

<b>Events .....</b>	<b>1</b>
Waste water phosphorus removal tomorrow: ambitions and reality.....	1
CRU Phosphates 2020.....	1
<b>Calls for papers.....</b>	<b>2</b>
Call for papers ESPC4.....	2
Call for texts: phosphorus stewardship and climate change.....	2
<b>Policy .....</b>	<b>2</b>
EU consultation on Circular Bio-Based Europe Partnership.....	2
EU call for expert consultants on fertilising product standards.....	2
ESPP input to Horizon Europe programme.....	3
EU Critical Raw Materials list update work underway.....	3
"STRUBIAS" final report published.....	3
Call for experts on nutrient recycling in processed manures.....	4
<b>Phosphorus sustainability in action.....</b>	<b>4</b>
Italmatch LIFE Trialkyl project successful.....	4
Finland gypsum soil treatment project.....	4
<b>Research.....</b>	<b>4</b>
9 <sup>th</sup> International Phosphorus Workshop (IPW9).....	4
120 days/year of phosphorus needs in food waste.....	5
Phosphorus and other metals from sunscreens.....	5
PolFerAsh P-recovery process.....	5
JRC-led study brings together environmental footprints.....	6
New phosphorus materials.....	6
Organic fertilisers from sewage sludge.....	6
Functionalised cow dung biochar.....	6
RECOVER resource recovery processes development Norway.....	6
<b>ESPP members .....</b>	<b>7</b>
<b>Stay informed.....</b>	<b>7</b>

## Events

### Waste water phosphorus removal tomorrow: ambitions and reality



9<sup>th</sup> October, Liège, near Brussels. In the context of the current revision of EU water policy (Water Framework Directive, Waste Water Treatment Directive), and with participation of the European Commission (DG ENVI, DG RTI), this workshop will enable dialogue between the water industry, experts and policy makers (EU, national) on perspectives for phosphorus removal: low discharge consents, flexible permitting / emissions trading, P-removal from small sewage works.

**Register now:** <https://www.eventbrite.co.uk/e/waste-water-phosphorus-removal-tomorrow-ambitions-and-reality-tickets-60192633788>

In partnership with / supported by: IWA (the International Water Association), Eureau, CIWEM (Chartered Institution of Water and Environmental Management), Université de Liège and ECSM'19 (European Conference on Sludge Management), Liège 6-8 October 2019 <https://events.uliege.be/ecsm2019/> for information on the phosphorus removal workshop, contact [info@phosphorusplatform.eu](mailto:info@phosphorusplatform.eu)

### CRU Phosphates 2020

Registration is now open for the 13<sup>th</sup> CRU Phosphates Conference, 8-10 March 2020 Paris. This is the world's leading phosphate industry meeting, with over 400 industry participants from 40 countries expected, covering supply, market trends and industry processes and technologies for phosphate rock, fertilisers, animal feed and industrial phosphorus applications. See summary of the 12<sup>th</sup> CRU Phosphates Conference (Florida, 2019) in ESPP eNews [n°33](#). Early bird registration rate to 31<sup>st</sup> October 2019.

CRU Phosphates 2020, 8-10 March Paris - <https://events.crugroup.com/phosphates>

See more upcoming events at [www.phosphorusplatform.eu/upcoming-events](http://www.phosphorusplatform.eu/upcoming-events)

## Calls for papers

### Call for papers ESPC4

The **call for abstracts and posters is now open (closes 31/12/2019)** for the 4<sup>th</sup> European Sustainable Phosphorus Conference, Vienna, 15-17 June 2020. Abstracts are invited for presentations for the six parallel sessions, for plenary success story mini-presentations, for posters or for stands. The parallel session themes are: economy (of phosphorus sustainability and nutrient recycling), enhanced efficiency fertilisers, sustainable phosphorus removal from waste streams, R&D cooperation and platforms, taking R&D developments through to the market and phosphorus sustainability perspectives. Proposed success story mini-presentations (3 minutes, plenary) should present your company, local authority (city, region ...) or stakeholder successes in implementing phosphorus recycling or phosphorus management. Posters and stands can address any subject related to nutrient sustainability.

Full details [www.phosphorusplatform.eu/espc4](http://www.phosphorusplatform.eu/espc4)

### Call for texts: phosphorus stewardship and climate change

ESPP (European Sustainable Phosphorus Platform) and the Sustainable Phosphorus Alliance (North America) are preparing a special SCOPE Newsletter edition on "Nutrients and Climate Change". This will consist of selected short texts presenting expert perspectives on how climate change will impact nutrient emissions and eutrophication as well as actions to mitigate this. Proposed texts are invited from researchers, companies, stakeholders and any interested party. Around twenty texts will be selected for publication by an editorial committee chaired by Jessica Stubenrauch, Beatrice Garske (FNK Leipzig & University of Rostock), Anders Nättorp (FHNW Switzerland) and Jim Elser (University of Montana). The SCOPE Newsletter is circulated worldwide to 41 000 companies, stakeholders, regulators and media interested in nutrient management, with a detected opening rate of 12-14%, and is published on the ESPP website [www.phosphorusplatform.eu](http://www.phosphorusplatform.eu) **Submit your text to be included!**

Send us your ideas for action for on nutrients and climate change to appear with the world's leading experts.

Maximum 600 words. Deadline 31.01.2020 latest.

Call details and instructions here: <https://phosphorusplatform.eu/callfortexts>

## Policy

### EU consultation on Circular Bio-Based Europe Partnership

The European Commission has opened, **until 6 November 2019**, a public consultation on twelve proposed "Partnerships" under Horizon Europe, including the proposed "Circular Bio-Based Europe Partnership". These Partnerships aim to extend and widen the "Joint Initiatives" approach of Horizon2020 and to bring together companies, other stakeholders and EU R&D funding to work towards a defined common goal, in particular to accelerate societal and market uptake. The proposed partnerships range from narrow sectors (three cover aviation, railways and automated road transport) to wide themes (e.g. "Innovative SMEs"). For each of the proposed Partnerships, an "Inception Impact Assessment" is published ([here](#) for Circular Bio-Based), that is the document already submitted to public consultation in August 2019, see ESPP eNews [n°35](#)). Comments are requested on this document, on the societal, economic and science impacts of the proposed Partnerships, and on how each Partnership proposal fits with other Horizon Europe or other public policy tools.

EU public consultation "European Partnership for a circular bio-based Europe (Horizon Europe programme)", open to 6<sup>th</sup> November 2019 [https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2019-4972449/public-consultation\\_en](https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2019-4972449/public-consultation_en)

### EU call for expert consultants on fertilising product standards

A call is opened for experts to assist the European Commission in assessing the compliance of **proposed** European harmonised standards with the new EU Fertilising Products Regulation ([2019/1009](#)). These "Harmonised Standards (HAS) Consultants" will assess to what extent documents drafted by the European standardisation organisation CEN comply with the European Commission standardisation request and address requirements set by EU legislation, and will provide advice to the relevant CEN committees. HAS Consultants are already widely used in other industry standardisation sectors, but this is the first time for fertilising products. The European Commission has delegated the recruitment and contracting of HAS Consultants to EY (Ernst & Young) for all sectors. The consultants will work closely with the European Commission, and have a formalised and decisive role in the EU standard development process. Applicant consultants should specify their price per day of work and available time, and their contracts are for one year with possible renewal. Inclusion in the validated pool of consultants does not guarantee assignment of work. Applicants are required to provide evidence of expertise on, and work experience with, harmonised and/or international standards and in fertilising products (see detail in call documents, below).

Full details of requirements, template contract and downloadable copy of the application form (which must be then completed online) are available here: <https://www.ey.com/be/en/services/specialty-services/ey-harmonized-standards-consultant>

## ESPP input to Horizon Europe programme

The European Commission published in July the proposed programme content (“Orientations”, 142 pages) for Horizon Europe, the EU’s 100 billion € R&D funding 2021-2028. ESPP welcomed the accent on Critical Raw Materials and on the Circular Economy, the Mission on “Soil health and food” and the proposed Partnerships on Circular Bio-Based Europe (see [consultation](#) to 6/11/19), on Water and on Raw Materials. In Cluster 6, ESPP welcomed the links made between environment, diets, resources, nutrients and water; the accent on circularity in the food system; and the proposal to develop a “comprehensive EU policy to balance nutrient cycles”. Amongst ESPP proposals are to include crop productivity and plant nutrients in the Mission “Soil health and food”; linking to the food and beverage industry and to agri-food circularity. ESPP underlined that the circular and bio-based economy is key to future prosperity, and that resources efficiency and recycling are key to competitiveness.

ESPP input to EU public consultation on Horizon Europe: <http://www.phosphorusplatform.eu/R&D>

## EU Critical Raw Materials list update work underway

The European Commission is currently carrying out (re) assessments of the 27 materials currently included in the EU Critical Raw Materials list (CRM), and also of a number of other materials for possible consideration to add to the list. The current (third) CRM list (2017) includes both “Phosphate rock” (in effect covering phosphorus in different forms in fertilisers, animal feed, chemicals and other uses) and “Phosphorus” (referring to elemental phosphorus P<sub>4</sub>, often known as white phosphorus, produced from phosphate rock in specific furnaces and essential for a wide range of organic phosphorus chemicals and electronics-grade phosphoric acid). The (re)assessment studies (Criticality Assessment excel files and backup information Factsheets) are being led by the European Commission’s Joint Research Centre (JRC) and aims to be completed by end 2019 / early 2020. For several materials including “Phosphorus”, a more detailed MSA (Materials System Analysis) is underway, over a longer timeline. Materials not on the 3<sup>rd</sup> EU CRM List and currently being assessed include Potassium. ESPP and DPP (German Phosphorus Platform) made input to and participated in an Expert Workshop on 12<sup>th</sup> September, however content and draft documents are subject to a Non Disclosure Agreement (NDA) so cannot be shared. If you wish to access documents and engage in this CRM update process, you must register as an expert and sign the NDA by contacting the emails indicated below. ESPP and DPP have input both factual information and data sources regarding different uses of phosphate rock and P<sub>4</sub>, and have emphasised the development of phosphorus recycling.

EU Critical Raw Materials webpage [https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical\\_en](https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en)  
Emails to contact to participate in the EU CRM (re)assessment process: [workshops@screen.eu](mailto:workshops@screen.eu) and [GROW-RMSG@ec.europa.eu](mailto:GROW-RMSG@ec.europa.eu)

## “STRUBIAS” final report published

The European Commission (JRC) has published the final ‘STRUBIAS’ report, proposing draft European criteria (under the EU Fertilising Products Regulation, 2009/1009 = FPR) for recovered struvite / precipitated phosphate salts, for ash-based materials and for biochars / pyrolysis / gasification materials. The draft criteria are presented as proposed “Recovery Rules”, pages 9-19 of the JRC report. The European Commission (DG GROW) will now prepare draft annexes to the FPR (“CMC” specifications) for each of these three categories of materials. These draft annexes must then be validated by the EU Fertilisers Working Group (hopefully before end 2019), which consists of Member States plus stakeholders (ESPP and Fertilizers Europe are members). This should not pose problems, because these parties were all consulted already during the JRC STRUBIAS process, which is ran 2016-2016. Before becoming applicable, these additions to the FPR Annex II (CMCs) must finally be published in the Official Journal. Key aspects of the proposed criteria, and modifications made since the final STRUBIAS meeting in September 2018, are indicated below. Please note that this is simplified (for precise wording see the document pages 9-19) and that it is a first analysis (ESPP will prepare detailed comments in coming weeks, any input is welcome).

Recovered phosphate salts: recovery from “manure” has been deleted and replaced by references to Animal By-Products having reached certain End Points (does this mean manure must be first sanitised?); recovery from animal feed industry and biofuel wastewaters is added; recovery from municipal sewage remains included; minimum phosphate level of 16% P<sub>2</sub>O<sub>5</sub> (DM) and maximum organic carbon 3% (DM) are not modified; “derivatives” of recovered phosphate salts are included, that is fertilising products produced by chemical processing of these salts. It has been added that recovered phosphate salts must not only be REACH registered, but that the Registration must have Annexes VI-VIII and CSR.

For ash materials (called “Thermal oxidation materials and derivatives”): in the input materials, sewage sludge is explicitly included, vegetable materials from the food industry and from virgin pulp & paper industries are added, specifications for animal by-products are modified (an End Point must have been reached – as above, does this mean that non-sanitised manure is excluded?); minimum combustion temperature is maintained at 800°C, or 450°C for some low-risk input materials; limits of 6 mg/kg DM PAH and 20 ng WHO tox.eq./ kgDM for PCDD/F are not modified (applicable to the ash itself, not to the final ‘derivative’); ash ‘derivatives’ are included (see above).

For “Pyrolysis and gasification materials” (inc. biochars): in the input materials, sewage sludge is excluded (despite the STRUBIAS group proposal to include this, however “JRC recommends undertaking more scientific research to ... show ... not present an unacceptable risk ... and are sufficiently effective ...”, pages 57-60), but food industry, virgin pulp & paper and biofuel residues are added; a minimum processing temperature of 180°C is added and the H/C<sub>org</sub> < 0.7 condition is maintained; PAH and PCDD/F limits are maintained (same as for ash, above).

*“Technical proposals for selected new fertilising materials under the Fertilising Products Regulation (Regulation (EU) 2019/1009). Process and quality criteria, and assessment of environmental and market impacts for precipitated phosphate salts & derivatives, thermal oxidation materials & derivatives and pyrolysis & gasification materials”, Huygens et al., European Commission JRC, 24/9/2019, ISBN 978-92-76-09888-1 <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/technical-proposals-selected-new-fertilising-materials-under-fertilising-products-regulation> and <http://dx.doi.org/10.2760/186684>*

## Call for experts on nutrient recycling in processed manures

The European Commission is calling for candidates, stakeholders and experts to provide input to the SAFEMANURE draft report. This European Commission (DG ENVI, JRC) project aims to define criteria for allowing certain nitrogen fertilisers derived (wholly or partly) from manure to be not treated as ‘processed manure’ under the Nitrates Directive (see ESPP eNews n°23). Actions engaged include: literature search, biogeochemical modelling, pot tests. Provisional planning is indicated to be draft report probably late 2019, expert consultative meeting early 2020.

Organisations interested should send contact details of up to two experts to [JRC-SAFEMANURE@ec.europa.eu](mailto:JRC-SAFEMANURE@ec.europa.eu) (subject line: SAFEMANURE interest list)

## Phosphorus sustainability in action

### Italmatch LIFE Trialkyl project successful



ESPP participated at the final meeting 25th June 2019 of the EU LIFE Trialkyl project, at Federchimica's Auditorium, Milan, opened by Nicoletta Fascetti Leon, from Italian Ministry for the Environment Land and Sea. This LIFE project is led by phosphorus chemicals specialist Italmatch, with the support of SC Sviluppo Chimica, Italy, and RISE Research Institute, Sweden. The Trialkyl project has successfully developed and demonstrated a new and more sustainable production route for high quality trialkyl phosphites (trimethylphosphite TMPi), an organophosphorus chemical used in a wide range of industry applications including fire safety, crop protection, plastics, childcare products and pharmaceuticals. Current production technologies use tertiary amines as

intermediates, and these are classified as hazardous, so that process wastewater has to be chemically neutralised and treated. Within the LIFE Trialkyl project, a new one-stage reactor process has been developed based on  $\text{PCl}_3$  (the standard chemical ‘vector’ for elemental phosphorus in the chemical industry) and alcohols, with sophisticated parameter control, leading to zero water usage and so zero wastewater, 20-30% less energy consumption, and a large reduction in the use of solvents. After successful laboratory scale testing, a pilot plant was set up and demonstrated in Italmatch's Arese plant (near Milan).

LIFE-Trialkyl [www.life-trialkyl.eu/en](http://www.life-trialkyl.eu/en) - see also ESPP eNews n°13

### Finland gypsum soil treatment project

The Finnish Ministry of the Environment has launched a research project to promote the spreading of gypsum to reduce soil phosphorus losses from fields, stating that the objective is to enable the inclusion of gypsum in HELCOM's Baltic Sea action plans. Field testing in Finland during the last 10 years, including over 4 000 hectares of fields in the SAVE project, has shown that gypsum application can reduce total phosphorus losses from fields by 50% and also reduce organic carbon losses. The quality of gypsum used is important (should not contain contaminants). The gypsum used has been from Yara's site in Siilinjärvi situated in Eastern Finland, where 1 million tonnes gypsum is generated annually in phosphoric acid production. Around 4 tonnes of gypsum per hectare are used, at a treatment cost of c. 220 €/ha, that is a cost of 60 – 70 € per kg P loss reduction, considered to be significantly less than costs of other currently available measures.

SAVE summary “Gypsum amendment of fields as a water protection measure in agriculture”, 10 pages, February 2019

<https://blogs.helsinki.fi/save-kipsihanke/files/2019/02/SAVE-Infopackage-of-Gypsum-Amendment.pdf>

“Finland aims to improve water quality in the Baltic Sea by applying gypsum to fields”, Finnish Environment Ministry, 11/9/2019

[https://valtioneuvosto.fi/en/article/-/asset\\_publisher/ymparistoministerion-tutkimushanke-selvittaa-kipsin-kayttoa-pelloilla-itameren-rantavaltioissa](https://valtioneuvosto.fi/en/article/-/asset_publisher/ymparistoministerion-tutkimushanke-selvittaa-kipsin-kayttoa-pelloilla-itameren-rantavaltioissa)

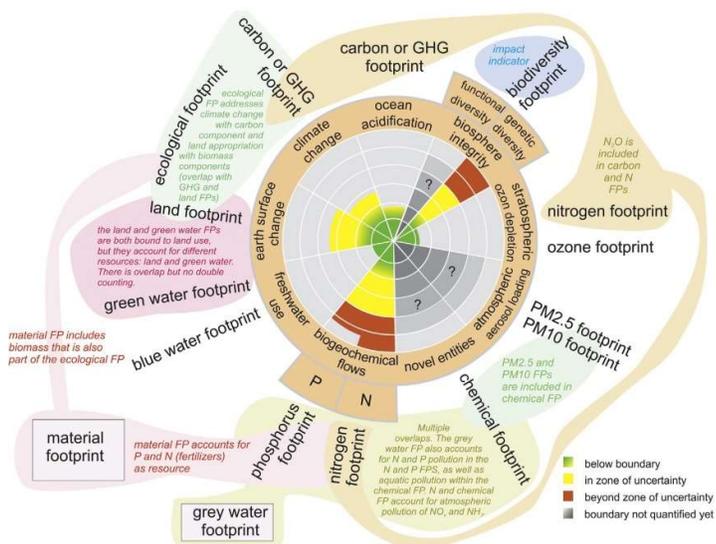
## Research

### 9<sup>th</sup> International Phosphorus Workshop (IPW9)

This conference in Zurich, July 2019, brought together over 200 participants from 31 countries worldwide, with over 80 plenary and parallel session presentations and more than 100 posters. It discussed the questions: “Putting phosphorus first? How to address current and future challenges?”. The conference built on the identification of research needs related to phosphorus in soil and in agriculture from previous IPW conferences, starting with IPW1 in Ireland in 1995. Key points raised include: awareness, phosphorus flows and cycles, data, P-recycling, regulation, market, importance of long-term field trials, impacts of dietary choices and livestock production, soil – fertilisation links, need for improved agronomic fertilisation recommendations. The conference and its conclusions are summarised in ESPP's SCOPE Newsletter n°131.

ESPP SCOPE Newsletters <https://phosphorusplatform.eu/scopenewsletter>

## 120 days/year of phosphorus needs in food waste



A study by experts at Nestlé and at WRAP UK assesses “nutrition days” lost in UK food waste, for 25 nutrients, vitamins and food values, and looks at different areas of environmental impacts. The study is based on detailed data on UK food waste (WRAP), with a total of around 5.4 million tonnes/year of avoidable or possibly avoidable, edible food waste (UK) compared to dietary needs (UK RNI: Reference Nutrient Intake, that is 0.55 gP/person/day for phosphorus). Phosphorus shows more wasted nutrition-days than for any other nutrient (120 phosphorus nutrition days wasted per capita per year) and is fourth of all food values assessed (after vitamin B12, vitamin C, thiamin). Considering all food values together, some 42 daily diets per person (nutritional value) were discarded annually in UK food waste. The authors note that losses are particularly significant for food values which are under-consumed in the UK, such as calcium, food folate and dietary fibre. This is one of the first scientific publications to look at nutrient losses in food waste, rather than simply tonnages of

waste and calories. A previous paper looking at US food waste (Spiker et al., 2017, with US Department of Agriculture participation) found similar results (using US Recommended Daily Allowance RDA, that is 0.7 gP/person/day for phosphorus), with the highest losses being again for vitamin B12, thiamine and phosphorus (92 nutrition-days, and a loss of 0.45 gP/capita/day). This new paper also looks at how environmental impacts are distributed, noting that the principal environmental impacts come from agricultural production (higher than food processing, distribution, etc.) and that meat and fish losses in food waste have the highest environmental impacts, but that fresh vegetables are also significant.

“Nutrition in the bin: a nutritional and environmental assessment of food wasted in the UK”, K. Cooper, T. Qusted, et al., Nestlé Research Centre, Lausanne, Switzerland, and WRAP United Kingdom, *Frontiers in Nutrition*, 5, 19, 2018, <https://doi.org/10.3389/fnut.2018.00019>

“Wasted food, wasted nutrients: nutrient loss from wasted food in the United States and comparison to gaps in dietary intake”, M. Spiker et al., *J Acad Nutr Diet* (2017) 117(7):1031–40. <https://doi.org/10.1016/j.jand.2017.03.015>

## Phosphorus and other metals from sunscreens

New research assesses nutrient and toxic metal releases from sunscreens and estimates the possible significance for coastal eutrophication and aquatic toxicity. Release tests were carried out on one widely used sunscreen product (SPF50, milk spray, not named, selected from ConsumerReports recommendations), assessing release into seawater under UV exposure comparable to a Mediterranean beach. The sunscreen contained phosphorus at over 300 ppm, and also ppm or ppb levels of metals including (highest levels first) titanium, lead, manganese, copper molybdenum, nickel, cadmium, aluminium and cobalt. The Mediterranean received over 330 million tourists in 2016. The authors estimate release of different elements into seawater using conservative estimates of number of bathers, use of sunscreen, part washed off in water, coastal water renewal rate, etc. suggesting that sunscreen could increase dissolved phosphate and silicon concentrations in coastal waters by 0.2% and 0.6%, and also significantly increase concentrations of titanium (nearly 20%), aluminium (4%) and lead (0.25%), posing possible toxicity risks.

“Sunscreens as a New Source of Metals and Nutrients to Coastal Waters”, A. Rodríguez-Romero et al., *Environ. Sci. Technol.* 2019, 53, 17, 10177-10187 <https://doi.org/10.1021/acs.est.9b02739>

## PoIFerAsh P-recovery process

Results are presented of lab-scale testing of gasification of dried sewage sludge (150 mm diameter, fixed-bed gasifier, 800 – 1 000 °C) followed by leaching of the solid gasifier residue (by phosphoric or nitric acids), the Cracow University of Technology patented PoIFerAsh process. 50 – 60 % of the sludge energy potential (after drying) was converted to syngas. The sewage sludge used was from a sewage works operating chemical P-removal and contained 6% phosphorus (P) and 6.7% iron (Fe). Use of dilute phosphoric or nitric acid enabled extraction of 70 – 85 % of the phosphorus in the gasifier residue, with better results (higher P, lower Fe) with phosphoric acid. Chromium, zinc and nickel were also significantly extracted and could pose quality issues for use of the leachate. The leachate showed concentrations of up to 360 mg H<sub>3</sub>PO<sub>4</sub>/l and could be used for fertiliser production or directly in liquid fertilisers.

“Sewage sludge as a fuel and raw material for phosphorus recovery: Combined process of gasification and P extraction”, K. Gorazda et al., *Waste Management* 73 (2018) 404–415, <https://doi.org/10.1016/j.wasman.2017.10.032>

## JRC-led study brings together environmental footprints

A study led by the European Commission Joint Research Centre (JRC), based on a workshop of 23 global experts (at which ESPP participated), systematises existing environmental footprints and proposes a footprint family framework. This is graphically summarised in the diagram shown. The aim is to provide a tool for environmental sustainability assessment, particularly targeting coherence with Planetary Boundaries, the United National Sustainability Goals (SDGs) and the Water – Energy – Food – Ecosystem (WEFE) nexus. The authors note that an increasing number of papers are being published on environmental footprints addressing mostly only one question, with over 6 700 such papers identified, but only 28 were found integrating multiple footprints. Phosphorus and nitrogen footprints are amongst the pressures and impacts considered (P, N, carbon/greenhouse gas, land use, water, ozone, atmospheric particulates, chemicals, biodiversity, raw materials). The authors conclude that environmental footprint indicators can be used to identify the extent to which different processes or societies contribute to exceeding of planetary boundaries, to identify potential measures to address this, and to quantify and communicate changes needed.

*"Environmental footprint family to address local to planetary sustainability and deliver on the SDGs", D. Vanham et al., Science of the Total Environment 693 (2019) 133642, <https://doi.org/10.1016/j.scitotenv.2019.133642>*

## New phosphorus materials

Phosphorus can be generated as single atom thickness sheets (2D black phosphorus or "phosphorene"), similar to the graphene form of carbon. This material, first demonstrated in 2014, offers potentially valuable properties, including high strength, electrical conductivity and electron transfer, modulable light energy adsorption (transforming light energy into chemical energy) and biocompatibility. It is today being researched for potential applications in electronics, energy storage, artificial photosynthesis, photosensors and biomedical systems. Possible energy storage applications include in lithium ion, magnesium ion or lithium sulphur batteries (LIB, MIB, LSB) or in ultracapacitors. 2D blue phosphorus, with a honeycomb structure, demonstrated in 2016, offers more varied electronic properties. A challenge, however, is that 2D black carbon is stable in air for only a few days, probably as a result of water condensation. It can be stabilised by encapsulation, functionalisation or doping (e.g. with diazonium or tellurium) or by use in a liquid phase (in water or in a solvent). 2D black phosphorus is biocompatible and in vivo biodegradable, and shows lower cytotoxicity than graphene. Potential biomedical applications include biosensors (to detect colours, electrical fields, gases ...), cancer imaging and cancer phototherapy, drug delivery.

*"2D Black Phosphorus: from Preparation to Applications for Electrochemical Energy Storage", S. Wu et al., Adv. Sci. 2018, 5, 1700491, <https://doi.org/10.1002/advs.201700491>*

*"Black Phosphorus and its Biomedical Applications", J. Choi et al., Theranostics 2018, Vol. 8, Issue 4, 1005-1026. doi: <https://doi.org/10.7150/thno.22573>*

## Organic fertilisers from sewage sludge

Kominiko et al., Cracow University of Technology, Poland, have published further work on production of granulated organo-mineral fertilisers using digested, dried municipal sewage sludge, combined with poultry litter ash, biomass combustion ash (flax straw) and mineral fertilisers, using sulphuric and nitric acid as binders. This follows a previous study summarised in ESPP eNews n°13. The new study includes nutrient and heavy metal data for (digested) sewage sludge from eleven Polish municipal sewage works, concluding that cadmium, chromium, lead, mercury and nickel were above limits for organic fertilisers (as per the Polish Fertilising Products Regulation) at several or most of the sewage works. The fertiliser granulation tests were carried out with batches of up to 2 kg dry weight. Digested sludge from the Żywiec municipal sewage works was used (works operating biological and occasional chemical P-removal), combining e.g. 40% sludge, 10% ashes, 40% mineral fertiliser and 10% of acid. The phytotoxicity tests showed that the sludge-combined fertilisers resulted in longer stalk growth and lower root growth of rapeseed in comparison with control sample

*"Potentiality of sewage sludge-based organo-mineral fertilizer production in Poland considering nutrient value, heavy metal content and phytotoxicity for rapeseed crops", H. Kominko, K. Gorazda, Z. Wzorek, Journal of Environmental Management 248 (2019) 109283 <https://doi.org/10.1016/j.jenvman.2019.109283>*

## Functionalised cow dung biochar

In lab scale tests, cow dung was dried and pyrolysed at different temperatures 450 – 750°C, with or without prior reaction with magnesium. These biochar materials were then tested for phosphorus adsorption from potassium phosphate solution, and the resulting P-loaded biochars were tested as fertiliser in 60-day pot trials with lettuce. The biochars showed P adsorption capacities up to 260 mgP/g. The addition of biochar significantly improved lettuce seed germination, early and late stage growth, with the Mg-modified biochar giving the best results, probably as a combined effect of phosphorus fertilisation and liming (pH of the Mg-modified biochar was >11). The authors note that a challenge would be scale up of the pyrolysis process to generate a consistent and stable product.

*"Cow dung-derived engineered biochar for reclaiming phosphate from aqueous solution and its validation as slow-release fertilizer in soil-crop system", Q. Chen, J. Cleaner Production, Volume 172, pp. 2009-2018, 2018 <https://doi.org/10.1016/j.jclepro.2017.11.224>*

## RECOVER resource recovery processes development Norway



The 2.8 M€ R&D project RECOVER (Research Council of Norway, 2015-2020) is developing new processes to recover phosphorus and nitrogen, as well as energy, from wastewater. The project involves three Norwegian research institutes (NTNU, NMBU and SINTEF) with industrial partners (Cambi, Doscon, Kemira, Krüger Kaldnes, Norconsult and Salsnes Filter) and several municipal

wastewater treatment plants (IVAR, HIAS).. Research is addressing process, control and monitoring solutions, in particular for biological phosphorus removal, phosphorus and nitrogen recovery, sensors for biological treatment systems, LCA and sustainability analysis.

RECOVER <https://www.ntnu.no/recover/doktorgradsarbeider> and <https://www.ntnutechzone.no/en/2017/02/recover-resource-recovery-from-wastewater/> and <https://www.researchgate.net/project/RECOVER-Nutrient-recovery-from-wastewater>

See also: "Sustainable Sewage Sludge Management: From Current Practices to Emerging Nutrient Recovery Technologies", S. Shaddel et al., Sustainability 2019, 11(12), 3435; <https://doi.org/10.3390/su11123435>

## ESPP members



## Stay informed

SCOPE newsletter: [www.phosphorusplatform.eu/SCOPEnewsletter](http://www.phosphorusplatform.eu/SCOPEnewsletter)

eNews newsletter: [www.phosphorusplatform.eu/eNewshome](http://www.phosphorusplatform.eu/eNewshome)

If you do not already receive SCOPE and eNews (same emailing list), subscribe at [www.phosphorusplatform.eu/subscribe](http://www.phosphorusplatform.eu/subscribe)

LinkedIn group: [www.linkedin.com/groups/4783093](http://www.linkedin.com/groups/4783093) (or search for ESPP)

Twitter: [@phosphorusfacts](https://twitter.com/phosphorusfacts)

Slideshare presentations: [www.slideshare.net/NutrientPlatform](http://www.slideshare.net/NutrientPlatform)