (France) – Universitat de Barcelona (Spain) – Chalmers Tekniska Hoegskola AB (Sweden) – 3VGreeneagle (Italy) – Vermicon Aktiengesellschaft (Germany) – ECT Oekotoxikologie Gmbh (Germany) – AnoxKaldnes AB (Sweden) – Atemis (Germany) – Mediterranea delle Acque (Italy), – Agriculture and Agri-Food Canada (Canada) – Universita degli Studi di Roma La Sapienza (Italy).
Contact details (name and e-mail)	Giuseppe Mininni: mininni@irsa.cnr.it
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 265156

Acronym	**R3Water**
Full name of the project	Demonstration of innovative solutions for Reuse of water, Recovery of valuable Substances and Resource efficiency in urban wastewater treatment
Summary of project objectives	The main objective of R3 Water is to support the transition from an urban wastewater treatment plant to a production unit of different valuables by demonstrating new solutions to address main challenges. Objectives are to: – Demonstrate technologies and solutions for increased efficiency in Urban wastewater treatment – Demonstration of innovative wastewater technologies that enable reuse of water and recovery of valuables such as nutrients – Facilitate market uptake in the European union and on a global market. R3Water: re-use, recovery, resource efficiency.
Project time frame	2014 - 2017
Project website	www.r3water.eu
Lead partner/coordinator	IVL Swedish Enviromental Research Institute (Sweden)
Current members	– Aquafin (Belgium) – VTT (Finland) – Ekolite (Finland) – Dechema (Germany) – AVA-CO2 (Germany) – Perlemax (United Kingdom) – Prediktor (Norway) – Adasa (Spain) – Icra (Spain) – Teqma (Spain) – Aqua-Q (Sweden) – IVL (Sweden)
Contact details (name and e-mail)	Uwe Fortkamp: uwe.fortkamp@ivl.se, Klara Westling: klara.westling@ivl.se
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 619093, with additional financing via partners

Acronym	**SusPhos**
Full name of the project	A European Training Network for Sustainable Phosphorus Chemistry
Summary of project objectives	SusPhos represents the first systematic investigation of phosphorus-based processes and materials in sustainable phosphorus chemistry. The main objectives are developing efficient methodologies and recycling schemes for the application of phosphorus in (in)organic chemistry, catalysis, materials science, and industrial chemistry. With its emphasis on industrial applications, technology transfer and the sustainable use of phosphorus, we create cross-fertilization of enhanced research synergies between the public and private European chemical sector. SusPhos organizes international conferences and scientific workshops in Sustainable Phosphorus Chemistry to create awareness of the phosphorus challenge in this specific field.
Project time frame	1 February 2013 – 1 February 2017
Project website	www.susphos.eu
Lead partner/coordinator	Dr. J.C. Slootweg (coordinator), VU University Amsterdam (The Netherlands)
Project partners	– VU University Amsterdam (The Netherlands) – ICCOM CNR Florence (Italy) – University of Leipzig (Germany) – Freie Universität Berlin (Germany) – University of St. Andrews (United Kingdom) – University of Bristol (United Kingdom) – Institute of Chemical Research of Catalonia (Spain) – CNRS - Ecole Polytechnique (France) – CNRS – Laboratoire Héterochimie Fondamentale et Appliquée (France) – ETH Zürich (Switzerland) – Arkema B.V. (The Netherlands) – Magpie Polymers (France) – DSM Innovative Synthesis B.V. (The Netherlands) – Leibniz Institute for Catalysis (Germany) – Willem Schipper Consulting (The Netherlands)
Contact details (name and e-mail)	Marissa de Boer, project manager: marissa.de.boer@vu.nl
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 317404

Acronym	**SuWaNu**
Full name of the project	Sustainable Water Treatment and Nutrient Reuse Options
Summary of project objectives	The main goal of SuWaNu is to promote wastewater reuse solutions through a transnational cooperation approach with "research-driven clusters", involving universities, regional authorities, research centres, technology developers, enterprises, farmers, and farmer´s associations from five different countries: Germany, Spain, Greece, Malta and Bulgaria. SuWaNu will develop strategies and exchange know-how on alternatives for the reuse of water and nutrient resources, create business opportunities in the area of focus and further expand support to stakeholders from countries outside the consortium. Main results include the development of SWOT analysis, Joint Action Plan, Research Agenda, Business Plans, e-learning platform, staff exchanges, etc.
Project time frame	1 July 2013 – 31 December 2015
Project website	www.suwanu.eu
Lead partner/coordinator	Bioazul S.L. (Spain)
Project partners	– **Spanish Cluster**: Bioazul S.L. (BIOAZUL), Dirección General de Regadíos y Estruturas Agrarias – Andalucía (DGEA-JA, third party), Asociación de Comunidades de Regantes de Andalucía (FERAGUA), Instituto de Investigación y Formación Agraria y Pesquera (IFAPA), Agencia de Gestión Agraria y Pesquera de Andalucía (AGAPA) – **Greek Cluster**: Terezi Pinelopi (TPA), Region of West Macedonia (RWM, third party), Panhellenic Confederation of Unions of Agricultural Cooperatives (PASEGES), Aristotelio Panepistimio Thessalonikis University (AUTH) – **Maltese Cluster**: Aquabiotech (ABT), Kooperattivi Malta (KM), University of Malta (UM), Ministry for education and Employment (MEDE) – **Bulgarian Cluster**: ZK "Edinstvo" – Kostievo (EDINSTVO), Plovdiv Municipality (PLOVDIV), Council of the Bulgarian Agricultural Organizations (CBAO), Agricultural University – Plovdiv (AU) – **German Cluster**: Hydro-Air GmbH (HYDROAIR), Stadt Braunschweig – Abteilung Umweltschutz (StadtBS), Abwasserverband Braunschweig (AVBS), Ttz bremerhaven (TTZ)
Contact details (name and e-mail)	Rafael Casielles: rcasielles@bioazul.com Antonia Lorenzo: alorenzo@bioazul.com
Principal funder(s) or programme	European Union's Seventh Framework Programme for Research (FP7) under grant agreement N° 319998

Acronym	**VALODIM**
Full name of the project	Optimal valorisation of digestate
Summary of project objectives	VALODIM is a 6-year research project (2014-2020) financed by the French Bank for industry (BPI). The objective is to optimize and standardise the digestate valorization units, evaluating the nutrient recovery techniques (N, P, K), considering both the nature of various substrates used in co-digestion units and the cultivation needs.
Project time frame	2014 - 2020
Lead partner/coordinator	ARTERRIS (France)
Project partners	– INSA Toulouse (LISBP) (France) – IRSTEA Rennes (France) – UTC Compiègne (France) – ARTERRIS (France) – Fertigaz (France) – Cap Seine (France) – UDM (France) – Vivescia (France) – Ovalie (France)
Contact details (name and e-mail)	Anne Paulhe Massol, ARTERRIS: apaulhe-massol@arterris.fr Mathieu Sperandio, INSA-LISBP: sperandio@insa-toulouse.fr
Principal funder(s) or programme	French Bank for Industry

Full name of the project	**Ostara Nutrient Recovery at Slough WWTP, UK**
Summary of project objectives	A full scale Ostara P recovery unit has been installed in Slough WWTP, UK. We are evaluating the long term effects of P recovery on the operation of the site.
Project time frame	2013 onwards
Lead partner/coordinator	Thames Water Utilities, Ltd. (United Kingdom)
Project partners	– Thames Water Utilities Ltd. (United Kingdom) – Ostara (Canada)
Contact details (name and e-mail)	Rosanna Kleemann: rosanna.kleemann@thameswater.co.uk, Libby Martin: libby.martin@thameswater.co.uk
Principal funder(s) or programme	Thames Water Utilities Ltd.

Full name of the project	**Value recovery from incinerated sewage sludge ash and pyrolysed sewage sludge char**
Summary of project objectives	Pilot scale recovery of P from incineration ashes and pyrolysis char with a view to making struvite fertiliser
Project time frame	2015 - 2017
Lead partner/coordinator	Thames Water Utilities Ltd. (United Kingdom)
Contact details (name and e-mail)	Rosanna Kleemann, rosanna.kleemann@thameswater.co.uk
Principal funder(s) or programme	Thames Water Utilities Ltd.

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This report constitutes a summary of presentations and discussions which took place at the workshop 'Circular approaches to phosphorus: from research to deployment' held in Berlin on 4 March 2015. The workshop was jointly organised by the European Commission (DG Research & Innovation), the European Sustainable Phosphorus Platform (ESPP) and the P-REX project.

The workshop aimed to bring together research and demonstration projects on phosphorus recovery and recycling from across Europe, with industry practitioners and experts, to:

— enable contact between the different projects in order to exchange information, transfer experience and build synergies,

— take stock of research and demonstration projects and related networks dealing with phosphorus recovery and recycling,

— identify further research and demonstration needs to support development of the circular economy for nutrients,

— discuss implementation, identify obstacles and opportunities for moving from research to market rollout and societal uptake, including adapting to different local contexts.

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