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### EU consultations

#### **EU consultation on Pollutant Release and Transfer Register**

Open to 26 October 2020. The E PRTR Regulation (EC) 166/2006 ensures that certain pollution emission data is made public. It currently covers emissions of 91 listed pollutants for installations in 65 sectors. Listed pollutants include nutrient emissions (total P, total N, ammonia). Confusingly, coverage is not the same as for the Industrial Emissions Directive IED: 30 000 installations in Europe concerned by the PRTR but 50 000 by IED. Sectors covered at present by PRTR include waste and wastewater treatment (whereas municipal sewage works\* are not under IED), slaughterhouses, food and beverage industry, large poultry and pig farms (same thresholds as IED, see below) but also aquaculture which is not covered by the IED (> 1 000 tonne fish or shellfish per year). The consultation on the PRTR considers possible widening of scope, additional pollutants (e.g. to emerging pollutants), collecting information relevant to decarbonisation and the Circular Economy and improving public information access. ESPP notes that the E PRTR pollutant list currently does not include a number of substances on the Water Framework Directive "Priority Substances" list: PFOS and its derivatives, a number of pharmaceuticals, brominated flame retardant HBCDD

\* i.e. those covered by the Urban Waste Water Treatment Directive 91/271/EEC EU public Roadmap consultation on the European Pollutant Release and Transfer Register (E PRTR) open to 26 October 2020 HERE

#### **EU consultation on Zero Pollution Ambition**

Open to 29 October 2020. The "EU Action Plan Towards a Zero Pollution Ambition for air, water and soil" stems from the Green Deal objective of zero pollution (see ESPP eNews n°39). The consultation document refers to pharmaceuticals, persistent and toxic chemicals and micro-plastics. It notes that pollution to soil should be addressed and is not well covered by existing EU regulation.

EU public Roadmap consultation on the Zero Pollution Ambition open to 29 October 2020 HERE





#### EU consultation on sustainable aquaculture

Open to 27th October 2020. See ESPP eNews n° 47. Consultation HERE

#### EU consultations on agriculture policy (CAP)

Open to 22<sup>nd</sup> October 2020. See ESPP eNews n° 47. Consultations here on water, on habitats, landscapes and biodiversity, and on sustainable management of soil.

#### EU consultation on environmental product claims

Open to 3rd December 2020. Consultation on product environmental claims and PEFs (Product Environmental Footprints) HERE

### **Policy**

#### **Updated EU Critical Raw Materials List published**

The European Commission has published the 4th version of the Critical Raw Materials List (CRM). Phosphate Rock (in effect, phosphorus in any form: rock, fertiliser, chemicals, organics ....) and "Phosphorus" (in effect, P4 and derivatives) are maintained on the list. This new list is the previous 2017 list plus four minerals (bauxite, lithium, titanium, strontium). The Commission announcement recommends inclusion of CRM investments in Covid recovery plans, development of recycling and domestic sourcing of CRMs, actions on value chains and international trade. The accompanying document identifies EU dependency on imports (84% import dependency, of which Morocco and Russia total 44) for phosphate rock and for P4/derivatives (100% import dependency, of which 98% from Kazakhstan, Vietnam and China). Overall emphasis in the short term is strongly on the "rare earth and magnet value chains", identified as relevant for renewable energy, defence and space. An accompanying study by EU JRC assesses CRMs relevant for "strategic technologies", identified as: lithium ion batteries, fuel cells, wind energy, electric traction motors, photovoltaics, robotics, drones, 3D printing and digital technologies. Unfortunately, this study does not consider "Phosphorus" (P4 and derivatives), which is almost totally absent from the study (e.g. absent from the conclusions and study cover Sankey diagram, which covers 24 other materials). Also, in Annex 2 to the European Commission official CRM List Communication, Phosphate Rock and Phosphorus are indicated as relevant to "Energy intensive industries" (bizarrely) and "Agri-food" but not to other sectors where P-based chemicals are important: renewable energy (e.g. in batteries), digital (e.g. microchip etching), electronics, aerospace (e.g. flame retardants). ESPP will write to the European Commission to address these omissions.

European Commission Communication COM(2020) 474 final, 3rd September 2020 "Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability" HERE

JRC "Critical Raw Materials for Strategic Technologies and Sectors in the EU – A Foresight Study", 2020, ISBN 978-92-76-15336-8 HERE

#### EU IED evaluation: resource use, recycling, agriculture

The European Commission has published its evaluation of the Industrial Emissions Directive which regulates over 50 000 installations in Europe, including food and dairy processing, waste treatment and large poultry and pig farms (replacing several Directives including IPPC). The evaluation is based on input to stakeholder consultations (see ESPP eNews n°42, ESPP input submitted here). Conclusions are that the Directive is effective, cost-efficient, coherent and provides EU added value. Amongst aspects which work less well or are to be addressed, the Commission identifies resource use and Circular Economy, greenhouse gas emissions, implementation of BAT technologies, emerging technologies and possible widening of scope. The report states that a few highly-polluting activities are not currently covered by the Directive, including cattle farms, aquaculture and poultry farms below the current IED threshold of 40 000 birds, but notes that extending to cover cattle farms has previously been considered and rejected because of the administrative burden.

"Executive Summary of the Evaluation of the Industrial Emissions Directive (IED)", European Commission SWD(2020)182 (Executive Summary) and SWD(2020)181 full report, 23 September 2020. The executive summary(182) is available by searching here. The full report (182) seems to not be publicly available at present but can in fact be found here.

#### **EFSA Opinion on PFAS**

Perfluorinated alkyl chemicals are a contaminant found in sewage sludge which raise particular concern (see SCOPE Newsletters n° 134, 129, 123) but which could be avoided if their use was restricted. The EFSA (European Food Safety Agency) Opinion covers PFOA, PFOS, PFNA and PFHxS (collectively termed PFAS). They are used in e.g. textiles, household products, fire-fighting foams, automotive, food processing, construction, electronics. EFSA indicates that there is evidence that these chemicals are bio-accumulative and are probably linked to reduced immune response, cholesterol, liver impacts, infant birth weight, with limited evidence of carcinogenicity. EFSA has fixed a TWI (tolerable weekly intake) of 4.4 nanogrammes/kg body weight (total PFAS substances).

"PFAS in food: EFSA assesses risks and sets tolerable intake", EFSA press release 17 September 2020 and EFSA Scientific Opinion adopted 6 July 2020 "Risk to human health related to the presence of perfluoroalkyl substances in food".

#### EEA Brief on biodegradable / compostable plastics

The European Environment Agency (EAA) has published a briefing document on biodegradable, compostable, bio-based and oxo-degradable plastics. This underlines the differences between these different categories: bio-based = fully or partly made from biological raw materials, but may or may not be readily degradable; compostable = in some cases in industrial composting systems (with controlled conditions), in other cases also in less well controlled garden composting; biodegradable = in natural media (soil, water ...) but with no recognised standard for testing conditions, and degradability in soil may not mean degradability in water; oxo-degradable = include additives which cause breakdown into microplastic particles or chemical decomposition. This vocabulary is not well understood by the public: in one survey in Germany, nearly 60% thought bioplastic implied biodegradable. The report suggests that marketing of plastics as "biodegradable" or "compostable" may need to be prevented to reduce consumer confusion and misuse of such plastics, but that such plastics can be useful in specific applications (e.g. bags for household separate collection of food waste or agricultural mulches), subject to respecting precise standards adapted to the specific application.

"Biodegradable and compostable plastics challenges and opportunities", European Environment Agency, <u>Briefing 9/2020</u>

#### **EU R&I Event: uncrossing planetary boundaries for nutrients**

John Bell, Director "Health Planet" at the European Commission DG Research, underlined that planetary boundaries are considerably exceeded for phosphorus and nitrogen and that urgent and systemic action is needed. Mark Sutton, International Nitrogen Initiative, underlined that both all nutrients need to be addressed, but that nutrients tend to be forgotten. He underlined the economic significance: nitrogen losses represent some 200 billion US\$ fertiliser value worldwide, and societal a further 70 to 320 billion US\$. That is in total, in Europe, around 1/3 of the CAP budget. He welcomed the proposed EU objective to halve nutrient pollution by 2030 in the Farm-to Fork strategy which echoes the United Nationals Environment Assembly resolution EA.4 (march 2019, see ESPP eNews n° 33). Chiara Manoli, ECOFI, underlined the progress made in organic fertilisers, with standardisation of production processes. This enables recycling of nutrients and carbon in secondary materials such as wine or food processing wastes, poultry litter from egg production, fish meal, residuals from tanning, etc., and brings organic carbon to soil, contributing to soil fertility and to water retention. She underlined the importance of the new EU Fertilising Products Regulation which puts in place, for the first time, EU criteria for organic fertilisers, but notes that outstanding regulatory difficulties remain with Organic Farming and with Animal By-Products. Jannes Mes, President of the European Council of Young Farmers, underlined that farmers are motivated to reduce nutrient pollution, but cannot fund actions to improve nutrient management without public support.

EU R&I Days 2020: 22nd September 2020, webinar with Katja Klasinc and John Bell, European Commission, Mark Sutton, International Nitrogen Initiative, Chiara Manoli, ECOFI and Jannes Maes, European Council of Young Farmers (CEJA) watch online

### **Webinars**

#### **Upcoming webinar: Phosphorus and climate change**

A session at the prestigious American Association for the Advancement of Science (AAAS) annual symposium, 8th February 2021, will address how phosphorus losses to surface waters can accelerate greenhouse gas emissions, and how climate change can feed back to accentuate eutrophication, with John Downing, University of Minnesota, Laura Johnson, Heidelberg University and Ahren Britton, Ostara. This is supported by the ESPP – US Sustainable Phosphorus Alliance joint SCOPE Newsletter special issues on nutrients and climate change: methane emissions (SCOPE Newsletter n°135); P runoff, catchment management and P in soil (coming soon); P and soil health links to climate; greenhouse emissions of nutrient management and recycling (both planned).

Phosphorus and Climate Change: A Vicious Circle, AAAS Annual Symposium, 8th February 2021, 12h - 12h45 ET https://meetings.aaas.org/

#### **German Phosphorus Platform (DPP) Forum**

The annual DPP Forum, 24th September 2020, took place as a hybrid event with 135 participants (75 in Frankfurt).

Presentations covered questions concerning the implementation of the German Phosphorus Recycling Ordonnance, status of development of P-recovery projects and installations in Germany, industry requirements and experience in processing recycled nutrient materials, and farmers' expectations concerning recycled nutrient fertilisers.

The specific requirements of the Organic Farming movement for recycled P products were discussed, including safety, life cycle analysis and of use of chemicals in processing.

The Forum also discussed a proposed DPP Memorandum under preparation to propose actions to politicians to move forward phosphorus recycling.

German Phosphorus Platform (DPP) annual Forum 2020.

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#### **US Sustainable Phosphorus Alliance annual Forum**

The two-day annual North America phosphorus event this year was two three-hour webinar sessions, with over 70 Participants worldwide.

#### Struvite recovery

Chris Hornback, National Association of Clean Water Agencies, underlined the need for federal clarification of the status of struvite recovered from sewage plants. The EPA enacted in 2017 that struvite could be authorised case by case\*. \* ESPP note: For example, Ostara CrystalGreen struvite is authorised in 42 US States (see SCOPE Newsletter n° 124).

Aaron Fisher, Water Research Foundation, underlined the advantages of struvite precipitation in reducing P in biosolids, reducing polymer use in dewatering and improving dewatering (higher dry matter content of biosolids).

Robert van Springelen and Matt Kuzma, Ostara, presented application of the company's Crystal Green PEARL® struvite recovery to phosphate rock processing water, both in operating installations and in leachate from phosphogypsum 'stacks' at closed sites. A pre-treatment step removes fluoride and silica using lime. After struvite precipitation and membrane finishing, the treated process water can achieve discharge water quality. The technique and process is in TRL 9 stage and proven successful in full scale.

#### Manure phosphorus

Rebecca Muenich, Arizona State University, underlined that manure is a major nutrient pollution challenge and the biggest potential source for P-recycling in the USA. There is no national inventory of CAFOs (Concentrated Animal Feeding Operations) or AFOs in that many do not have federal environmental permits\*. R&D work is underway to develop a virtual mapping of AFOs and CAFOs across the USA based on remotely-sensed data. \* ESPP note: the US EPA AFO web pages indicate that < 7 000 out of nearly 21 000 AFOs with numbers of animals above thresholds requiring NPDES permits did not have such a permit in 2019). The thresholds are equivalent to c. 700 dairy cows, 2 500 pigs or 125 000 broiler chickens. The EU requires permitting (under the Industrial Emissions Directive) from 2 000 pigs or 40 000 poultry (but not yet for intensive cattle installations).

Jeff Dawson, Renewable Nutrients, indicated that the company now holds the licence to the USDA QuickWash® process (see SCOPE Newsletter n°119). The enables P recovery from manure by acid solubilisation followed by calcium phosphate precipitation and can be combined with ammonia recovery using a gas-permeable membrane.

Rick Johnson, Applied Environmental Solutions, indicated that livestock farms face increasing manure management costs. NRC 590 limits spreading of phosphorus per hectare, so increasing manure transport distances and costs. P-recovery from manure can reduce the hectares needed for manure spreading by as much as 40%

An opportunity for the future was identified as mobile manure processing units, to enable cost-sharing between farmers.

#### Perspectives for nutrient management

Kerry McNamara, OCP, outlined the company's actions to maximize phosphorus sustainability across its entire value chain, and to support sustainability at the farm level. We have to make nutrient stewardship economically sustainable for farmers. OCP is committed to optimal use and recycling of phosphorus, as part of the company's overall sustainability objectives, which include 100% clean energy and zero non-renewable water use by 2040 and carbon neutral by 2040, as well as maximizing P recovery at all stages of its operations. As one example of that, OCP is currently exploring Ostara struvite recovery technology for its own processing discharge in Morocco, and also possibilities for phosphorus recycling from municipal sewage works.

Don Boesch, Maryland Center for Environmental Science, summarised actions to restore the Chesapeake Bay since the 1980's. Objectives for nutrient input reductions fixed for 2000 and 2010 were not met. Mandatory TDMLs (Total Maximum Daily Loads) are now set for 2025, but reductions are likely to again fall short. Nutrient loads have been reduced since the 1990's and smaller hypoxic areas are now seen in the Bay, but nutrient levels are not falling as fast as management models indicate. This could result from "lag time" due to P remobilisation from soil and sediments and nitrate storage in groundwater, but it could also be that agricultural nutrient BMP measures (Best Management Practices) are not being implemented as they should be, or that they are less effective than assumed. On the other hand, there seems to be more urban nutrient retention than management models estimate.

#### Agricultural nutrient loss models and their implementation

Carl Bolster and Barret Wessel, USDA-ARS, summarised work ongoing assessing models of farm nutrient runoff in the West Lake Erie Basin (TBET and Apple models). The objective is to be able to model losses by field, as a function of agricultural practice, with a model which uses available data and which is accessible to extension agents. Model results show high levels of uncertainties, and a challenge is how to identify these and how to communicate uncertainties to users.

Jon Winsten, Winrock International (a large non-profit organisation addressing agricultural, environmental, and social issues around the world) summarised test programmes in Ohio, Vermont, Wisconsin and Iowa. Farmers are paid for quantified outcomes, calculated for actions intended to reduce nutrient losses. Payments are, for example, c. 80 US\$/kg P loss reduction, c. 11 US\$/kg N, based on modelling, on a field by field basis. The models show very high variations between fields. Winrock provides farmers with field-by-field calculations of modelled nutrient loss reductions, of resulting payments, of estimated costs (e.g. income loss for land converted to buffer strips), and helps farmers find the most cost-effective actions.

Sustainable Phosphorus Alliance annual forum 2020 - watch online.

#### Sewage sludge incineration ash recycling

This webinar organised by EasyMining discussed possibilities for recycling phosphorus, iron/aluminium and silica sand recovered from sewage sludge incineration ash.

Dines Thorberg, Biofos (Copenhagen public water company), indicated that farmers are sceptical about possible value of sewage sludge incineration ash as a P-fertiliser, and zinc and chrome levels are too high for land application. Ash produced today has c. 10%P (dry weight), and Copenhagen has a landfill of 350 000 tonnes of sludge incineration ash from the past with average c. 5% P. In the past, part of the ash was recycled into mineral wool construction materials. Biophos is currently tendering to find a process to recover phosphorus from the sludge incineration ash.

Yariv Cohen, EasyMining, indicated that the company's Ash2Phos process (see ESPP P-Recycling Technology Catalogue) enables recovery of c. 90% of phosphorus and c. 80% of calcium are recovered from ash as quality grade calcium phosphates. 60-80% of aluminium and 10-20% of iron can be recycled to sewage works as coagulants. Higher levels of iron could be recovered, but at a higher cost and chemical consumption, whereas there is at present no regulatory or market driver. Over 95% of heavy metals are removed, leaving a clean silica sand material which can be used in concrete production. A 30 000 t(ash)/v Ash2Phos plant will generate c. 13 000 t/y of calcium phosphate product and 23 000 t/y of silica sand.

Cement production has high climate emissions (5 – 8% of anthropogenic GHG), so partial replacement with this silica sand could be very attractive to cement companies and could bring climate offset income.

Lisbeth Ottosen, Technical University of Denmark, summarised testing of EasyMining recovered silica sand to replace cement in concrete production. Kg-scale trials have shown that 20% of cement in concrete can be replaced by recovered silica sand, on condition that it is briefly milled (10 seconds) and with use of plasticisers to improve concrete quality. The resulting concrete has a reddish colour (iron in the silica sand) which can have aesthetic advantages, and shows only a small loss of strength. Further research is needed to understand the chemistry of cement phases, to optimise plasticiser use and to test durability of the resulting concrete over time.

Katrine Orland Led, Ramboll, outlined conclusions of a market analysis study into use of silica sand to replace cement in concrete. Interest of the cement industry to reduce climate emissions could be a driver. Potential applications include facades, pre-fabricated concrete structures, ground stabilisation, binding layers, paving stones and fibro-cement materials.

"Value adding recycling of sewage sludge in concrete. Making concrete more sustainable", EasyMining webinar, 2<sup>nd</sup> October 2020, available here https://www.easymining.se/article-startpage/sustainable-concrete-webinar/

#### P fertilisation and legacy P

Crop P needs in soils with "legacy phosphorus" were discussed as part of the IFS agronomy webinar series, with **Sophie** Nawara, currently working at the Soil Service of Belgium (the presented research was part of her PhD study at KU Leuven). Much of Europe had a highly positive soil P balance from the 1940's (phosphorus application as mineral fertiliser and/or manure greater than crop offtake and runoff). There has been a decrease in phosphorus fertilisation in Western Europe over the last decades, and Western Europe's overall P-balance is negative since around 2000 (from Fig. 5 in Zhang et al. 2017, see SCOPE Newsletter n°128). However, the over-fertilisation during decades has caused an accumulation of soil P ("legacy P") resulting in current high soil P contents in some regions in Europe.

Two year greenhouse trials were carried out with eight different Flemish soils, using rye grass (fast growing, needs rapid P supply). Results showed that, in this specific case and after two years of P "draw down" by the rye grass, legacy P in soil alone (without addition P fertilisation) led to a significantly lower cumulative biomass than with P fertilisation in six out of eight of the soils, when adequate nitrogen was supplied, see Nawara et al. 2018.

Modelling suggests that a fast reacting P pool (e.g. adsorbed P in soil) can be accessed sufficiently rapidly by crops, but that legacy P is more present in a slow reacting P pool (e.g. into soil particles with ageing), which is only slowly accessible to plants. Fast growing plants experience P deficiency faster than slowly growing plants because of their higher P demand rate which exceeds faster the soil P supply rate.

Also some soil P tests were evaluated in their capacity to predict crop yield in a P depleting scenario. None of the soil P tests outperformed the others, meaning that, for European soils, the crop accessible P is generally well measured by the Olsen-P (0.5M NaHCO<sub>3</sub>) test and by the ammonium lactate soil test, both which are often used as standard soil P tests..

International Fertiliser Society (IFS) webinar series: programme, registration, access to recordings of past webinars (free for IFS members):

#### Variable effectiveness of bio-based fertilisers

Data from ongoing trials of different secondary or recycled P fertilisers materials were presented in the IFS agronomy webinar series, with Patrick Forrestal, Teagasc, Ireland. National testing in Ireland in 2019 (n=30,466) show that around ¾ of Ireland's soils need P applied to meet crop off-take (Index 1, 2 and 3 under the Irish system). Half of soils (in Index 1 and 2) also need P application to fill soil P sinks to be raised to the agronomic optimum (Index 3).

Seven different bio-based P materials were compared to control (no fertiliser) and TSP (triple super phosphate) in field trials in 2019 (results presented) and 2020 (ongoing): two struvites, cattle manure slurry, chicken litter ash, sewage sludge incineration ash, dairy residues complexed with aluminium or calcium. Ireland produces some 140 000 t/y of P-rich dairy processing



residues. Soil was Index 1 and pH was limed to 6.1. Phosphorus was applied at 60 kgP/ha/year was applied, as per agronomic recommendations with four grass cuts per year.

Control with no P application showed only 40% of the yield with TSP. Yields were broadly similar for all the bio-based materials and for TSP.

For P-uptake, which is significant because it impacts P levels in grazing cattle diets, struvite and slurry shows, in results to date, P uptake somewhat higher than for TSP, poultry litter ash and Al-complexed dairy residue similar to TSP, and sewage sludge incineration ash and Ca-complexed dairy residue somewhat lower.

These results should not be considered conclusive, and statistical analysis will be completed when the 2020 field trial results can be also included in the dataset.

Limerick collaborators showed that certain soil P solubilizing bacteria are more active with bio-based fertilisers than with TSP. Higher P uptake with struvite, compared to TSP, may be because slower P release from struvite could be an advantage in this field setting where soil is competing to fix available P while crop uptake is progressing.

This work is funded by the EU Interreg project ReNu2Farm and the EU H2020 project Nutri2Cycle. International Fertiliser Society (IFS) webinar series: programme, registration, access to recordings of past webinars (free for IFS members): HERE

### **Nutrient recovery**

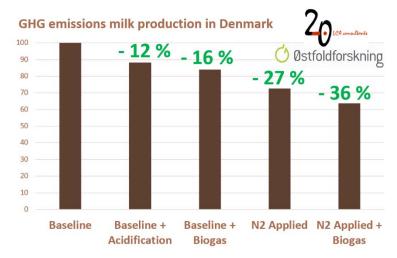
#### **RAVITA P-recovery test results published**

Lab tests were carried out on sludges resulting from post-precipitation of phosphates from the Viikinmäki municipal sewage works, Helsinki: coagulant dosing downstream of secondary treatment, followed by disc filtration (RAVITA process, see SCOPE Newsletter n°132). The RAVITA sludges were precipitated using either iron or aluminium coagulant and were tested as received (11 – 14% DM) or after incineration (550°C for 2 hours). Leaching with phosphoric acid was done in previously optimised conditions: 0.5M acid, 6 hours for aluminium; 2M acid, 1 hour for iron. Results showed c. 85% extraction from sludge and 99% from ash for aluminium; but only c. 37% from sludge and 68% from ash for iron. Approx. 95% leaching of phosphorus was achieved with both ashes, but no data is given for P leaching efficiency from the sludges (because of water content). The higher leaching of P compared to Fe or Al suggests that a significant part of these elements is not bound to phosphorus. The authors note that with aluminium, the leached P is mainly as soluble phosphate, whereas with iron, most is as soluble FeH<sub>2</sub>PO<sub>4</sub><sup>2+</sup> ions, so that further processing would be necessary to separate the phosphorus from the iron. Heavy metals were analysed in the RAVITA sludges and found to be low, but it is not clear whether this is because they are retained in the secondary sludge or whether the Helsinki sewage has lower heavy metals than generally in Europe. The authors conclude that incineration of the RAVITA sludges improves potential for recovery of P and of Fe/Al. However, this may not be practical because the organic content of these post-precipitation sludges is low.

"To incinerate or not? Effects of incineration on the concentrations of heavy metals and leaching efficiency of post-precipitated sewage sludge (RAVITA™)", S. Reuna, A. Väisänen, Waste Management 118 (2020) 241–246, DOI.

#### N2 Applied inaugurates new production hall

On 21st September, ESPP member N2 Applied opened a new nitrogen recovery unit production hall, with Raymond Robertsen, Norway State Secretary of Regional Development and Erik Solheim, former UNEP Director and Norwegian Minister, and Ola Hedstein, CEO of Norwegian Agricultural Cooperatives.N2 Applied's plasma technology uses air, electricity and manure slurry to create an organic and mineral N containing fertiliser which has no odour, reduced emissions and higher nitrogen content. Farm installations fit into a haulage container. An LCA study by 2.-0 LCA indicates that a combination of digestion of manure to produce biogas and N2 Applied technology can reduce greenhouse gas emissions from dairy farming by -36% (compared to baseline): anaerobic digestion of manure to produce biogas -16%, N2 Applied alone (treating manure) -27%; biogas + N2 Applied (treating digestate) -36%.





#### German national "RePhoR" P-recovery projects announced

The German Federal Research Ministry (BMBF) has published stage two results of its RePhoR = Regional Phosphorus Recycling call for projects. The call was published in February 2018 and consisted of two stages: a "concept" stage, and an "implementation" stage.

19 projects were selected in stage 1, which funded the preparation of "regional P-recycling and sewage sludge reuse strategies" (leading to a 25-page document). These are listed on page 343 of this document (article by Helmut Löwe, BMBF.

The list of projects now published corresponds to the second stage of this call, that is those selected to "receive funding for the implementation of the concepts". The call states that these should be "large-scale implementation of ... processes" and specifies "exemplary development and large-scale implementation of processes for P recovery under real conditions for different plant sizes and types (at least TRL 6 for short)".

However, some of the seven selected projects nonetheless appear to be R&D scale and to not correspond to the large-scale process implementation specified in the call.

- ESPP member Outotec is part of the R-Rhenania project, which will build and operate an AshDec® plant to recover phosphorus from 30 000 t(ash)/y of sewage sludge incineration ash, with the Altenstadt – Emter sewage sludge incineration plant (Bavaria) and the fertiliser manufacturer sePura, with BAM, KWB, LfL in Bavaria, FEhS and Bonn University. AshDec: see SCOPE Newsletter n°132.
- Amphore (Ruhr) website, led by Ruhrverband, will address the full value chain of P recycling as an integral part of sewage sludge use, including the development of sludge and ash management structures organised by five public waterboards. The project will built a 3 tonnes/day (1 000 t/(ash)y) plant, at a site of Emschergenossenschaft / Lippeverband (ESPP member), using adjusted PARFORCE technology (see ESPP P-Recycling Technology Catalogue). Two other ESPP members, Yara and the German Phosphorus Platform (DPP), are also involved in the project.
- ESPP member Veolia (Veolia Klärschlammverwertung Deutschland GmbH) is part of the DreiSATS project (Saxony), website, with Carbotechnik Energiesysteme GmbH, Pontes Pabuli GmbH, Lufttechnik Crimmitschau GmbH, Fraunhofer IKTS and with MFPA at the Bauhaus University Weimar. The objective is to develop combining incineration of dried sewage sludge (DM > 90%) in a dust firing system. The ashes are then treated with acid, followed by a solid-liquid separation, then granulation of the treated ash solids (Pontes Pabuli process), to produce fertilisers. Heavy metals are removed in the incineration process by a hot gas filtration unit and additionally during the ash treatment process. A 20 - 50 kg/h ash demonstration plant is planned.
- KlimaPhoNds (Lower Saxony), website, led by CUTEC Research Centre of Technical University Clausthal) aims to combine P-recovery with sewage sludge drying and combustion technologies to enable reductions of greenhouse gas emissions. Struvite will be precipitated from sewage sludge liquors (by a new process), then calcinated to recover ammonia and remove organics, then processed using PARFORCE technology (different from the PARFORCE ash process cited in SATELLITE below) to produce phosphoric acid and magnesium chloride. Announced scale is 1-2 t/day struvite processing, with struvite production and sludge processing commercial scale.
- P-Net (Harz Heide region), led by Technical University of Braunschweig, aims to improve process engineering of struvite production and to develop regional markets for recovered struvite, with a regional cluster of sewage works recovering struvite. Scale of R&D pilot plant not specified.
- RePhoRM (Frankfurt Rhein Main region) will extend the Glatt PHOS4green technology (see ESPP P-Recycling Technology Catalogue). Heavy metal content in sewage sludge incineration ash will be reduced by a wet chemical process. The ash will then be reacted with phosphoric acid to improve plant availability of phosphorus in the ash, then granulated as fertiliser. The heavy metal reduction process will be tested in a 50kg batch pilot. The PHOS4green technology will be tested up to 200 kg/batch. The enhanced PHOS4green technology will be implemented on a commercial scale (capacity to be defined) at the Hoechst Industrial Park, Frankfurt am Main.
- SATELLITE (Lower Saxony), website, led by ISAH Leibniz Universität Hannover, involves an inter-municipal cooperation for sludge incineration and P recovery (23 shareholders, sludge of over 40 communities, https://www.knrn.de/). Research focuses on upstream sludge quality and transport logistics and will also look at the potential of farm manure and nitrogen. The project includes decentralised recovery of P as struvite or calcium phosphate, ammonia recovery by sequential evaporation (SEQUESTA) and stripping, and centralised sludge incineration (37 000 tDM sludge/year) at Hildesheim. PARFORCE technology is cited for P-recovery from the sewage sludge (see ESPP P-Recycling Technology Catalogue This is different from the PARFORCE struvite process in KlimaPhoNds above). The SATELLITE project includes research in phase 1 of the project, implementation in phase 2.

RePhoR, Germany, regional phosphorus recycling joint projects, September 2020 https://www.bmbf-rephor.de/verbundprojekte/ RePhoR launch event and internal workshop, 3rd & 4th November 2020 https://www.bmbf-rephor.de/veranstaltungen/rephor-kick-off-seminar/

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#### Solubilisation of P from ash and other materials by microorganisms

Several papers present tests ongoing in Poland (Wroclaw, Olsztyn, Puławy) solubilising phosphorus secondary materials using 7-day culture with microorganisms, granulating the resulting material, and then testing in field trials. Secondary materials used in the different tests reported are ground bio-P-SSIA (sewage sludge incineration ash from a sewage works operating biological Premoval), ground bones (cooked chicken or fish bones), MBM (meat and bone meal ash). Microorganisms tested include Bacillus magaterium, a large, rod-like, Gram-positive bacteria, naturally occurring in a range of habitats, and widely studied, and used in industry (to produce penicillin amidase, used to make synthetic penicillin) and Acidithiobacillus ferrooxidans [a] Bacillus cereus, Bacillus subtilis and Bacillus thuringiensis (results not yet published).

For example, in a 2019 paper [b], at 30 litre batch reactor lab scale, with bio-P-SSIA and poultry bones as substrates, pH in the culture fell to c. 4-5 within one day, then was relatively stable. P in the culture solution increased after 7 days during B. magaterium culture from near zero to c. 200 mgP-PO<sub>4</sub>/I for sewage sludge incineration ash or over 600 mgP-PO<sub>4</sub>/I for poultry bones, that is c. 9% for ash and 23% of total P in the materials. Around 100% of the P in ash and was found to be extractable (with water or citrate) after 7 days.

Granulation has been tested [c] at semi-technical scale (c. 100 kg/h capacity batch plate granulator), after drying of the whole culture at 60°C for three days, thus retaining the P in the culture solution, using various granulation agents: dried blood, superphosphate, bentonite, gypsum, sodium lignosulphonate, molasses.

The granulated micro-organism-activated materials (based on bones and sewage sludge incineration ash) have been tested in four field trials in Poland with winter and spring wheat, showing fertiliser effectiveness similar to phosphate rock and to a lowmedium dose of superphosphate (18 or 26 kgP/ha) but lower that a standard agronomic recommendation dose of superphosphate (35 kgP/ha) when comparing to the same dose of P in the recycled fertiliser material [f].

Contaminant levels in the produced recycled fertilisers were low with bones, but up to 22 mg/kg for lead, 0.8 mg/kg for cadmium and 880 mg/kg for copper (from sewage sludge incineration ash). However, application at c. 35 kgP/ha resulted in no detectable change in levels of cadmium or lead in soil or in crops grown [d].

Assessment in the field trials also showed that the use of these recycled fertilisers did not modify number, biomass or species composition of earthworms [e].

[a] Valorization of Phosphorus Secondary Raw Materials by Acidithiobacillus ferrooxidans, M. Wyciszkiewicz, A. Saeid, et al., Molecules 2017, 22, 473; DOI: 10.3390/molecules22030473 and Valorization of ash and spent mushroom substrate via solid-state solubilization by Acidithiobacillus ferrooxidans, A. Saeid & A. Patel, Waste Management 87 (2019) 612-620, DOI: 10.1016/j.wasman.2019.02.048

[b] Production of phosphorus biofertilizer based on the renewable materials in large laboratory scale, M. Wyciszkiewicz, A. Saeid, et al., Open Chem., 2019; 17: 893-901, DOI: 10.1515/chem-2019-0057

[c] Obtaining granular fertilizers based on ashes from combustion of waste residues and ground bones using phosphorous solubilization with bacteria Bacillus megaterium, M. Rolewicz et al., J Env Management, Volume 216, 15 June 2018, Pages 128-132 DOI: 10.1016/j.jenvman.2017.05.004

[d] New phosphorus biofertilizers from renewable raw materials in the aspect of cadmium and lead contents in soil and plants, M. Jastrzebska, A. Saeid, et al., Open Chem., 2018; 16: 35-49 DOI: /10.1515/chem-2018-0004

[e] Phosphorus Fertilizers from Sewage Sludge Ash and Animal Blood Have No Effect on Earthworms, M. Jastrzebska et al., Agronomy 2020, 10, 525; DOI:10.3390/agronomy10040525

[f] Fertiliser from sewage sludge ash instead of conventional phosphorus fertilisers? M. Jastrzebska, A. Saeid, et al., Plant Soil Environ., Vol. 64, 2018, No.10, 504-511 DOI: 10.17221/347/2018-PSE

#### P-recovery from pharmaceutical industry wastewater

A process to remove and recover phosphorus from wastewater from the production of the antibiotic, Fosfomycin (1R-2Sepoxypropyl phosphonic acid), was tested at the lab scale. The wastewater contains, in particular, high levels of antiobiotic, preventing biological treatment, refractory organophosphorus chemicals, solvents and the complexing agent EDTA. A thermal process (wet air oxidation WAO, 200°C, oxygen @ 1 MPa, pH 11.2, 3 hours) converted 99% of organic phosphorus into soluble inorganic phosphate and removed nearly 60% of COD. Phosphorus was then removed and recovered from the liquor (which had nearly 1 000 mgP/l) by precipitation of calcium phosphate or struvite, achieving in appropriate conditions over 99% P removal and residual phosphorus below 5 mgP/l. The precipitated phosphates showed low heavy metal levels, but organic or pharmaceutical residues would need to also be verified. The treated liquor was suitable for biological treatment.

"Phosphorus recovery from fosfomycin pharmaceutical wastewater by wet air oxidation and phosphate crystallization", G. Giu et al., Chemosphere 84 (2011) 241–246, DOI

### Research

#### **UN Oceans Science**

OceanForesters are looking for partners, supporters or for other technologies to include, for a project for the United Nations Decade of Ocean Science for Sustainable Development. The project will target "Nutrient Recycling Seafood Science".

United Nations Ocean Decade. 'Nutrient Recycling Seafood Science' project page on the United Nations Decade website. Contact Mark Capron, OceanForesters.

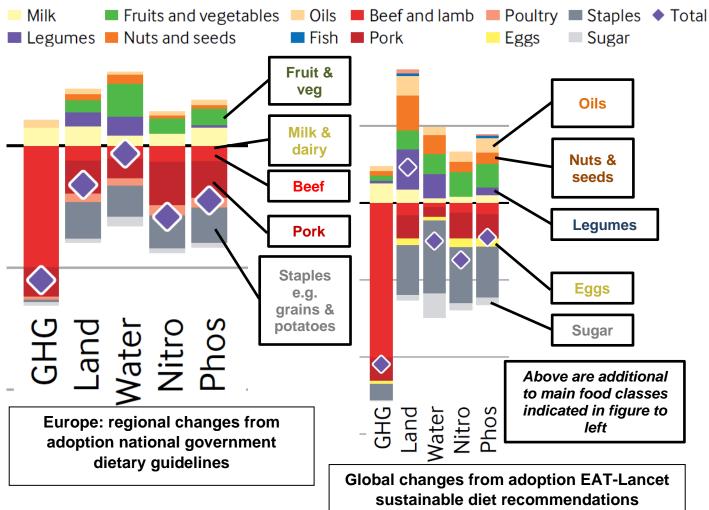




#### Government dietary guidelines inadequate for health and environment

A modelling study published in the British Medical Journal (Springmann et al. 2020), publicised in the media (see e.g. The Guardian), compares national governmental food based dietary guidelines in 85 countries, WHO dietary recommendations and the EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems 2019 recommendations (see ESPP eNews n°30). Based on country-specific data, impacts were compared to internationally agreed objectives on greenhouse gas emissions (Paris), health (Action Agenda on Non-Communicable Diseases), freshwater use, land use (Aichi biodiversity targets), nitrogen and phosphorus fertiliser application (planetary boundaries). Adoption of current national dietary guidelines would result in an overall reduction in premature mortality of 15% (obesity, heart disease, etc) and a similar reduction in greenhouse gas emissions. However, most of the national guidelines are not adequate to achieve the internationally agreed environmental or health objectives. The EAT-Lancet recommendations would deliver around 1/3 more reduction in mortality and around 3x more reduction in greenhouse gas emissions than the national guidelines.

#### Below: extracts from fig. 5 page 9 of the paper.



The analysis concludes that adoption of national dietary guidelines worldwide would not significantly modify global use of phosphorus and nitrogen fertiliser (slight increase in P consumption, near zero decrease in N consumption). This is not shown in extracts above where only Europe is shown, see fig. 5 page 9 of paper. This is because increased fertiliser use for fruit, vegetable and dairy production offsets reduced demand for staple crops (grains, potatoes), meat and sugar. In Europe, however (see extracts above), adoption of national dietary recommendations leads to around -10% reduction in N and P consumption, mainly because of reduced pork and staple crop consumption.

At the global level, adoption of the EAT-Lancet recommended diet would lead to significant (c. -10%) reduction in phosphorus use, and an even higher (c. -15%) reduction in N use, again mainly because of reduced consumption of pork and staples (grains & potatoes), despite the increases resulting from consumption of fruit & vegetables, oils, nuts & seeds.

The authors note that national dietary guidelines generally recommend an increase in dairy consumption (see extract figure for Europe above) whereas EAT-Lancet recommends to reduce dairy to one serving or one glass of milk per day. They also note



that reducing dietary calory intake, particularly associated to staple crops and sugar, is significant in reducing phosphorus and nitrogen use, whilst also reducing health risk from obesity.

ESPP notes that the impacts on P and N use seem to differ significantly from the impacts on greenhouse gas emissions, in that the latter are principally driven by red meat consumption (which also drives health impacts) whereas P and N use are not mainly driven by red meat consumption. Also, adoption of national dietary recommendations leads to increased GHG emissions in all regions worldwide, whereas it appears to lead to reduced P and N use (fig. 6, page 10 of the paper). ESPP underlines, especially for P, that the results of this paper are based on other publications' estimates of e.g. impacts of meat production on overall phosphorus use, which probably need further research, so that although the direction of conclusions is clear, further research is needed for quantification.

In an earlier study (2018), Springmann et al. modelled increases in environmental impact from the food system by 2050 resulting from world population and income increases, concluding c. 50% increases in phosphorus and nitrogen use and c. 90% increase in greenhouse gas emissions. Whereas changes in diets alone are estimated to potentially (with most ambitious scenario) reduce future GHG emissions to below current levels and close to respecting planetary boundaries, diet changes are estimated to have much lower impact on N and P use. On the other hand, technologies, including improved fertiliser and animal feed use, water basin management and manure management, alone, are estimated to potentially reduce P use below current levels and within planetary guidelines, and are also the measure with the highest mitigation potential for N use. The authors conclude that a combination of dietary change, technologies and reductions in food loss and waste is necessary to avoid increased environmental pressure from the food system and to enable respect of planetary boundaries.

"The healthiness and sustainability of national and global food based dietary guidelines: modelling study", M. Springmann et al., MJ 2020; 370: m2322 DOI

See also the EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems 2019 in ESPP eNews n°30 "Options for keeping the food system within environmental limits", M. Springmann et al., Nature volume 562, pages519–525(2018) DOI

#### **Circular Agronomics project update**

This Horizon 2020 project is now running for 2 years and aims to improve agricultural nutrient use efficiency whilst reducing greenhouse emissions, protecting soil carbon stocks and addressing the social, economic and political dimensions. The project looks at practices including seeding, type and application of recovered fertilisers, dairy cow feed composition and manure derived fertigation. Nutrient recovery techniques including vacuum degassing and struvite precipitation without addition of chemicals are tested.

Despite difficulties related to Covid and to irregular weather conditions, the six case studies have already generated valuable results:

- Catalonia (Spain): precision feeding of cows reduced N concentrations in urine by 40% without impairing milk production.
- Brandenburg (Germany): low rainfall can lead to overapplication of up to 50 kg/ha N
- Lungau (Austria): above average (6,480 l/ha) milk yields in Organic Farming in the Austrian Alpes
- Emilia Romagna (Italy): fertigation by sub-surface drip lines with ultra-low N emissions and crop yield and energy (fuel) use advantages of sod-seeding (minimum tillage) of winter wheat
- Gelderland (the Netherlands): demonstration of struvite, not only as P fertiliser, but also as an effective N fertiliser with very low N2O and NO3 emissions compared to urea, and that digested pig slurry has much lower N2O emissions than raw slurry for the same crop yield. Perennial grass types, alone or in combination with clover can also have a significant impact on N emissions but clover monocultures should be avoided.
- Moravia (Czech Republic): whey from dairies can be used as nutrient carrier whereas dosage and application still need to be determined.

https://www.circularagronomics.eu/

#### Global soil P depletion due to erosion

Modelling of P inputs to and losses from cropland suggests that soils are losing 2 kgP/ha/yr on average worldwide (-1.5 for Europe). Worldwide, the study estimates that arable land is depleted of c. 6.3 MtP/y (1.5 lost in organic P and 4.6 lost as inorganic P). This compares to estimates of losses ranging from c. 1 to 18 MtP/y in other publications. Soil P depletion is worst in Africa and Eastern Europe. The authors estimate that around half of this worldwide soil P depletion is due to soil erosion by water, concluding that agricultural management practices to reduce soil erosion are important to reduce soil P depletion.

"Global phosphorus shortage will be aggravated by soil erosion". C. Alewell et al., (2020) 11:4546, DOI: 10.1038/s41467-020-18326-7



#### Fate of pharmaceuticals in manure processing

Twelve pharmaceuticals were detected in pig manure and slaughterhouse sludge in Catalunya, Spain. All twelve were found in manure, at concentrations up to 6600 µg/kg in the solid fraction (for doxycycline, a tetracycline antibiotic used to treat pneumonia, Lyme disease, cholera ...), and most were found in the slaughterhouse waste. Both these 12 pharmaceuticals and five ARG (antibiotic resistance genes) were measured through a processing plant handling c. 7 000 t/y of manure and 11 000 t/y slaughterhouse sludge with an anaerobic digester (mesophilic, 75-80 days, producing biogas), followed by solid/liquid separation (centrifuge) and finally reverse osmosis (RO) of the liquid digestate. Mass balances for the pharmaceuticals were calculated based on measured concentrations and flows. Results are complex, in that for some periods/substances the flow of pharmaceuticals out of the anaerobic digester seems to be higher than that in the inlet (negative removal). This could be explained by several factors, such as the collection of the samples within the same day and to some analytical constraints (i.e. matrix effects). Overall, the anaerobic digester very significantly removed macrolide antibiotics (tilmicosin, tylosin), somewhat removed flubendazole and flunixin, but did not generally remove (except in some specific cases) lincomycin, fluoroguinolone or tetracycline antibiotics. In solid/liquid separation, most of the pharmaceuticals were retained in the solid fraction (except lincomycin and tiamulin), with sorption not being correlated to logKow values. The RO membrane however generally removed up to 90% of the pharmaceuticals. For ARGs, reduction was also limited in the anaerobic digester, little or no reduction in solid/liquid separation and again significant reduction through the RO membrane.

"Fate of pharmaceuticals and antibiotic resistance genes in a full-scale on-farm livestock waste treatment plant", M. Gros et al., Journal of Hazardous Materials 378 (2019) 120716, DOI

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