European Sustainable Phosphorus Platform

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SCOPE NEWSLETTER

Sustainable phosphorus policy

R&D partnership
Knowledge institutes invited to join ESPP Platform

ESPP is inviting partnership from knowledge institutes to participate in Platform actions, networks and projects.

European Innovation Partnership
EU Strategic SIP Plan on Raw Materials

The EU's strategic implementation plan for innovation cites phosphorus as a challenge to be addressed.

USA & Canada
Towards a North America phosphorus partnership

Stakeholder cooperation and value-chain development for sustainable P management in North America.

Arizona
US P Research Coordination Network (P-RCN)

The 2nd P-RCN meeting worked on projects and called for partners for other research areas.

Food waste
Circular economy vision

The UK resource efficiency organisation WRAP estimates that 50% of food waste could be saved by 2025.

Reuse and recycling of biosolids P

Declaration
Stakeholder proposals manure nutrient recycling

ManuResource call to align stakeholders' views and to render coherent and stable the EU legal framework.

ManuResource Conference 2013
Manure management and valorisation

Nutrient recycling appears as a key element for sustainable manure management

Nitrates Directive:
Must it be an obstacle to manure P recycling?

How to ensure that the limit to application of 'processed manure' does not impede P-recovery from manures?

End-o-Sludg
Perspectives for phosphorus management

Two conferences presented technologies for sewage biosolids treatment to recycle sewage P to farming.

P recycling technologies

Arbor
Nutrient recovery from digestates

Inventory and summary assessment of technologies for recovering nutrients from digestates

China - Germany
Lanthanum loaded zeolites tested for P-recovery

Effective adsorption of P from pure solutions, with high levels of regeneration using salt solution.

British Columbia (UBC)
P-recovery from solubilized dairy manure

Thesis presents pretreatment then calcium, struvite and potassium recovery from dairy manure.

Projects & opportunities

Industrial test: recycled glass filtration / P-recovery
Organic fertiliser network (MC-ITN)
Research proposal: P for horses, diet and manure
Sustainable phosphorus research coordination
North America phosphorus "partnership"
ESPP meeting on R&D project opportunities 7/2/14

Agenda: dates 2013-2014

The partners of the European Sustainable Phosphorus Platform

Thames Water · Outotec · Nutrient Platform NL · PAPA Phosphoric Acid & Phosphates · ICL Fertilizers Europe · United Utilities · ecophos · Ostara · Fertilizers Europe · NuReSys · Kemira · n|w Fachhochschule Nordwestschweiz · Severn Trent Water · Science Campus Phosphorus Research Rostock · Vlaams Nutriëntenplatform · Baudirektion Kanton Zürich AWEL Amt für Abfall, Wasser, Energie und Luft

R&D partnership

Knowledge institutes invited to join ESPP Platform

The European Sustainable Phosphorus Platform is inviting partnership from research organisations, universities, knowledge institutes, in order to participate in Platform actions, networks and projects.

After confirming partnership in from a core group of companies and institutions, since its launch in March 2013, **the European Sustainable Phosphorus Platform (ESPP) is inviting partnership from knowledge institutes** (R&D, universities, …).

Partnership enables institutes to participate in Platform activities and networks, ensure access to and exchange information, promote activities and achievements, meet potential consortia partner companies and collaborate in joint projects.

The ESPP Platform is already active in a range of activities including circulating information concerning sustainable phosphorus management, both through the ESPP / SCOPE Newsletter and through specific networks, regulatory developments and coordination with research networks worldwide.

2014 R&D related activities

In 2014, the Platform's R&D and implementation related activities will extend to

- address the EU's **2020 project calls**,
- define a "**research, integration and implementation agenda**" for phosphorus sustainability,
- establish specific tools for exchanging information on **projects and opportunities**.

How to become an ESPP partner

Companies and institutions (national and regional authorities) pay annual fees for European Sustainable Phosphorus Platform (ESPP) partnership. **Knowledge institutes and NGOs** can also choose to be paying partners and to appear alongside these partners, or can become partners in kind by one of the following routes:

- **Bring** to the Platform a paying company or institutional partner
- Include the Platform in a **project funding proposal** or similar: this should contribute net funding to develop the Platform's core activities (dissemination, networking, value-chain coordination …)
- Provide equivalent **in-kind services**, identified as directly contributing to the Platform's activities and objectives

Information for knowledge institutes wishing to become Platform partners is available on the Platform's website *www.phosphorusplatform.eu*

This includes an application form enabling institutes to summarise their specific expertise and experience related to phosphorus sustainability and phosphorus management, and to provide details of the direct or in-kind contribution proposed.

Contact: info@phosphorusplatform.eu

European Innovation Partnership

EU Strategic Implementation Plan on Raw Materials

The EU finalised late 2013 the SIP (Strategic Implementation Plan) for the EIP (European Innovation Partnership) on **Raw Materials**. EIP's are one of the EU's tool to develop R&D, and innovation implementation over the next decade (2020).

Two other EIP's are relevant as well regarding phosphates: **EIP Water** and **EIP Sustainable Agriculture**. The EIP SIP on Raw Materials cites phosphorus as a challenge because of >90% import dependency, stating that recycling technologies must be developed.

EU proposals

The high level panel of the EU's EIP for Raw Materials has called for the EU to consider banning landfilling of recyclable wastes and banning incineration of waste which has not been sorted and separated and of recyclable waste. If extended to phosphorus, this could concern landfilling of sewage sludge incineration ash if phosphorus recycling is not implemented.

The EIP panel's proposals are summarised in an EU Commission Memo on "**Priority actions to reduce**

the EU's dependency on raw materials" and also include minerals mining and supply policies, developing sustainable circular business models for recycling, increasing knowledge about raw materials flows in wastes, setting qualitative targets (material and country specific) for materials recycling.

Phosphorus in EIP Raw Materials SIP

The **EIP for Raw Materials** SIP (Strategic Implementation Plan) particularly emphasises rare metals (used in electronics), which are identified as critical raw materials by the EU, but also cites phosphorus amongst other minerals requiring action. The national nutrient platforms and the European Sustainable Phosphorus Platforms are cited as examples of 'raw material partnerships' necessary to ensure optimal use and recycling of materials along the value-chain (action area II.10).

The commitment of Netherlands Water Boards to equip 30% of sewage treatment with phosphorus recovery and recycling by 2015 is cited as an example.

Phosphorus Circular Economy project

The Commission has launched a 'Call for Commitment' to contribute to the SIP implementation. European Partners for the Environment, which hosts the European Sustainable Phosphorus Platform, is preparing a **Raw Materials Commitment (RMC) named 'Covenant Circular Economy 2022'**, which would develop local circular economies for a number of raw materials, driven by European regions, cities and companies. Phosphorus would be an example for developing and implementing Circular Economy methodology and guidelines.

EU Commission Memo on "Priority actions to reduce the EU's dependency on raw materials" , IP/13/863 dated 26th September 2013: http://europa.eu/rapid/press-release_MEMO-13-819_en.htm

EU "Strategic Implementation Plan for the European Innovation Partnership on Raw Materials", final version, 18/9/2013: http://www.asmet.at/images/stories/news/EIP-RM_SIP-draft_20130327.pdf

EPE contact for Raw Materials Commitment (RMC)'Covenant Circular Economy 2022' raymond.vanermen@epe.be

USA & Canada

Towards a North America partnership for phosphorus sustainability?

At the 2nd P-RCN meeting (see above) key stakeholders present identified the need to go beyond the coordination of research and to establish a North America "partnership" to actively develop sustainable phosphorus management and the business value chain.

The **operational form** of the "partnership" remains to be defined (network, structure, cooperation platform …), probably with **regional implementation** in different zones of the USA and Canada. Motivated RCN participants are now contacting frontrunner companies and organisations to launch a pre-launch phase of stakeholder contact, project definition, feasibility and funding, initially coordinated by the P-RCN Steering Committee.

The development of such a "partnership" is seen as one long-term outcome of the 5-year P-RCN project. The P-RCN (Phosphorus Research Coordination Network) has research objectives only, and does not have a remit or resources to develop operational phosphorus value chain actions or business facilitation. The North America sustainable phosphorus "partnership" project is therefore independent of P-RCN, although it is being initially taken forward by several P-RCN participants. The project will address similar objectives to P-RCN, but **from an operational business and stakeholder perspective**, including implementation-oriented R&D.

The "partnership" may best be structured regionally because phosphorus management issues are variable in different parts of the continent (e.g. regional livestock manure surpluses, water quality issues, urban structure, biofuels development, industry …).

It is noted that it may not be appropriate to create a new (legal) structure: hosting within an existing body may be more efficient in terms of operating cost and administrative simplification.

The project will **benefit from the experience of the European Sustainable Phosphorus Platform and the Japan Phosphorus Recycling Council**, both of whom participated at the second P-RCN meeting, January 2014, Arizona.

Possible "partnership" objectives

The objectives of the proposed North America sustainable phosphorus "partnership", **to be refined and reviewed with the initial participants**, could include:

- **Networking** between operators and stakeholders concerned by phosphorus management in different sectors
- Make **business chain contacts** to facilitate implementation of viable, innovative activities and operational partnerships
- **Directory of resources**: competences, products, phosphorus flows, technology suppliers, R&D and implementation expertise
- **Technology monitoring**, including feasibility assessment, inventory of suppliers, cost/benefits, LCA …
- **Regulatory information and proposals**, necessary to accompany management of phosphorus, including waste, environmental, discharge, agricultural aspects
- **Outreach** / awareness raising / targeted communications
- Ensure representation of US and Canada phosphorus management stakeholders and frontrunners in **international meetings** and initiatives
- **Prepare operational projects/tenders** in order to obtain funding for research, demonstration projects, integration and dissemination, where identified as useful

Setting up a North America Sustainable Phosphorus Partnership

Business sectors and organisations that may be motivated to join the "partnership" include those concerning fertilisers, soil amendments, composting and anaerobic digestion, biochars, phosphate mining, solid waste management, wastewater, technology suppliers and engineering consultants (nutrient recycling, P-removal …), agricultural and related sectors (livestock production, phytase, seeds, animal feeds, …), biofuels, cities / states / counties, utilities, agencies / funding programmes and knowledge institutes' technology transfer sections.

The first stage proposed would bring together a small group of **frontrunner companies and organisations** (businesses and operators, industry sectors, water and waste utilities/regional authorities) willing to fund a first establishment and evaluation phase, and who will together define the objectives, scope and governance of the "partnership".

The proposed calendar is to identify these frontrunners over coming months, then (with these initial participants) to put in place dedicated human resources to define and develop the project, possibly leading to a launch meeting in parallel to the 3rd P-RCN meeting in Washington DC, May 2015 (to be decided by the initial participants).

Contact

Interested companies and structures should contact Jim Elser, Arizona State University, P-RCN lead investigator j.elser@asu.edu

Arizona
US Phosphorus Research Coordination Network (P-RCN)

The US National Science Foundation funded Phosphorus Sustainability Research Coordination Network (P-RCN) is a five-year project (2012-2017) to coordinate and exchange research relating to "pathways to improve phosphorus efficiency and generate robust P recycling pathways".

The P-RCN network is funded by the US National Science Foundation, is led by Arizona State University and the University of Arizona, and its steering committee also includes personnel from the US Department of Energy, the Stevens Institute and IPNI (International Plant Nutrition Institute).

The first P-RCN meeting in 2013 (SCOPE Newsletter n°94) opened stakeholder discussion to define research priorities for addressing the "Phosphorus Challenge". This **second P-RCN meeting (6-10 January, Phoenix, Arizona)** brought together some 25 researchers from the USA, and 16 from other continents (China, India, Australia, the European Sustainable Phosphorus Platform, and a number of researchers from the UK funded by the British Consulate). The meeting enabled researchers to work together to define and begin to develop content of joint research projects based on a prioritised subset of these questions.

North America phosphorus "partnership"

Independently of the research coordination objectives of P-RCN, a number of the participants also discussed the possibility of establishing a North America "partnership" to **facilitate implementation of sustainable phosphorus management**, working with businesses, decision makers, agriculture and other stakeholders: see separate article in this Newsletter.

Stakeholder identified R&D priorities

Following the first P-RCN meeting (Washington, May 2013, see SCOPE Newsletter 94), a **stakeholder consultation was carried out to identify priority R&D questions concerning phosphorus sustainability** (SCOPE Newsletter n°96). This stakeholder consultation, with 30 respondents, identified the following priorities as important to society:

- What are the most promising **strategies for reduction and recovery of P flows** in human, animal, and waste systems?
- What are the full **economic costs/benefits of P recycling**, including disposal, recovery, value of conservation, distribution costs, benefits and welfare? How do these differ in different regions or countries?
- How do **different cropping systems** (e.g., monoculture, rotation, inter-planting, permaculture) affect soil P and fertilizer needs? Given economic constraints, how can cropping systems be used as a tool to reduce P in high P fields?
- What **policy instruments and geopolitical scales** (local, regional, national, global) would be the most acceptable and effective for addressing P stewardship? What are the motivations/arguments for and against coordinated P policies at different scales?
- What are the economic, social, institutional, and informational **barriers and opportunities** for conservation practices, adoption of new technologies, and acceptability of P efficient crops and recycled fertilizer?
- What policy measures might promote or **accelerate responses to P management practices**?
- How do **conservation practices** (e.g., no till) and their effects (on P uptake, AMF, microbial root interactions, etc.) influence P application and efficiency compared to conventional methods?
- How efficient are various **waste management strategies** in retaining and returning P to food production?
- **Is price a stronger driver of P stewardship practices than direct regulation**?

P-RCN projects

The 2nd P-RCN meeting enabled participant researchers to work together on the outline and content of R&D projects within these priorities. These projects include not only research papers but also collating inventories of existing information, surveys of stakeholders, developing management and policy support tools and proposed dissemination / communication tools:

- Defining a framework for enabling **transformative change** in sustainable phosphorus governance
- Application of this framework to (e.g.) **intensive livestock production regions** in Northern Ireland, Australia, Kenya, U.S. and Switzerland
- Sustainable **P management in Africa**, incl. foreign investment (P fertilizers, efficiency techniques, land management, advice for contracts, small-holder farmer access)
- Developing a **P-management visualisation tool** for decision makers ("PhosphoSim")
- Developing a **phosphorus-footprint** calculator
- Defining the **national security** issues related to phosphorus supply
- The effects of global **socioeconomic and ecological factors** on phosphorus demand
- Modeling the consequences of **dietary changes** in China on phosphorus flows
- Predicting the phosphorus requirements of US **biofuels** production and implications on P removal to use ratio
- The phosphorus demand and loss consequences of **food waste**
- The phosphorus demand implications of possible **oceanic CO_2 sequestration** projects
- Opportunities and constraints on uses of **nutrients from biosolids** in the US (sewage, manure)
- GIS mapping of **P-hotspots in USA** (local/regional phosphorus surplus, surface water sensitivity), with analysis of opportunities and challenges

- **Phosphorus mass flow analysis**: identifying and quantifying P in non-conventional sources and sinks
- Establishing a **P-balance for river basin(s) in India**
- Establishing a **historic P-balance for three river watersheds (Thames UK, Maumee, USA and Yangtze, China**) in order to show changes of P use and losses to surface waters and impacts of soil “legacy P” (P accumulated in agricultural soils)
- The socioeconomic and ecological drivers of **Yield Gap**
- Dynamics of **P removal to use ratio** in the USA
- **“Legacy P” in agriculture** (that is phosphorus accumulated in agricultural soils): history, dynamics, magnitude, typology, spatial distribution. Overview articles and communication tools for farmers, water managers …
- Define a **legacy P management framework** and develop detailed legacy P analysis for catchments in e.g. USA, UK, China. Designing transformative change processes for managing soil legacy P
- Assessing **phosphorus use efficiency techniques for low and high soil legacy P systems** and defining measures to “draw down legacy P” to levels which still ensure crop productivity, including field studies
- Survey of stakeholders concerning **adaptive capacity to “legacy P”**
- Annotated list of **existing (or underway) inventories or assessments of nutrient recovery routes** and technologies
- **Making waste a resource (Total Value Recovery):** mapping potential co-products which can be recovered from wastes alongside nutrients
- Survey of farmer **needs and requirements for recovered phosphorus products** (supply logistics, form, specifications …)
- Identify farmers’ needs and attitudes to **alternative sources of nutrients in India** (e.g. reuse of or recycling from urine or sewage), using survey techniques
- Identification of **opportunities to reduce phosphorus consumption at source** (rural and urban contexts)
- **Techno-economics of P recovery** in developing country contexts
- Leap-frogging : identifying the drivers for **appropriate / decentralised technologies for P recycling**

Call for partners to develop R&D projects

The P-RCN meeting also identified R&D projects considered as important, to which the P-RCN participants are interested in contributing, but for which the network is calling for new partners to propose projects and take leadership:

- Identifying which **public policies** have (incidental) impacts on P management

- Phosphorus as a local/regional **Circular Economy opportunity**: methodologies for developing a circular economy for phosphorus, successful business models, economic cost-effectiveness and sustainable job creation

Knowledge institutes interested in taking forward projects in these areas should send a short description of proposed R&D content and possible project organisation (funding, resources ….) to *j.elser@asu.edu*

US P-RCN (Phosphorus Research Coordination Network): http://www.nsf.gov/awardsearch/showAward?AWD_ID=1230603 *and* http://sustainability.asu.edu/research/project.php?id=704

Summary video of 2nd P-RCN meeting: http://youtu.be/DzDQIjLavJk

The third P-RCN meeting will take place in Washington DC, May 2015. R&D institutes interested in participating in the Network’s activities should contact j.elser@asu.edu

RCN student network: contact rimjhim.aggarwal@asu.edu

Food waste

Circular economy vision

The EU’s Roadmap to a Resource Efficient Europe proposed to cut food waste by 50% by 2020. The UK’s resource efficiency organisation WRAP, looking at a vision for a circular economy, estimates that halving household food waste by 2025 could save UK households £45 billion.

To date, **France** has adopted a target to reduce food waste by 50% by 2025, **The Netherlands** has adopted and **Sweden** is discussing an interim target of -20% by 2015 (see SCOPE Newsletter n° 97). Other national targets are expected to be included in Member States’ ‘waste strategies’ to be completed by end 2013.

Food waste in the EU today probably contains nearly 200 000 tonnes of phosphorus (per year), see explanation of this estimate in SCOPE Newsletter n° 95. Part of this phosphorus is already recycled (e.g. where food waste is used for animal feed, or composted or digested to produce soil amendments recycled to agriculture) but part is lost (e.g. to landfill or incineration and then disposal of the ash). However, **the real phosphorus wastage is considerably higher** because only a part of the phosphorus used to produce this (wasted) food actually reaches the food product, whereas a larger part is lost in soil runoff or to agricultural wastes.

The European food industry association (**FoodDrinkEurope**) has launched an initiative "**Every Crumb Counts**" to support the EU objective of halving food waste losses by 2020 (see SCOPE Newsletter n°95)

Circular economy

WRAP's vision for a circular economy suggests that by 2020 the UK could use 30 million tonnes/year fewer materials input, produce 20% less waste, and that businesses could save UK £23 billion per year. WRAP expanded on this work to produce **a vision for the EU circular economy 2020** which outlines the potential for economic growth, employment and international trade. This estimates business competitiveness improvements of £330 billion; an additional 160,000 people to be employed in the recycling sector; improved trade balance of £90 billion between Europe and the Rest of the World; and 500 million tonnes of CO_2 equivalent avoided – the same as EU territorial emissions from agricultural production.

In addition to reducing food waste, improvements could be realised through **extending product lifetimes** (through reuse, increased durability and design improvements), **reducing the materials** within products, **reducing waste in the supply chain** and increasing the use of **recycled materials**.

WRAP's vision for UK circular economy to 2020 http://www.wrap.org.uk/content/wraps-vision-uk-circular-economy-2020 *and* http://www.wrap.org.uk/content/eu-vision-2020

EU Roadmap to a Resource Efficient Europe http://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm

FoodDrinkEurope "Every Crumb Counts" campaign declaration http://fooddrinkeurope.eu/industry-in-focus/food-wastagedeclaration/ *and toolkit:* http://fooddrinkeurope.eu/industry-infocus/foodwastagetoolkit/

Reuse and recycling of biosolids P

ManuResource Declaration

Stakeholders launch declaration for increased nutrient recycling from manure

A stakeholder declaration, concluding the first ManuResource conference, Bruges, 5-6 December, calls for more efficient use of and an increased recycling of nutrients in manures.

The declaration underlines the **need for a stable, pragmatic, clearly defined and coherent regulatory framework**, providing quality assurance, to facilitate manure nutrient recovery and recycling.

In particular, the declaration calls for **harmonised integration of recycled nutrients, such as organo-mineral fertilisers**, in the currently-ongoing modification of the EU Fertiliser Regulations, consistency between the Nitrates Directive and End-of-Waste criteria, appropriate treatment or exemption for recovered substances and manure-based substances under REACH, and coherent application of other regulations including the Water Framework Directive, Waste Framework Directive, Animal By-products Regulations, Organic Farming Directive , Common Agricultural Policy …

The declaration will now be submitted to members of the member states and EU consultative bodies in request of their support.

ManuResource Declaration: online at www.phosphorusplatform.org *under 'Downloads'*

ManuResource Conference 2013

Manure management and valorisation

The first international conference on manure management and recycling, ManuResource, Bruges, Belgium, 5-6 December 2013, brought together over 200 people from 25 countries, including regulators, farmers and agricultural organisations, companies involved in manure management and in resource recycling.

With the increasing geographical concentration and intensification of livestock production, and implementation of demanding water quality protection legislation, **manure treatment is a strong growth industry, with energy recovery and nutrient recycling as key drivers**.

Manure as a resource

The strong interest in ManuResource and the range of presentations (more than 50 speakers and nearly 40 posters) confirmed that manure is no longer simply seen as a waste to be disposed of by spreading on land. Implementation of EU water protection policy (Nitrates Directive, Water Framework Directive) and regional and national environmental protection policies mean that farmers with concentrated livestock production are now obliged to process manure. This opens **considerable opportunities for technologies using manure as a resource** and no longer as a waste.

Important conference outcomes include the **Declaration calling for a coherent and stable legal framework** for nutrient recovery from manure (see above), discussions as to how to optimise manure nutrient recycling within the constraints of the Nitrates Directive (see this Newsletter), and the presentation by the Dutch Innovation Network and the Flemish Centre for Manure Processing of the new North Sea Manure Initiative.

Boi-resources R&D cluster

Also the **Biorefine project** *www.biorefine.eu* announced the launch of R&D cluster bringing together projects related to bio-resource processing and nutrient recovery from bioresources and from agriculture and food industry wastestreams.

The Biorefine Europe R&D cluster:
www.biorefine.eu

Alterra Wageningen UR http://www.wageningenur.nl/en/Expertise-Services/Research-Institutes/alterra.htm

Bauhaus-Universität Weimar www.uni-weimar.de

Biogas-E www.biogas-e.be

DLV Inno Vision www.dlvinnovision.be

Enerbiom www.enerbiom.com

Gembloux Agro-Bio Tech www.gembloux.ulg.ac.be

Ghent University www.ugent.be

Inagro www.inagro.be

Laboratoire Départemental d'Analyses et de Recherche http://aisne.com/LDAR

University of Leeds www.leeds.ac.uk

VCM www.vcm-mestverwerking.be

Vlaco www.vlaco.be

Vlakwa www.vlakwa.be

North Sea Manure Initiative (NSMI)

NSMI is an innovation programme is now in preparation and aims to **develop markets and build supply chains for products derived from manure**, in the context of reducing nutrient emissions to the North Sea and so combating eutrophication. The programme will look for funding from the North Sea Region Programme, the North Western Europe INTERREG programme and Horizon 2020 (environment, resource efficiency, raw materials).

NSMI intends to develop "innovation not research", public-private partnerships, cross-border and cross-sectoral cooperation (between e.g. energy, agriculture and chemicals sectors), based around **anaerobic digestion of manure to produce methane/energy, and processing of the digestate to produce marketable fertiliser products**. Developing markets for these products and ensuring an appropriate regulatory framework are identified as key objectives.

Contact for North Sea Manure Initiative (NSMI): Jan de Wilt
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Manure hotspots

Current manure processing is generally driven by environmental regulations which require removal of a specified % of manure nutrients (e.g. 50% P removal required in The Netherlands, 75% N and 75% P removal often required in Brittany …)

Learning and experience transfer is possible from the **wastewater treatment sector** which has been implementing environmental requirements and discharge consents for decades.

The concentration of livestock production in certain regions of Europe results in hotspots of manure production, where **nutrient production considerably exceeds needs of local land**. Manure treatment is thus necessary, with the key issues being stabilisation and transport costs of water and of organic carbon. Technologies enabling the stabilisation and concentration or drying of manures can enable storage and transport over medium distances to regions where the organic carbon and nutrient content can be valorised on crops.

However, there are issues in some cases with the image of manure as an agricultural amendment, because of perceived concerns about quality or health risks.

There are also a range of **administrative and regulatory difficulties impacting manure processing, transport and land application**, including the specific terms of the Nitrates Directive (see in this Newsletter), inclusion underway of organic fertiliser products in the currently ongoing revision of the EU Fertiliser Regulations, questions regarding waste or chemical regulations …

Organic carbon

Participants underlined the **importance of organic carbon in agricultural soils** and the fact that carbon content has been significantly reduced in many European intensive farmland soils over recent decades. Soil carbon is a CO_2 sink, improves water retention and so drought resistance, contributes to soil fertility. However, soil carbon is not only a function of carbon added in amendments such as manure or biosolids, but is strongly impacted by crop management practices such as tilling, crop rotation.

Although the organic carbon in manure has an agricultural value, this is limited, so that **transport of manure carbon content** (even dry) is generally neither economically nor ecologically justified (CO_2 transport emissions).

Processes for recovery of energy from manure are therefore developing strongly in areas of concentrated livestock production, both anaerobic digestion and thermal or thermo-chemical processes.

Wim Rulkens (Wageningen University and Research Centre, The Netherlands) presented the perspectives and made a comparison of thermal and innovative thermo-chemical processes to recover energy and minerals (P,K,N) from pig manure. The processes discussed were: incineration, gasification (650 – 750°C, producing syngas or electricity), pyrolysis (300 – 700°C, producing P-biochar and transport fuel), supercritical wet gasification (550-750°C, pressure > 22.1 MPa, producing syngas or electricity), supercritical wet oxidation (550-750°C, producing thermal energy), subcritical wet oxidation (260-290°C, producing volatile fatty acids and thermal energy), catalytic subcritical wet gasification (<360°C, use of catalyst, producing syngas or electricity). P can be recovered from the produced ash.

David de Pue (Ghent University) presented a comparison of two different routes for recycling nutrients in digestate (from manure anaerobic digestion): transporting and using the digestate directly on fields, drying the digestate (with air cleaning) before transport and use. This showed that the drying route was more expensive, but that its CO_2 emissions were around 10% lower (energy used in drying and air cleaning compared to reduced transport energy).

Public policies

The European Commission, Claudia Olazábal (DG Environment) and Eric Liegois (DG Enterprise and Industry) emphasised that in the cascade of uses of biomass, energy production is the lowest priority.

The Commission wishes to bring nutrients into the **EU Raw Materials Roadmap policies**. Increased political awareness and understanding of nutrient cycles must be developed. Solutions and approaches need to be specific and different, as a function of local issues and opportunities, and to involve all concerned stakeholders.

There was debate as to the pertinence of public funding support for manure treatment, either by subsidies for manure storage and processing (eg. via the CAP) or through feed-in tariffs or subsidies for energy produced from manure carbon content (e.g. anaerobic digester methane production). Some participants emphasised that although such policies may appear to be positive for environmental protection or renewable energies, they are also effectively **subsidising the increased concentration of livestock production**, and so may contribute to accentuate the root cause of the related environmental and societal problems.

Most participants however agreed that manure processing will continue to develop strongly, with a tendency to increasingly large-scale installations. Energy valorisation and climate change footprint will be strong driving forces. The quality of the products resulting from manure processing will be essential, so that products correspond to farmers' needs, with objective of developing a market pull for recycled nutrients from manure.

Nutrient recovery potential from manure

One of the four sessions of the ManuResource2013 Conference was specifically devoted to "**Nutrient recovery from manure and digestates**", chaired by **Erik Meers (Ghent University and Biorefine project)**.

Ludwig Hermann (Outotec) summarised the potential for phosphorus recovery from animal manures in Europe. He calculates that **total animal manure production in Europe is around 140 million tonnes dry matter, with a technical energy potential of nearly 3 700 PJ, that is c. 5% of Europe's total energy consumption**. Outotec have developed technology adapted to incineration of dewatered pig manure (75% dry matter), on its own or mixed with sewage sludge, producing heat, electricity and nutrient rich ash. Whereas sewage sludge ash has only a limited use for phosphorus recycling by wet chemical technologies because of its high level of impurities, manure ash is suitable, under the condition that iron is not used for phosphate precipitation in manure treatment. Outotec considers that sludge and all iron rich ashes are more appropriate for thermochemical treatment (e.g. ASH DEC) because of iron and other impurities consuming additional acid and forming hardly soluble phosphate compounds.

Pentti Seuri (MTT Agrifood Research Finland) presented work underway to develop a **Nutrient Footprint over the food chain**, distinguishing between primary nutrients (new nutrients for the techno sphere) and secondary (recycled) nutrients, e.g. manure. The objective is to assess the amount of used nutrients needed to produce different products, for example 1 kg oat flakes. On the other hand, it is also important to know which portion of the captured nutrients are lost over the food chain. The "lost nutrients" are determined as the nutrients that cannot be recycled.

Field and pot testing of recycled nutrients

Silvia Bachmann (University of Rostock, Germany) presented results of a 4-year field trail comparing undigested and digested dairy slurry on maize. Although the maize yield and plant P uptake were the same, and the soil available P content was comparable (and in both cases higher than a no-slurry control), the **soil organic carbon and soil microbial activity were significantly lower in the field receiving digested slurry**. Furthermore, first results of a project funded by the German Federal Ministry of Research and Education evaluating the P fertilizer value of digestate treated by mechanical solid liquid separation were presented.

Bart Ryckaert (Inagro, Belgium) presented results of a 3-year field on maize, comparing a number of different manure digestate or processing products. **No statistically significant difference in crop yield, soil fertility or soil quality** were found when comparing digestates to standard mineral fertiliser plus stabilised manure application.

Ivona Sigurnjak (Ghent University - poster) presented field trials (maize, cauliflower) underway on a range of products processed from manures: liquid fraction of manure, digestate, liquid fraction of digestate, acid air scrubber recovered ammonia, pig urine derived urea, reverse osmosis concentrate, evaporated effluent from biological treatment of manure.

Fabrizio Adani and Andrea Schievano (Gruppo Ricicla, Milano University degli Studi, Italy - poster) presented field trials comparing mineral urea fertiliser to manure digestate and its liquid fraction, including testing different application techniques (Nero project). The **digestate performed similarly to the mineral fertiliser**. For both, injection appears as the best application technique to minimise emissions. In the project (Ecobiogas) a Life Cycle Assessment of the Lombardy biogas production chain was carried out, including digestion, biogas valorisation and digestate management, showing that nutrient recovery enables considerable impact reductions.

Also, a mineral fertilizer was produced by reverse osmosis and ultrafiltration digestate treatment (C. Ledda, A. Schievano, S. Salati, F. Adani, Water Research 47, 6157-6166, 2013), recovering water and nutrients. This **"N-Free" process** (Fiolini e Savani, Italy) was tested at two plants, one using digestate from pig manure, the other using digestate from cattle manure. The N-Free installations operate in batch mode, treating 50 – 100 m^3 of manure digestate per day. The digestate passes through solid/liquid separation (screw press, then dosing of polyamide flocculant and centrifuge), then ultrafiltration (at 3 – 4 bars pressure), then reverse osmosis (2 consecutive passages on reverse osmosis membranes), then refining in zeolite beds to produce clean water (40 – 50% of initial digestate volume) which can be discharged to the environment. The reverse osmosis concentrate is mixed with lime to increase pH, so driving off ammonia nitrogen with air-stripping, which is then recovered using sulphuric acid (producing 8% N wet weight solution of ammonium sulphate). The lime residue, in the form of a slurry, containing the phosphorus and potassium form the digestate, can be used as a fertiliser.

David Fangueiro (UIQA, Lisbon University - poster) et al. presented pot trials with ryegrass, simulating a leaching event 3 months after planting. Different animal manures were tested including pig slurry, dairy slurry, dairy farmyard and duck slurry. **Phosphorus leaching varied significantly between the different manures for the same application level**. Even, leaching was higher for pig manure solid fraction than with pig slurry. Nitrogen leaching was mainly as organic nitrogen.

Nitrogen recovery

A number of speakers presented **processes for recovering nitrogen from manure, usually by ammonia stripping** by blowing through air, then reaction of the ammonia gas into an acid (e.g. with sulphuric acid, to produce ammonium sulphate solution).

Miriam Cerrillo and August Bonmatí (IRTA-Giro, Barcelona) presented an integrated manure processing system, experimented at lab scale, **combining anaerobic digestion and microbial fuel cell (MFC).** Ammonia is transferred from the anode to the cathode compartment of the MFC, and it is recovered in a subsequent stripping-absorption process. The combined process enhances the energy recovery and produces a concentrated ammonia solution.

Sergio Piccinini (CPRA, Reggio Emilia, Italy) presented 1 m^3 pilot tests of **ammonia N recovery, using air stripping at 60°C and then sulphuric acid to fix ammonia**. Without using chemicals to raise of the pH, the process showed to be effective in combination with anaerobic digestion, because of the availability of heat input and the reduced solids content of the digestate. Issues remain control of foaming in the ammonia stripping chamber and finding a market for the resulting liquid ammonium sulphate.

Dick Starmans (Wageningen University, The Netherlands) presented an **innovative system for transferring ammonium from manure processing effluents to sulphuric acid** without air-blowing and in a continuous system, termed the **LGL stripper**.

Parallel narrow baths containing the effluent are intercalated with baths containing sulphuric acid, with **1.5m diameter discs spinning slowly (5 rpm) in each, on the same axis**, so that the bottom half of the disc is in the bath and the top halves are close together moving in parallel through the air. In the air, **ammonia moves from one disc to the other and so is transferred into the sulphuric acid**. The units are fed in a counter current cascade to optimise transfer, and sodium hydroxide is dosed in small quantities to raise the pH of the digestate and so facilitate ammonia transfer. Energy consumption is very low (one motor turning the discs slowly). Six 1 week runs have been carried out consecutively using a 100 litres/hour test installation. Around 40% of the digestate ammonia was removed resulting in a 14%N ammonium sulphate solution.

Phosphorus recovery as struvite

Marie-Line Daumer (IRSTEA, Rennes, France) presented ongoing work on **phosphorus recovery from manures and agro-food wastestreams in France**. Following laboratory tests to optimise parameters (see SCOPE Newsletter n° 91), a 500 litre pilot struvite reactor is now starting in a pig-farm. The objective is to propose an alternative to the currently widely used pig slurry processing technologies of removing phosphorus by decanting centrifuge, which generate a product which is not always adapted for economic transport and use. Acidification to pH 4.5 is initially necessary to solubilise phosphorus in the solid fraction of manure. **Magnesium oxide, a by-product of the animal feed industry, is then added to precipitate struvite**. Important operating parameters are the N:P ratio and the quality of the magnesium oxide. The recovered struvite contains around 10% organics. Biological processes are being investigated to ensure the initial acidification, in order to avoid acid costs.

Witold Kwapinski (University of Limerick, Ireland) presented a process to **treat pig manure by pyrolysis** (after centrifugation to reduce water content), thus enabling energy recovery as syngas. The resulting biochar solid was treated with nitric acid to produce a mineral nutrient rich solution. Magnesium nitrate $Mg(NO_3)_2$ was added to this solution to precipitate struvite. The remaining solution could be used as a liquid fertiliser.

Daniel Frank (Fraunhofer Institute for Interfacial Engineering and Biotechnology, IGB) presented laboratory tests of K-struvite precipitation (potassium magnesium phosphate $MgKPO_4$) from different types of manure. Fraunhofer IGB is working on several phosphorus recovery projects: BioEcoSim *www.bioecosim.eu* PhosFarm *http://www.igb.fraunhofer.de/en/press-media/press-*

releases/2013/phosfarm-agricultural-phosphorus-recovery.html and PhosKa. He also cited the **PHRED + QuickWash technologies** (from the USA, see SCOPE Newsletters 78 and 90 from 2011 and 2012).

ManureEcoMine

Siegfried Vlaeminck (Laboratory of Microbial Ecology and Technology, Ghent University), presented the **ManureEcoMine project (Green fertiliser upcycling from manure)**, an EU 7th Framework Programme funded project to build, operate and assess a demonstration plant (150 litres of manure/day) to produce renewable energy and recycle nutrients from livestock manure by thermophilic/mesophilic anaerobic digestion, followed by ammonia recovery (stripping then reaction into sulphuric acid), then different possible combinations of struvite or K-struvite precipitation, solid/liquid separation and biological nitrogen removal (partial nitration/anammox). Blending of the **recovered nutrient products to produce fertilisers**, assessment of the plant-availability of the nutrients in these fertilisers, life cycle and economic analysis will be carried out.

Processing manures to recycle nutrients

Paolo Mantovi (CRPA, Reggio Emilia, Italy) presented results of the EQUIZOO project, which tested **drying and pelleting of different manures, with the objective of producing a stable, transportable product** which can be handled and sold in bags. Solid fractions of fresh slurry and of anaerobic digestate separated by screw or drum press were tested. Drying was carried out at 200°C in a turbine dryer part of a closed cycle equipment. A cyclone was used to separate solids from the air, followed by a condenser for water vapour. The condensate was purified using reverse osmosis, with nutrients and organics being returned to the drying chamber.

Nazli Pelin Kocaturk (University of Copenhagen) presented experimental work using clinoptilolite (a natural zeolite), and using biochar activated by different chemical agents, **to adsorb nutrients from manure digestate**. Clinoptilolite captured ammonium, potassium and phosphorus. Biochar activated with sodium hydroxide adsorbed ammonium but not significant potassium. *SCOPE Editor's note: the aluminium content of clinoptilolite could pose questions for agricultural use.*

Christian Kabbe (Berlin Centre of Competence for Water) presented the **P-REX project demonstrating and evaluating processes for recovering phosphorus from wastewaters** (see SCOPE Newsletter n° 98 and 94).

Phosphorus in municipal wastewater in Germany could potentially supply 50% of the country's mineral phosphate fertiliser imports.

He emphasised the opportunities for the manure processing industry to **learn and to transfer experience from the sewage treatment sector**, where a number of nutrient recovery technologies are already implemented full-scale or tested at pilot scale.

ManuResource Conference website: www.manuresource2013.org

Processed manure:
Must the Nitrates Directive be an obstacle to manure nutrient recycling ?

The Nitrates Directive is central to regulatory protection of water quality in Europe , alongside the Urban Waste Water Treatment Directive and with both now also integrated into the Water Framework Directive. It is essential to reducing eutrophication of marine and surface waters and nitrate contamination of groundwaters. However, certain terms used in the Nitrates Directive are seen by some stakeholders as an obstacle to recycling of phosphorus and nitrogen from manures (e.g at the ManuResource Conference, see in this Newsletter).

The Nitrates Directive specifies that in **"Nitrate Vulnerable Zones" (NVZ)**, Member States must put into place **Action Programmes** to limit discharge of nitrogen compounds from agricultural sources. These Action Programmes take into account specific environmental constraints such as such as ammonia deposition, soil nitrogen residues and the relationship between economy and environment. **Nitrate Vulnerable Zones are all areas draining into waters susceptible to eutrophication related to such agricultural discharges**. Member States may also take a whole territory approach and establish Action Programmes for their entire territories, and many have done this.

Overall, the area covered by NVZ Action Programmes extends to about 50% of EU territory. Codes of Good Practice under the Directive apply in the remainder of the territory. These are voluntary but provide a basis for environmental measures under the CAP.

The Directive specifies (Annex III) that Action Programmes must **limit both the total application of all fertilisers** in Nitrate Vulnerable Zones (this covers mineral fertilisers, organic fertilisers, manures …) **but also specifically limit the application of livestock manures**. The livestock manure application limit is thus within the total fertiliser limit (not additional). The limit for total fertiliser application is defined by the Member State with respect to each crop having regard to the aims of the Directive. The Directive specifies that **the limit for livestock manures must not exceed 170 kgN/ha/year, unless a 'derogation' is obtained** and this requires the opinion of the EU Nitrates Committee and a subsequent Commission decision.

Questioning the Nitrates Directive

The manure recycling industry, in its current stage of development suggests that **this specific limit for livestock manure nitrogen application poses difficulties for manure nutrient recycling** because it applies not only to manure itself but also to "processed forms" of manure, as specified in the definition in art. 2(g) of the Nitrates Directive: "**'livestock manure': means waste products excreted by livestock or a mixture of litter and waste products excreted by livestock, even in processed form**". The Nitrates Directive also includes specific definitions of "fertiliser" and "chemical fertiliser" in art. 2(e) and (f).

It is suggested that this specific limit (if products are considered to be processed manures) **places processed manure products at a disadvantage compared to mineral fertilisers of chemical origin** (or even, compared to fertiliser products from processing of food wastes or sewage biosolids). Concerned companies tend to be located in areas of manure surplus and most possibilities for processed manure recycling are outside these areas with the exception of the possibility to replace manure N by processed manure N for which, at least theoretically, opportunities could exist within surplus areas.

Depending on the crop concerned, the limit for total fertiliser application may be somewhat higher than the specific limit for livestock manure nitrogen application in Action Programmes and, in any event, livestock manure application may often be largely covered by local manure production.

The ManuResource conference thus saw a number of participants calling for this clause of the Nitrates Directive to be modified.

The logic of the Nitrates Directive manure nitrogen limit

There are, however, **fundamental reasons for the specific limit on livestock manure nitrogen application** both in the Nitrates Directive Action Programmes and in the Codes of Good Practice in zones outside NVZ, including:

- Manure nitrogen is generally only slowly available to plants, whereas chemical fertilisers are generally immediately available. This means that, when applied appropriately according to crop need and environmental constraints or imperatives as set out in the Nitrates and Water Framework directives, the nitrogen in chemical fertilisers should be largely taken up by crops. **Manure nitrogen, on the other hand (only slowly available) is more likely to be not taken up by crops and so to be "lost"** to air, soil organic matter, surface or underground water, particularly if applied above these limits.
- Largely for such reasons, **manure is generally not calculated at 100% of its nitrogen content in Nitrates Directive Action Programmes**, but normally as a % corresponding to the estimate of its "efficiency". **This "efficiency" is an estimate for the purposes of this calculation only, and does not necessarily represent market or agronomic opinion**.
  For example, if manure nitrogen is considered to be 60% "efficient" and an Action Programme sets a limit of 300 kgN/ha/y for total fertiliser application for a specific crop, then the limit of 170 kgN/ha/y manure will be considered to bring 60% x 170 = 102 kgN and the farmer will be allowed to apply an additional 300 - 102 = 198 kgN/ha/y of chemical fertiliser.
- **Importantly, the manure application limit set by the Nitrates Directive also limits manure phosphorus application**. If higher levels of manure application are authorised then the consequence will often be phosphorus application levels which result in run-off contributing to eutrophication or soil P saturation, both of which are widespread in parts of the EU and contribute to

biodiversity decline. Although the Nitrates Directive does not mention phosphorus and specifically defines its objective (and Action Programmes) as addressing pollution of waters by nitrogen of agricultural origin, the Directive is integrated into broader EU environmental policies, and in particular into the Water Framework Directive, where phosphorus limitation to address eutrophication is a key objective.

Derogations and valorisation of manure nutrients

As indicated above, Member States can apply for "derogations" from the general manure application limit of 170 kgN/ha/year set by the Nitrates Directive. **Derogations do not deviate from the logic of the NVZ Action Programmes, so that if a higher use of manure nitrogen is authorised then a corresponding lower use of chemical nitrogen is fixed to ensure the same overall nitrogen limit**. In return, higher levels of manure and other management by the farmer are required. Clearly, the situation of phosphorus has a central place in all derogation considerations and decisions and it is worth noting that a number of NVZ Action Programmes already include phosphorus management provisions.

Over the past decade, several Member States have obtained derogations, in order to develop manure use possibilities for one or more livestock sectors within an NVZ. Mostly to date, these derogations do not cover manure processing. Italy and Belgium (Flanders) provide the current exceptions.

A new situation is arising with the emergence of new and innovative manure processing techniques. The argument of the processors is that they can, commercially, produce several new products and essentially separate N and P processed manures. How can this be squared with the provisions of the Nitrates Directive? Is it possible for a Member State to seek a derogation to set a higher limit for "manure" nitrogen in Action Programmes when processed manure N with little or no P content is involved? Prior to posing such a question, it is necessary to establish very clearly the state of the art with respect to commercial scale processing, including a complete examination of potential and pitfalls. This is a task not yet completed but which requires verification prior to requesting a derogation involving processed manure.

Can derogations address the concerns of manure processors?

However, on the assumption that all potential and pitfalls are established and the advantages, commercially and environmentally, outweigh the disadvantages, then **what are the possibilities for extending the scope of the derogation concept within the present legislative set-up?** It has been suggested that the European Commission should consider such a derogation **if the objective is to facilitate manure nutrient recycling, subject to the following conditions**, necessary to ensure protection of the environment, being fulfilled in full:

- **the increased "manure" nitrogen limit cannot exceed the total fertiliser nitrogen limit** set for each crop in the Action Programmes (as indicated above)
- the increased limit could be **specified to be for "processed manure" only**, **indicating certain minimum processing requirements** not least regarding P and salt content
- the limit for "processed manure" products will assume that these have **100% nitrogen** "efficiency". *To take the example above, if the manure limit is increased from 170 to 250 kgN/ha/y (with the total fertiliser limit is unchanged at 300 kgN) and processed manure is applied at the limit of 250 kgN (calculated at 100% not 60% as above), then only 300 - 250 = 50 kgN/ha/y of chemical fertiliser could be applied (compared to 198 kgN/ha/y above).* It might even be argued that such processed N could even fully replace all chemical N if the derogation limit were to be raised to the overall N limit for the crop in question. It is stressed that the key element in this argument is that the processed manure N has the same calculated "efficiency" as mineral fertiliser N, namely 100%.
- **it must be clearly established that the increased limit for "processed manure" will not result in increased phosphorus application at levels which would increase eutrophication risks**. This could be done by ensuring that phosphorus application limits are in place, or by demonstrating that the types of "processed manures" authorised have low or no phosphorus content (e.g. digestate liquids from which phosphorus has been removed by a phosphate precipitation process).
- **the manure nutrient products should also comply with other legislation**, in particular the EU Fertiliser Regulations after these are revised to cover not only mineral fertilisers

The use of such derogations would enable processed manure to be treated within the provisions of the Nitrates Directive in the same way as mineral fertiliser of chemical origin, and, if all the criteria set out above are strictly fulfilled, would do so without reducing the level of environmental protection intended by this Directive.

This should logically only concern processed manure products offering high quality and reliably consistent characteristics: low or stabilised organic content, nitrogen and phosphorus of known plant availability …

Are derogations only a partial answer?

The application for and obtaining of such a derogation is **only feasible if the manure processing and nutrient recycling policy is developed at a large scale/regional level** and is recognised by the Member State, which applies for the derogation. It is unclear whether a Member State would engage a derogation procedure for a small-scale production of a processed manure product and processors will need to address this question of scale.

There may also be difficulties for companies producing recycled nutrient products where the company wishes to export to a different Member State. Another Member State may not wish to seek a derogation or to include processed manure in its scope, in order to enable use of imported recycled manure nitrogen, if there is no domestic production.

The European Commission should seek to ensure that these questions are addressed in order to avoid the Nitrates Directive being an obstacle to manure nutrient recycling (see below).

Looking for solutions without modifying the Nitrates Directive

It seems unlikely that the EU will envisage a modification of the Nitrates Directive in the foreseeable future: **this is considered by many to be undesirable, as it would open a long, potentially divisive and probably damaging debate on the legislation aimed at protecting and restoring the quality of Europe's waters**.

Also, any modification of the Directive would inevitably be a very slow process, whereas solutions to enable the development of manure nutrient recycling are needed rapidly.

It therefore appears necessary to find other regulatory approaches to facilitate the recovery of nutrients from manure and their use in agriculture:

- **Clarification should be sought as to whether certain products can be NOT considered as "processed manure",** for example products with low organic content (nutrients in mineral forms produced from manure), or products coming from a mixture of biosolids of which manure is not the largest part (e.g. compost or digestate from mixed bio-wastes).
- This clarification can possibly be facilitated through **coherence with, and appropriate inclusion of recycled manure products in, the revision of the EU Fertiliser Directive**
- The **possibilities already offered by the Nitrates Directive derogations** should be explored and implemented, including with coordination between Member States to facilitate dialogue and transfer of successfully demonstrated solutions, and including addressing the questions raised above such as export of recovered nutrient products.
- At the same time, **further work is needed to demonstrate the commercial and environmental sustainability of manure processing**, as part of the complete agriculture – food-chain system.

EU Nitrates Directive 1991/676/EEC: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991L0676:EN:NOT

ManuResource Conference Declaration concerning manure nutrient recycling and EU regulatory framework http://www.phosphorusplatform.org/downloads.html

End-o-Sludg

Perspectives for phosphorus management

The conferences organised by the EU-funded 7th FP project "End-o-sludg" in London and Brussels, 3rd and 11th December 2013, presented both results of the project's work underway into processing sewage biosolids for safe and efficient agricultural nutrient use (see SCOPE Newsletter n°96), and the regulatory context and perspectives for sewage phosphorus recycling.

Murray Hart (Defra, UK ministry for Environment, Food and Rural affairs) outlined why sustainable use of phosphorus is important for the UK, presenting the key uses of phosphorus, sources and environmental impacts. He indicated that known phosphorus reserves are unlikely to be depleted for several hundred years, but that there are **issues of geopolitical concentration and supply stability and of long term sustainability**, and that **improving phosphorus management can offer cost savings**.

In particular, **reducing losses to surface waters is a key issue**, because phosphorus inputs cause more water bodies in England to fail to achieve Water Framework Directive good status than any other factor. Agriculture is responsible for around 25% of phosphorus losses to England surface water, sewage effluent 60 – 80%.

Dr Hart indicated figures for phosphorus content of different secondary resource streams in the UK:

- Manures and slurries = 119 000 tonnes P/year (this includes only manures collected manures from livestock in buildings)
- Composts = 5 700 tP/y
- Anaerobic digestates of food wastes = 600 tP/y
- Sewage sludges = 31 400 tP/y

Improving phosphorus management in England

Dr Hart identified the following key routes to improve phosphorus management in England:

- **Reduce inputs**, but with the proviso that average P fertiliser application rates have already been reduced by around 50% since the late 1990's
- **Reduce food waste**
- **Capture and recycle P in food wastes** (anaerobic digestion, composting)
- **Improve nutrient use from manures and slurries**: address geographical imbalance of animal production, improve agricultural use by soil testing and application planning
- Recover phosphorus from waste streams
- Improved and increased agricultural use of sewage sludge
- g

Richard Clark and Son Le (United Utilities, Coordinator of the End-o-Sludg project) presented an overview of the End-o-Sludg project, which **looks at the whole sewage biosolids cycle** with the aims of reducing sewage sludge production, improving safety of biosolids reuse in agriculture, developing product to facilitate sludge nutrient recycling, and overall sustainability assessment (project summary see SCOPE Newsletter n°96).

Sewage sludge production is today around 10 million tonnes/year in Europe, increasing with increasing sewerage connection, improvement of sewage treatment and population increase. Phosphorus is the limiting element for sludge application to agricultural land, in particular in much of North West England.

The range of **technologies investigated within the End-o-Sludg project** include :

- **Breakdown of the sludge matrix**, by micro-milling with ceramic beads, to improve sludge breakdown and reduce final sludge volumes after digestion
- **Inverted phase fermentation**, to enhance sludge digestion and to improve methane production and final sludge quantities, enabling flotation-separation of solid particles and production of fatty acids, which can be used to feed biological phosphorus removal processes, microbial fuel cells or bio-plastics production
- **Production of BIOPOL**, a biopolymer comprising mainly of nucleic acids , which present a potential route for phosphorus recycling through use as a fertiliser component or as a chemical agent for phosphorus recovery from wastewater.
- **Competitive exclusion** as a method to reduce E. coli in sludge cake (development of competiting bacterial populations)
- **Drying and granulation of digested sludge** to produce an OMF (Organo Mineral Fertiliser) product, adapted to farmers fertiliser spreading equipment (dry, calibrated, non caking pellets)

Keith Chaney (Harper Adams University, England) presented field trials of the OMF (organo mineral fertiliser) produced by the End-o-Sludg project. The 3 – 5mm pellets contained mainly organic matter, 10% water. As produced, the pellets contained 1.5x more phosphorus than nitrogen, so nitrogen was balanced by addition of urea.

The OMF pellets showed similar crop productivity to ammonium nitrate on winter wheat and grassland. Compatibility with farmers' existing spreading equipment was demonstrated with regular spreading up to 24m width of spread, but beyond that the pellets tended to break. The pellets also showed difficulties in windy weather, because of lower density than mineral fertiliser pellets.

Ruben Sakrabani (Cranfield University, England) presented an **overall sustainability assessment** of the End-o-Sludge project elements and sewage sludge management, including Life Cycle Assessment (LCA), environmental impact assessment (EIA) and strategic environment assessment (SEA), social, political, geographical, market and legal aspects. These are integrated into an assessment data base and a SWOT analysis. A regional case study was presented (Asturias, Spain) using the analysis tools to proposed a 25-year plan for sewage sludge management to resolve the situation where sludge is currently mainly landfilled. The plan proposes a combination of sludge reduction technologies and use of sludge to restore mining brownfield sites for energy crop production.

Peter Vale (Severn Trent Water Ltd, England) presented perspectives for phosphorus removal from sewage and the example of phosphorus recovery as struvite at Stoke Bardolph sewage works (Nottingham, England), expected to be commissioned in 2014.

Mr Vale indicated that by 2015 the large majority of Severn Trent sewage will be treated in sewage works operating phosphorus removal. Until now, the driver for this has been the EU Urban Waste Water Treatment Directive 1991/271, but the Water Framework Directive 2000/64 will require even tighter phosphorus discharge levels.

Moving away from chemical P-removal

The conventional technology for phosphorus removal in the UK has been chemical P-removal, using iron or aluminium chemicals, and this remains the only effective option for small sewage works. **However, chemical P-removal necessitates additional filter systems** to remove iron or aluminium particles from discharge (**both are specific pollutants subject to discharge consents**) and poses issues with both the **cost and the supply of iron salts**. Also, the phosphorus is locked up by the iron or aluminium and is not readily available for crops.

Where sewage works can be upgraded to biological phosphorus removal, combined with anaerobic sludge digestion for energy recovery, then phosphorus recovery as struvite is an attractive option. At Severn Trent's Stoke Bardolph sewage works, the ASP (Activated Sludge Process) sewage works, , is being **upgraded to Enhanced Biological Phosphorus Removal (EBPR) – Annamox** to achieve a 1 mgP/l discharge consent in 2014.

The **full scale struvite recovery installation under construction will operate on the anaerobic digester outflow liquor**, removing phosphorus and some ammonia before return of this liquor to the EBPR process. This will improve biological phosphorus removal performance and facilitate the Anammox process (which is inhibited by high phosphorus levels), enabling the P discharge consent to be respected, reduce operating costs related to nuisance deposits, save costs of "anti-struvite" chemicals to prevent deposits, save iron dosing costs.

The **produced struvite (containing 120 kgP/day - phosphorus) will be sold to a local fertiliser blending company** for incorporation into a liquid suspension fertiliser.

Simon Black (Anglian Water and chair of Water UK Biosolids Network) summarised issues and perspectives for sewage biosolids reuse in agriculture. At present, around 1 million tonnes (dry solids) of sewage biosolids are applied annually to around 1.5% only of the UK's farmland, that is 77% of UK sewage sludge. Nearly 90% of these biosolids are applied before sowing arable crops.

Agricultural use is the best solution for sewage biosolids in the waste hierarchy and completes natural soil carbon cycles. In order to ensure sustainability and contribute to acceptance of sewage biosolids reuse, Water UK (the UK water industry association), ADAS (agricultural consultancy) and Defra (UK government) have developed the "**Safe Sludge Matrix**". This is additional to regulatory controls and industry codes of practice. The objective is a 'multiple barrier approach' to food safety, including specifications for sewage sludge treatment (reduction in pathogens), appropriate land spreading (specific loadings for different soils and crops) and selection/timings for crops to which sludges are applied (application of enhanced-treatment sludges only and 10 – 30 month interval between application and crop harvest for fruit, salads, vegetables, horticulture, grazed grassland).

The Safe Sludge Matrix also specifies maximum application levels of sewage sludges as a function of

biosolids type (lime stabilised or not) and soil phosphorus index, in order to ensure that sludge is applied according to crop nutrient needs. This is conform to **Common Agricultural Policy "cross compliance"** (UK implementation) which requires that sludge application should take account of crop nutrient needs, protect soil quality and avoid deteriorating surface and groundwater.

Tomas Turecki (European Commission, DG Research & Innovation) explained that End-o-Sludg is one of a several projects funded by the EU concerning sewage biosolids management, citing:

- **ROUTES**: minimisation of sewage sludge volume and sludge optimisation for agricultural use *www.eu-routes.org*
- **BioEcoSim**: valorisation of biosolids nutrients as biochar *www.bioecosim.eu*
- **P-REX**: recovery of phosphorus from sewage *www.p-rex.eu*
- **ManureEcoMine**: see presentation at ManureResource conference in this Newsletter

Mr Turecki indicated that the **EU's Horizon 2020 programme will offer further opportunities for funding nutrient recovery from sewage biosolids**, including in the call now open and through the SME funding instrument. In particular, Horizon 2020 aims to facilitate development from R&D to market implementation, including both demonstration projects and first application in the market.

Bartosz Zambrzycki (EU Commission, DG Environment) presented the legislative context for sewage sludge nutrient reuse. In his view, the **assessment of the EU Sewage Sludge Directive demonstrated that many member states already have stricter requirements in place so that modification of the European legislation would not have significant effects**, and that the JRC FATE SEES study 2012 shows that there is no immediate risk from contaminants.

Regarding End-of-Waste criteria for composts and soil amendments, Mr Zambrzycki considers that this is unlikely to be lead to European criteria. He notes that **sewage sludge has been excluded from the current proposals (for European criteria) not on scientific evidence but on the "precautionary principle".**

He notes that the EU Commission plans a **communication on the "Circular Economy" in 2014** which should open further opportunities for nutrient recycling.

Also, the revision of the EU Fertiliser Regulation is underway, and discussion of different existing legislations may also result from the REFIT ("fitness check") audits currently underway.

Giuseppe Mininni (CNR-IRSA, Monterotondo, Rome, Italy), coordinated of the **ROUTES** EU-funded FP7 project (see above) presented EU Commission report data 2000 – 2009 for sewage biosolids production in different Member States, indicating an average per capital sewage sludge production of c. 56 g/person/day (range of 20 – 80 g/person/day, excluding low outliers). He two high-technology processes, using membranes and currently at the R&D or laboratory experimental stage, which could potentially reduce sewage sludge generation: membrane batch reactor plus anaerobic side stream reactor (MBR+AnSSR) and microbial electrolytic cell (MEC). He also presented the a sequencing batch biofilm granular reactor process (SBBGR), which tested at the pilot scale allows to reduce sludge production by more than 70%: this technique appears to be adapted for application in small installations. He also briefly presented an **alternate cycle biological nutrient removal process tested at four sewage works by Battistoni et al.** (see SCOPE Newsletter n° 72), combining biological P and N removal and a sidestream lysis process to break down the sewage sludge: this achieved 16 – 43% sludge reduction and seems applicable for medium installations.

Mikhail Butusov (Activil Ltd) presented the **PHORTE sewage sludge treatment system**, involving a combination of drying, pyrolysis, gasification and pelletisation. This produces pellets with zero organic content, containing 7-8% phosphorus (P) and low levels of heavy metals. Heavy metals are moved to a waste stream representing around 10% of inflow sewage sludge dry matter. The process has been tested at c. 2 m^3 reactor capacity scale.

Wilbert Menkveld (Nijhuis Water) presented technology tested within the End-o-Sludg project for **DAF (dissolved air flotation)** removal of suspended solids from inflow sewage in municipal waste water treatment works. A 2.5 m^3/hour pilot tested in several sewage works removed 50% of suspended solids (or 100% if iron flocculant was dosed) compared to only 25% removal in standard primary sedimentation tanks.

The installation is also 15x smaller. Mr Menkveld underlined that an alternative to iron as a flocculant needs to be identified. The removed solids can go directly to anaerobic digestion, for example, in order to reduce sewage sludge production.

Christian Kabbe (P-REX project) summarised the status of phosphorus recycling technologies in Europe, showing the map below indicating **P-recovery installations operational or planned to date** (soon online at *www.phosphorusplatform.eu*)

He presented the case of **Neuwerk sewage works (Niersverband, Germany),** nearly one million person equivalents. Installation of struvite precipitation from anaerobic sludge digester liquor (**AirPrex® by PCS**), upstream of the sludge dewatering, operational since 2009, enables recovery of 1 500 kg struvite/day. **The struvite is sold as fertiliser**. However, the economic driver for the P-recovery process is not the value of the recovered phosphorus, but the **operational savings for the sewage works**: avoidance of nuisance deposits and clogging, improved sludge dewatering, ~500 000 €/year savings due to reduction in sludge disposal cost, reduced chemicals consumption and maintenance.

End-o-Sludg project summary: see SCOPE Newsletter n°96

All conference presentations summarised above: slides available online at www.end-o-sludg.eu

Arbor
Nutrient recovery from digestates

Anaerobic digestion is developing as a treatment route for animal manures, in order to recover energy as biogas. In regions of intensive animal production, such as the Flanders (Belgium) – Netherlands zone, nutrients in digestate cannot be returned to farmland because of environment protection legislation, and it is necessary to develop processes to either remove or recover the nitrogen and to recover the phosphorus and potassium. The 26 page report by the EU-funded Arbor Interreg IVb project provides an overview of techniques and a summary assessment of implementation and potential.

The report opens with a one-page **summary of digestate characteristics** (dry matter content, pH, nitrogen and phosphorus content, impurities and contaminants), emphasising that digestate can vary considerably depending on the nature of the biomass input to the digester and the digestion process.

Nitrogen in unprocessed digestate can vary from around **0.2 to 0.8 % total N**, with around 40% ammonium (that is, rapidly plant available form) in digesters treating mixed biosolids to over 80% ammonium from digestion of pig manures. Total phosphorus can vary from around **0.05 to 0.2% P** and potassium from **0.08 to 0.2 % K**. These figures are % of wet weight, so should be multiplied by 10-20x to give % dry weight.

Digestate processing techniques

Two stages of processing are identified: **initial treatment of the digestate, then nutrient recovery** from either the liquid or the solid fraction resulting from this treatment.

Different manure treatment techniques are summarised (mechanical separation, composting, thermal drying, liquid evaporation, biological nitrification / denitrification) and the following techniques specifically for nutrient recovery are presented:

- **Biomass production and harvest**, in particular using the digestate as a feed for algae production. The harvested algae can serve as feedstock for the biofuel or chemical industries, or possibly be used as animal feeds. Pilot tests only exist to date but the technologies are known. Regulatory and contamination issues need to be resolved if the produced algae are to be used in animal feeds.

- **Pressurised membrane filtration, or reverse osmosis**, generating a mineral concentrate which can be marketed as a fertiliser. Prior treatment is necessary to remove suspended solids (centrifuge, dissolved air flotation, coagulants) because membrane fouling and clogging is an operating issue.
- **Ammonia stripping then recovery by scrubbing**. Ammonia is generally removed by blowing air or steam through liquid digestate fraction, generally after pH adjustment, then recovered by reaction with sulphuric acid to produce ammonium sulphate solution (up to 10% ammonium sulphate). More efficient systems of ammonium recovery are also being tested such as combination with simultaneous struvite precipitation in WSA (water sparged aerocyclone) or the Dorset rotating disc system. Ammonia stripping and recovery is considered to be proven and operational full scale, with work needed to optimise operation.
- **Ammonia recovery from gas streams**, e.g. from digestate drying or evaporation. This is already widely implemented because of legal obligations to clean such gases before discharge into the air. As above, this generates ammonium sulphate solution (3 to 7% nitrogen).
- **Phosphorus precipitation as struvite, potassium struvite or calcium phosphates**. **This technology is considered to be commercially operational full scale on other waste streams** (including manure slurry), and a pilot plant is testing operation on cattle slurry digestate (Fermtech at De Marke, Netherlands).
- **Other technologies currently at the laboratory pilot phase**, such as forward osmosis, electrodialysis or transmembranechemosorption
- **Extraction of phosphorus products from solid fraction of processed digestate after incineration or pyrolysis**. Technologies exist for e.g. sewage sludge incineration ash but have not been tested on digestate ash or biochar. This is not considered a promising route as thermal process of the digestate solids does not seem ecologically appropriate, but other technologies for phosphorus extraction from the solid fraction could appear in the future.

The report concludes that **development of a range of process routes can be expected**, in particular integrating phosphate precipitation to recover and recycle phosphorus (and possibly potassium).

A key challenge to be addressed is that processes must generate end-products in a **form adapted to market requirements**.

The **regulatory context** is considered important (classification of end-products as "mineral fertilisers").

"Inventory techniques for nutrient recovery from digestate", Arbor biomass for energy EU Interreg IVb project, 26 pages, April 2013
www.arbornwe.eu

China - Germany

Lanthanum loaded zeolites tested for phosphate recovery

Lanthanum-zeolites were prepared by combining powdered natural zeolites with lanthanum oxide (La_2O_3) solution, calcinated, then tested for phosphate adsorption from pure chemical solutions in presence of potassium, sulphate, calcium, carbonate, sodium and chloride ions. Regeneration using brine (sodium chloride solution) at pH 10.5 showed >90% phosphate recovery rates after 7 bed regenerations.

Natural zeolite from Hebei province, China, was used. This was shown by XRD to be principally **clinoptilolite**, with traces of granite, quartz and red stone. This was ground to 90nm, then reacted with lanthanum oxide (La_2O_3) solution, then calcinated, to produce lanthanum loaded zeolites (LZA). Optimal conditions showed to imply calcination at 600°C.

Adsorption from pure chemical phosphate solutions was tested, at different pH and in the presence of controlled concentrations of other inorganic ions.

99% adsorption

With c. 0.8g of **lanthanum loaded zeolites (LZA)** used per litre phosphate solution (1.5 mgP/l, pH7), over 99% of phosphate was adsorbed to the LZA after 2 hours. This corresponds to an adsorption capacity of 8g as phosphorus / g LZA.

Adsorption was tested over the pH range 2 – 9. The phosphate adsorption was slightly lower in acidic conditions, and significantly lower in alkaline conditions (possible competition with hydroxyl ion for adsorption sites).

The other ions tested in solution (K, SO_4, Ca, CO_3, Na, Cl) **did not significantly deteriorate phosphate adsorption**.

Regeneration and phosphate recovery

The LZA was **regenerated using 0.8 molar sodium chloride (brine)** at pH 10.5. 90% recovery of the adsorbed phosphate was achieved using 10 bed volumes of regenerant in seven regeneration cycles.

The authors conclude that the lanthanum loaded calcinated zeolites showed **high adsorption selectivity for phosphates and good regenerability**, so making them an interesting potential material for phosphorus recovery from wastewaters for P-recycling. However, the impacts of other contaminants (other ions, organic chemicals, suspended solids) in real wastewaters on the phosphate adsorption and regeneration remain to be demonstrated.

"Phosphate removal from wastewater by model-La(III) zeolite adsorbents", J. Environmental Sciences 20, pages 670–674, 2008 www.jesc.ac.cn

P. Ning, Z. Yong, Dept. Environmental Science and Engineering, Kunming University of Science and Technology, Kunming 650093, China. H-J. Bart, Lehrstuhl f'ur Thermische Verfahrenstechnik, TU Kaiserslautern, D-67653 Kaiserslautern, Germany. B. Li, X. Lu, Dept. Environmental Engineering, Southeast University, Nanjing 210096, China. ningping58@sina.com

British Columbia
P-recovery from solubilized dairy manure

Because most phosphorus in dairy manure slurry is insoluble, pretreatment is necessary to enable P-removal and recovery as struvite. In this thesis, an advanced oxidation process was developed, where the manure was acidified, then subject to combined peroxide plus microwave treatment, followed by calcium removal, solid-liquid separation and precipitation of struvite. Potassium was also partially recovered, largely as hazenite.

Slurry was collected from UBC's Dairy Centre**, a 250-cow facility at Agassiz, British Columbia**, Canada. Manure and other materials were collected by a mechanical scraper, stored in an agitated pit, before large particles (undigested fibres, bedding) were separated out for composting. The remaining liquid slurry passes through a clarifier to remove bedding sand. This slurry had a total solids concentration of 840 - 2 000 mgTS/l, soluble phosphate 74 – 123 mgPO_4-P/l, total phosphorus 164 304 mgTP/l, ammonia 772 – 961 mgNH_4-N/l

Advanced oxidation

The slurry treatment tested consisted of:

- **initial manure acidification**, using 30% v/v sulfuric acid, in a continuously operated 200 litre tank. The pH was controlled to ensure progressive 0.5 pH reductions followed by mechanical mixing (to limit foam problems) and the slurry was taken down to pH 3, 3.5 or 4 for different experiments. In all cases, the volume of acid added was less than 5% of the slurry volume.
- **semi-continuous hydrogen peroxide/microwave process**. Hydrogen peroxide was mixed in to the slurry as it entered an upward flowing helicoid coil microwave chamber at up to 1 litre/minute, with 1-8 kW microwave power at frequency c. 2450 MHz. The 30% hydrogen peroxide supplied was diluted before use to adjust concentrations in the microwave chamber.
- **solid-liquid separation**, after the microwave treatment, by gravity settling in a conical tank with floating weir
- **calcium removal by oxalic acid addition** and stirring. Soluble calcium present formed calcium oxalate which could be removed and collected by settling for 5 hours.

After these stages, the liquid fraction of the slurry had a pH of around 2 so could be stored.

The author underlines the **need for rigorous and frequent cleaning of the microwave system** and avoidance of plugging by solids, which could lead to overheating and potentially spontaneous combustion.

This process enabled around 100% of phosphorus present in the influent manure slurry to be made soluble. Microwave treatment alone did not result in phosphorus solubilisation. The process also considerably reduces the solids content of the slurry, facilitating meeting discharge consents or disposal.

Up to 95% of nitrogen and magnesium were also rendered more soluble by the treatment, further facilitating struvite recovery (even though ammonia nitrogen was in any case in molar excess for struvite).

Flocculation of treated manure

Citric, oxalic and sulfuric acids were tested for the initial manure acidification. Sulfuric acid was less effective than the two organic acids in solubilizing phosphorus and magnesium, however sulfuric acid was chosen for further development because the available concentration meant much lower quantities were needed and, interestingly, because with sulfuric acid, only, a flocculation phenomenon occurred after the peroxide-microwave treatment, facilitating the solid-liquid separation and reducing the suspended solids entering the struvite reactor. The author suggests that this may be due to sulfuric acid inducing proteins to form large particles and precipitate.

This flocculation phenomenon, never previously noted for dairy manures, enabled efficient solid-liquid separation upstream of the struvite precipitation reactor (in optimal conditions, c. 90% of total solids settled after 7 hours).

Calcium removal and recycling

The principal metals solubilized by the hydroxide-microwave process are calcium and magnesium. The latter is useful for struvite precipitation whereas soluble calcium can inhibit this.

Oxalic acid was used to remove the calcium, because this does not result in potentially problematic residual chelated substances in the liquid effluent which will be recycled to land and because calcium oxalate can in certain circumstances be **used as a cattle feed additive**.

90% soluble calcium removal was achieved at a molar ratio of 2:1 oxalic acid: calcium and soluble magnesium was not significantly decreased. However, the oxalic acid caused a pH decrease, resulting in increased sodium hydroxide consumption in the struvite recovery reactor.

Struvite recovery

Struvite was precipitated from the resulting liquid slurry in a 7.8 litre total volume, fluidized bed reactor of height 230 cm, with sections of different diameters (top 153 mm, 51, 38 and base 25 mm). Outflow from the top of the reactor went to a clarifier tank from which the liquor was partly recycled back to the reactor base (from near the clarifier base) and partly removed as final treated effluent (from the clarifier top). The recycle enables adjustment of the upflow velocity (at 400 – 600 cm/minute) and residence time in the reactor. Precipitated struvite was analysed for elemental chemical constituents and by X-ray crystallography.

Sodium hydroxide was dosed to the reactor base to adjust pH to around 7, but **magnesium addition was not necessary** because of concentrations in the manure slurry.

Experiments were carried out with different reactor hydraulic residence (by adjusting recycle rates) times and different struvite supersaturation ratios (by adjusting pH). Higher supersaturation ratios (>2) tended to give a precipitate which was fragile and fuzzy, probably because of agglomeration of fines, rather than well defined crystal pellets.

A **build-up of fine struvite particles** in the clarifier parallel to the reactor was noted and could be problematic. This could maybe be addressed by improving the settling in the top part of the reactor (larger diameter to reduce upflow velocity in this zone).

70% – 99% soluble phosphorus removal was achieved, as well as around 25% nitrogen removal.

In one experiment, potassium was also precipitated as **hazenite** $KNaMg_2(PO_4)_2{\cdot}14H_2O$ but attempts to replicate this were not successful, suggesting that it is dependent on very specific reaction conditions and that further work would be helpful, in that potassium recovery would be useful both for reducing effluent potassium levels and recycling potassium in the recovered fertiliser product.

The authors conclude that this combination of sulphuric acidification, hydroxide - microwave treatment, calcium removal and struvite precipitation could offer an **effective route to remove phosphorus (and to some extent nitrogen and possibly potassium) from dairy manure slurries**, with recovery of the nutrients as a valuable fertiliser (struvite).

"Pilot scale application of microwave technology for dairy manure treatment and nutrient recovery through struvite crystallization", University of British Columbia thesis (Master of Applied Science in Civil Engineering), August 2013
https://elk.library.ubc.ca/bitstream/handle/2429/44766/ubc_2013_fall_zhang_hui.pdf?sequence=1

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Partnership opportunities

Application testing partners wanted:
Recycled glass filtration/phosphorus recovery ?

AFM surface treated recycled glass. Looking for routes to integrate into P-recovery.

Dryden Aqua's **AFM (Activated Filter Medium)** is a high performance filter/adsorption material **produced from waste glass**, used as an activated filter medium in drinking water treatment. The material can remove organic and inorganic particles, or soluble phosphate (by adsorption), in all cases with recovery by flushing before material reuse.

Dryden Aqua are looking for wastewater industry or technology partners to develop process applications in phosphate removal and recycling, for example: capturing small inorganic crystals in phosphate precipitation P-recovery processes, removal of organic particles upstream of P-recovery, P-recovery by adsorption onto the AFM, or systems combining these different functions.

Dryden has recently opened a 40 000 tonnes/year AFM production plant in Scotland, up-cycling waste glass from voluntary collection street containers and other sources, receiving the Vibes environmental awards in Scotland for Hydro Nation and Circular Economy. The glass is processed to produce AFM beads with a very high specific surface area (1 million m^2/tonne, bead size 0.5 – 1 mm) which will remove >80% of particles > 5 microns by filtration and smaller particles by adsorption. AFM can double the performance of filter beds (compared to sand), removing 95% of suspended solids in tertiary wastewater treatment, so reducing chlorination needs by 50% or polymer dosing by 25%

The company already implements AFM combined with lanthanum to enable phosphate removal (e.g. in fish farms, aquaria water recycling) and **is currently working on a modified AFM, to increase phosphate adsorption without use of the rare earth to specifically enable phosphate recovery by backwash**. Dryden are looking for partners to test this specific AFM product in real wastewater treatment or to use AFM's particular organic and inorganic particle removal and recovery potential to integrate into phosphorus recovery processes.

Contact: info@phosphorusplatform.org

See https://twitter.com/drydenaqua *and* www.drydenaqua.com

Looking for partners MC-ITN network
Organic fertiliser network

Proposed MC-ITN (Marie Curie Initial Training Network) proposal, suggested title 'Technologies for organic waste based biofertilizer upcycling in agriculture'.

Deadline for submission = early April 2014.

Contact: Lars Stoumann Jensen, Detpt. Plant and Environmental Sciences, University of Copenhagen lsj@plen.ku.dk

US & Canada
Phosphorus research network and proposed phosphorus partnership

North America Sustainable Phosphorus "Partnership" project j.elser@asu.edu

US National Science Foundation funded P-RCN (Sustainable Phosphorus Research Coordination Network) j.elser@asu.edu

P-RCN student network: contact rimjhim.aggarwal@asu.edu

EU Horizon 2020 project
Phosphorus Circular Economy Covenant

European Partners for the Environment is preparing a Raw Materials Commitment (RMC) named 'Covenant Circular Economy 2022' for the EU 2020 Raw Materials SIP. Phosphorus would be an example for developing and implementing Circular Economy methodology and guidelines.

EPE contact for Raw Materials Commitment (RMC)'Covenant Circular Economy 2022' raymond.vanermen@epe.be

EU COST R&D network project
Efficient P resource management

Proposed COST Action (R&D network *www.cost.eu*) project "Innovation for efficient resource management: the example of phosphorus". Objectives: to engage a multidisciplinary network of scientists and stakeholders to (1) identify, assess and integrate the most promising innovations for better P recycling and use efficiency including potential constraints, and (2) share efforts for dynamic modelling of P flows in society and the environment and assess integrated scenarios of sustainable P management across.

If interested, contact: pellerin@bordeaux.inra.fr *or* kimo.vandijk@wur.nl

Research proposal:
P for horses, diet and manure

Commercial horse feeds contain excess P, leading to high P in manures. Research proposal to assess P needs, P in manure, propose improved diet products.

A small sampling of commercial horse feeds revealed that **90% of the feeds sampled contained higher levels of P than needed to supplement horses grazing pastures** grown on P-adequate soils and 2/3 contain added inorganic phosphates. Following a Masters in equine nutrition at University of Kentucky (Dept. Animal and Food Sciences), sponsors are invited to enable further research into horse dietary P needs (as a function of P supplied in grazing), resulting P in horse manure, forms of P and availability to equine digestion and horse health impacts of levels of P supplied in the diet.

Aspects proposed to investigate include, and can be adjusted in consultation with project sponsors:

- Phosphorus content in pasture grass at different times of the year
- Plant availability of P in pasture soil
- Comparison between pregnant mares and foals fed a standard diet and those fed an adjusted diet, over the year
- Assessment of horse health, growth, bone development, blood sampling, monitoring of orthopaedic or physitis problems
- Analysis of total P and phytate P in manures, to assess environmental significance of P and to measure digestive availability of phytate P in feed in the horse

Contact: info@phosphorusplatform.org

Fowler, A.L., L.A. Strasinger, T.L. Hansen, B.E. Davis, S.H. Hayes, and L.M. Lawrence. 2013. The availability of dietary phosphorus to long yearlings and mature horses. Journal of Equine Veterinary Science. 33(5): 342 – 343. http://www.j-evs.com/article/S0737-0806(13)00162-7/abstract

Fowler, A.L., L.A. Strasinger, S.H. Hayes, and L.M. Lawrence. 2013. An in vitro method for determing phosphorus availability in horse feeds. Journal of Equine Veterinary Scienc. 33(5): 332 – 333. http://www.j-evs.com/article/S0737-0806(13)00143-3/abstract

Fowler, A.L., L.M. Lawrence, S.H. Hayes and S.R. Smith Jr. 2012. Mineral concentrations of cool season grasses as affected by specie and season. J. Anim. Sci. Suppl. 3. 90: 549 – 550.

Department of Animal and Food Sciences, University of Kentucky http://afs.ca.uky.edu/

PhD student
Looking for phosphorus related postdoc

Xiaoning Liu, PhD from University of Chinese Academy of Sciences for "**Phosphorus recovery from human urine through struvite formation**", experience in nutrient control from livestock production, composting, plant carbon use in semi-arid regions, is looking for a postdoc position relating to phosphorus management.

Contact: zhyhu@ucas.ac.cn *or* liuxn10b@mails.ucas.ac.cn

New link
Meat Atlas

Heinrich Böll Foundation, Berlin and Friends of the Earth, Brussels publish the new **Meat Atlas 2014**, giving 68 pages of facts and figures about global meat production and consumption and the related societal, economic and ecologic impacts and developments.

http://www.boell.de/en/2014/01/07/meat-atlas

Communicating partnership opportunities

Projects and opportunities
Looking for partners? Process to test? Contacts wanted?

Send your information now to for publication in this Newsletter and on the ESPP website: to *info@phosphorusplatform.eu*

*The **SCOPE Newsletter** is now published by the **European Sustainable Phosphorus Platform**.*
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Agenda 2013 - 2014

- 6 February, afternoon, Brussels, **ESPP recovered phosphates and revision of EU Fertiliser Regulations** *info@phosphorusplatform.eu*
- 7 February 9h00 – 12h30, Brussels, **ESPP WG on R&D funding opportunities for P stewardship** and 13h30-16h00 **WssTP WG on nutrient recovery and recycling R&D projects** *info@phosphorusplatform.eu*
- 20-14 February, Dublin, **Anaerobic Digestion Europe 2014** *www.adeurope2014.eu*
- 23-25 March, Paris: **Phosphates 2014** (CRU) The annual phosphate industry conference *www.phosphatesconference.com*
- 24-26 March, Sofia, Bulgaria: **EWPC11 European Workshop on Phosphorus Chemistry** *http://ewpc11-bg.org/index.php*
- 1-4 April, Amsterdam: **International Fertiliser Association Global Technical Symposium** *www.fertiliser.org*
- 6 May, 16h-18h, Munich, Germany: **phosphorus recycling conference at IFAT** (world trade faire for water, waste and raw materials management) *www.ifat.de*
- 4-6 June, Valladolid, Spain: 10th International **Renewable Resources and Biorefineries** (RBB) (5th June: Nutrient & Energy cycling sessions) *www.rrbconference.com*
- 19 June, Leeds, England, **Future options for food waste** *http://www.aquaenviro.co.uk/view-product/Future-Options-for-Food-Waste*
- 23 June, Brussels, **Biochar safety, economy, legal harmonisation** (REFERTIL) *biochar@3ragrocarbon.com*
- 26-28 June, Gödöllö Hungary, **ORBIT 2014 Organic Resources and Biological Treatment** *http://orbit2014.com*
- 29 June – 3 July, Dublin: **20th International Conference on Phosphorus Chemistry** *www.icpc2014.ie*
- 13-17 July, Harbin, China: **IWA Science Summit on Urban Water** *http://www.iwahq.org/28f/events/iwa-events/2014/urban-water.html*
- 26-29 August 2014, Montpellier, France: **5th Phosphorus in Soils and Plants symposium** *http://psp5-2014.cirad.fr/*
- 1 - 3 Sept., Montpellier, France 4th world **Sustainable Phosphorus Summit** *http://SPS2014.cirad.fr*
- 27 Sept. – 1 Oct., New Orleans **WEFTEC2014** (Water Environment Federation) *www.weftec.org*
- 26-30 Oct, Kathmandu, Nepal **IWA: Global Challenges for Sustainable Wastewater Treatment and Resource Recovery** *http://iwa2014nepal.org*
- 3-5 Nov 2014, Long Beach, California **ASA, CSSA, SSSA** (US & Canada soil and agronomy) meetings, Water Food, Energy, Innovation for a Sustainable World *www.acsmeetings.org*
- 3rd-4th March 2015, Berlin: **2nd European Sustainable Phosphorus Conference**
- 23-25 March 2015, Florida: **Phosphates 2015** (CRU)
- 29 March – 3 April 2015, Australia. **Beneficiation of phosphates VII** *http://www.engconf.org/conferences/environmental-technology/beneficiation-of-phosphates-vii/*
- May 2015, Morocco: **SYMPHOS** *www.symphos.com*

Nutrient Platforms

- **Europe:** ***www.phosphorusplatform.org***
- **Netherlands:** ***www.nutrientplatform.org***
- **Flanders (Belgium):** ***http://www.vlakwa.be/nutrientenplatform/***
- **Germany:** ***www.deutsche-phosphor-plattform.de***