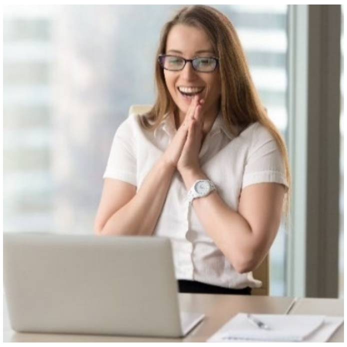
ESPP job offer



Are you looking for a new challenge in sustainability, with networking across industry, science and regulation? ESPP is looking to engage a Brussels representative, full or part time. Your role will be to develop networking, industry participation and Platform membership, including widening scope beyond phosphorus to recovery of nitrogen and other nutrients. We are looking for someone who can analyse and communicate technical, scientific and regulatory information on phosphorus, nutrients and recycling, who is motivated for environmental objectives and combines a business-development and an association consensus culture. Minimum 5 years' experience, existing network Employment could be as salaried staff, consultant status or shared staff with another organisation having similar objectives.

Full job description here www.phosphorusplatform.eu/joboffer2022 Send CV to info@phosphorusplatform.eu ***before 5th March 2022****.*
Please pass on this information to potentially interested contacts.

Calls and consultations

Call for abstracts open to 27/2/22: phosphorus research and innovation (PERM5)

ESPC4, Monday 20th and Tuesday 21st June 2022, will be followed by **PERM5, the 5th Phosphorus in Europe Research Meeting**, Wednesday 22nd June 2022, making the link between R&D, industry and policy (summary of PERM4, June 2021, 370 participants, in SCOPE Newsletter n°141).

Phosphorus in Europe Research Meeting
PERM5
VIENNA | 22 June 2022

Sessions proposed include: nutrient recovery in the dairy industry, iron and phosphorus interactions, new fertilisers and biostimulants to improve crop nutrient uptake, Farm-to-Fork Zero Pollution: reducing P losses from agriculture, nature based solutions, decentralised sanitation / separative urine systems, nutrient flow studies …

The call for abstracts is now open for PERM5 (22 June 2022, Vienna Austria & online) deadline for submission 27th February 2022 https://phosphorusplatform.eu/espc4

Call for input: Legacy Phosphorus in Soils

Over 560 participants joined the ESPP- BOKU webinar on the impacts of reducing "Legacy Phosphorus" in agricultural soils, 2nd February 2022, with a very active oral and online chat discussion. As proposed, ESPP will now engage a working group and workshop to write an operational definition of "Legacy P" (input is welcome). The webinar will be followed by SCOPE Newsletter special issue, summarising the webinar presentations and discussions, and also summarising a selection of scientific papers and other reports relevant to Legacy P.

Webinar presentation slides, video recording, Chat record will be made available here www.phosphorusplatform.eu/LegacyP
Please send papers for consideration for inclusion to *info@phosphorusplatform.eu* by 27th February 2022

EU public consultation on the Waste Framework Directive

An EU public 'Roadmap' consultation is open to 22nd February 2022 on revision of the Waste Framework Directive 2008/98, aiming to prevent waste generation, address food waste and waste oil, and improve separate collection. The Roadmap consultation stage enables impact on the objectives and aspects to be considered in the revision. The Commission's proposed Roadmap suggests options including better implementation of waste prevention, re-use and recycling; clarifying EU guidance on separate collection and on EPR (extended producer responsibility) and possible regulatory measures on waste reduction and prevention, EPR (in particular for online sales), source separation, waste oil collection and regeneration. ESPP underlines that improving separate collection of household organic waste and prevention – reduction or re-use of food waste are of potential importance for nutrient stewardship.

EU public consultation on the Waste Framework Directive, open to 22nd February 2022, submission = 4000 characters text statement and/or document HERE.

ESPP to address nitrogen recycling

As indicated in our previous eNews, the 2021 General Assembly decided to widen ESPP's action (currently all aspects of phosphorus sustainability) to cover recycling of nitrogen and of other elements. The General Assembly decided to widen to recovery/ recycling/ reuse of nitrogen and of other elements, but not to engage ESPP in questions such as crop nitrogen use efficiency, nitrogen losses from agriculture, nitrogen in the food chain or nitrogen and climate change.

In 2014, it was decided by the founding members of ESPP to establish a "phosphorus" platform and not a "nutrient" platform, in order to not duplicate existing initiatives on nitrogen. Thus, ESPP's name is "Phosphorus" platform. We have seen however that ESPP's action concerning phosphorus recycling (e.g. regulatory questions, science, recycling technologies, organic inputs, recycled fertilising products …) is often also relevant to recycling of nitrogen and/or other elements, and often engages the same network of contacts.

There is currently increasing interest in nitrogen recovery driven by pressures to "capture" N emissions (ammonia = National Emissions Ceilings Directive, N_2O greenhouse gas) and (maybe temporarily) by natural gas price and supply issues.

The ESPP Board has discussed how to take forward the General Assembly decision to widen of ESPP's activities to cover recycling of nitrogen and other elements, and proposes to make small changes to ESPP's statutes to modify the association's objective of "*phosphorus sustainability in Europe*" to add "*and recycling of other nutrients*".

The Board has decided to launch an **ESPP 'Working Group on Recycling of Nitrogen and Other Elements'** to meet 2-3 times per year to discuss how to take forward ESPP action: defining priorities, partner organisations, resources. If you are interested to participate contact info@phosphorusplatform.eu

Precise texts of proposed modifications to ESPP statutes in French (legally binding) and English (indicative translation) are online here https://www.phosphorusplatform.eu/platform/about-espp and comments are welcome. Comments will be submitted to a General Assembly to be held by email in early Spring 2022 (quorum to modify association objectives: 2/3 of Members participating in vote, 4/5 of votes in favour - statutes art. 15).

Phosphorus events

ESPC4
20-22 June 2022, Vienna Austria & online

https://phosphorusplatform.eu/espc4

VIENNA 20 - 22 June 2022 ESPC4 European Sustainable Phosphorus Conference

The detailed programme of the
4th European Sustainable Phosphorus Conference (ESPC4)
is now published.

Confirmed speakers include **Virginijus Sinkevičius European Commissioner for Environment;** Sibylla Hardmeier, Swiss Federal Office for the Environment (BAFU); Andrea Roskosch, German Federal Environment Agency (UBA); Franz Josef Radermacher, Research Institute for Applied Knowledge Processing (FAWn), Germany; Mahesh Pradhan, United Nations Environment; Wenfeng Liu, China Agricultural University …

ESPC4 (20-21 June 2022, Vienna and hybrid) will be the first major phosphorus stakeholder meeting globally for 4 years (since ESPC3 Helsinki, with 300 participants from 30 countries, see SCOPE Newsletter n°127).

The published programme includes pre-selected speakers for the six ESPC4 parallel sessions:
- Nutrient recovery technologies operational showcase
- Nutrient recovery technologies in development
- Phosphorus recovery from ashes
- Biochars and hydrothermal carbonisation
- Regional nutrient policies and actions
- New and bio-based fertilisers

ESPC4 will include a **Nutrient Recovery Technology Fair**, with stands, presentations and possibility to meet technology suppliers presented in the ESPP-DPP-NNP Catalogue of Nutrient Recovery Technologies, currently being updated (see below).

https://phosphorusplatform.eu/espc4

Phosphates 2022

7 – 9 March 2022, Tampa, Florida. Programme now online. This is "the" phosphate industry professional conference, with over 400 participants. Phosphates 2022 will be in-person (with an online option), and a major chance to re-connect with the phosphate industry, from mining through rock and acid processing, to fertilisers, feed phosphates and technical phosphates. The two-day conference will have a dual agenda: commercial - market – regulatory, and technical and industry operational. **10% discount for ESPP** members: request the code from ESPP. *CRU Phosphates 2022*: https://events.crugroup.com/phosphates/home

EU Fertilising Products Regulation (FPR)

CMCs for by-products & certain recovered minerals, inc. ammonium salts

The European Commission has now finalised FPR criteria to add CMCs (Component Material Categories) for CMC11 (By-Products) and CMC15 (certain recovered minerals), including phosphogypsum and recovered ammonium salts. In the FPR, the CMCs provide a limitative list of materials which can be used as ingredients for EU fertilisers (CMC1 allows use of any 'virgin' material = non-waste derived. Secondary materials can only be used if specifically covered by one of the other CMCs).

CMC1 allows the use of (non-waste derived) by-products as precursors for chemical reactions to produce FPR ingredients, but does not allow the use in EU fertilisers of By-Products (not chemically reacted). The **criteria for CMC11 now specify which By-Products can be used directly as ingredients**, as such. The finalised criteria cover a short list of seven specific industry by-products (see below) plus more generally certain pure mineral salts (including phosphate and ammonium salts) subject to 95% purity and < 0.5% organic carbon. ESPP regrets that organic by-products are thus excluded (unless specifically covered in other CMCs), as are mineral by-products derived from plant materials (e.g. in the paper and pulp industries). This is because information on examples of such by-products was not provided by industry. In all cases, certain contaminants are specifically limited in by-products under CMC11: radioactivity (request made by ESPP), total chromium, thallium, vanadium. **Quality phosphogypsum will thus be eligible**. Phosphogypsum is today used widely in Finland as a soil amendment with proven effect in reducing phosphorus losses to surface waters (see ESPP eNews n°36).

CMC15 opens use in EU fertilisers to **certain waste-recovered pure mineral salts**. Purity requirements are as above (95% purity, < 0.5% $C_{\text{-org}}$) plus limitations of certain contaminants and pathogens. As under CMC11, only certain mineral salts are covered, including phosphate and ammonium salts. ESPP requested that potassium and magnesium salts be also included, but this was not implemented because industry had not provided examples. The mineral salt must be recovered from "*waste generated from*" either (art. 2a) "*a production process*" or (2b) "*a gas purification or emission control process designed to remove nutrients from off-gases*" with certain input materials (non-waste, separately collected bio-waste, municipal refuse, sludge, manure, livestock housing and certain other wastes).

It is ESPP's understanding that CMC15, as finalised, therefore covers (subject to the purity and contaminant criteria), inter alia:

- **struvite or phosphate salts recovered from phosphogypsum**, where the phosphogypsum is a waste which has been generated from phosphate rock processing (gypsum stack), or recovered from other fertiliser industry waste streams. Phosphogypsum produced as part of the rock processing would be CMC11 (By-Product);
- **ammonium salts recovered from gas treatment**, such as anaerobic digester biogas purification or from digestate gas stripping, or from municipal waste incineration off-gas, or from manure storage or livestock stable off-gas.

ESPP suggested that ammonia salts recovered from manure storage, livestock stable ventilation gases or off-gases from e.g. manure digestate should be subject to Animal By-Product End Point requirements, in order to guarantee sanitary safety. It was answered that gases are excluded from the Animal By-Product regulations.

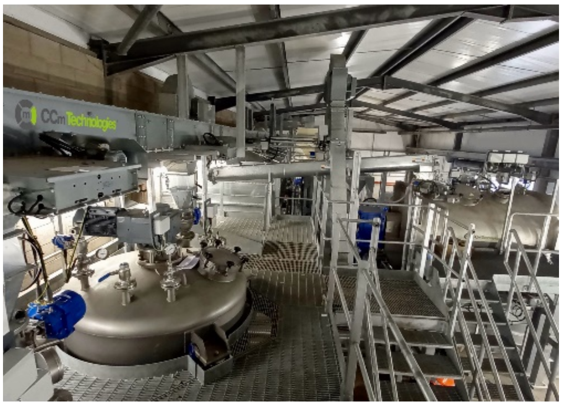
ESPP suggests that a number of questions concerning CMC11 and CMC15 need to be clarified, with examples, in the European Commission's FPR 'FAQ' (Frequently Asked Questions). In particular:

- ? if a struvite or a precipitated phosphate is recovered from phosphogypsum during the phosphate rock processing (before the phosphogypsum becomes a "waste"), then is this precipitated phosphate CMC1, not CMC15 (so not subject to any purity or contaminant criteria) ?
- ? what about ammonium salts recovered from gases which are not "waste" (CMC15 covers only recovery from waste), e.g. recovered from digester biogas purification (can this be CMC1 despite the digester taking waste as input) ?
- ? if gases are not Animal By-Products, and so also not ammonia salts recovered by ammonia stripping from digestates or from manure storage off-gas, then how can sanitary safety be guaranteed ?
- ? what about pure mineral products with 'waste' status (such as spent acids) which are used as precursors in chemical processes for fertiliser production (excluded from CMC1 because of waste status, not CMC15 because not used as such in the EU fertiliser product ?

Specific by-products listed in CMC11 (in addition to pure mineral salts): from methionine process, processing mineral ores, Solvay process, acetylene production, iron industry, metal surface treatment (micro-nutrients), humic/fulvic acids from drinking water treatment – see criteria for precise specifications. The finalised criteria for CMC11 and CMC15 are now under translation, and will then be published in the Official Journal, hopefully in time for the entry into implementation of the EU Fertilising Products Regulation 2019/1009 in July 2022.
Finalised versions: CMC11 delegated act text and criteria - CMC15 delegated act text - CMC15 criteria

Nutrient recycling

CCm to implement P and N recovery with Yorkshire Water



CCm Technologies' process uses captured ammonia and CO_2 from anaerobic digestion to combine with organics, stabilising N and P to produce a pelletised organo-mineral carbonate fertiliser, so reducing greenhouse gas emissions, see ESPP SCOPE Newsletter n°134. The technology has been demonstrated for three years in the UK (500 t/y output pilot). Full scale plants (10 – 12 000 t/y fertiliser production) are in operation since 2021 at Severn Trent Water Minworth UK wwtp (sewage sludge digestate) and in delivery with Walkers Crisps (Pepsico), Leicester, UK (food industry digestates). A pilot (4 m^3/day) also recovering phosphorus from P-rich sludge dewatering streams is also under construction at Yorkshire Water Caldervale wwtp. The CCm plant at Walkers (Pepsico) will recycle ammonia and organics from potato peelings anaerobic digestion and CO_2 from a brewery to organo-mineral fertiliser, so reducing Walkers potato supply chain carbon emissions by 70%. The CCm technology has been featured on BBC Radio's Farming Today 2/7/2021. Field tests of the fertiliser product show compatibility of the pellets with existing farm fertiliser equipment: rotating discs up to 30m wide spreading radius), crop performance comparable to commercial mineral fertilisers and positive impacts on soil bioflora, water retention, soil carbon and reduced nutrient runoff.

BBC "Beer and crisps used to help tackle climate change", 7/12/2020.
BBC Farming Today 2/7/2021 (4 minutes radio report, trial site, Bedfordshire, UK, with Cranfield University).
CCm Technologies: http://ccmtechnologies.co.uk/ and technology details in the ESPP-NNP-DPP Nutrient Recycling Technology Catalogue http://www.phosphorusplatform.eu/p-recovery-technology-inventory
Photo: full scale plant operating at Severn Trent Water, Minworth wastewater treatment plant, UK

Ductor recycled nitrogen approved for use in US Organic Farming

ESPP member, Ductor, has obtained California Department of Food and Agriculture (CDFA) Organic Input Material (OIM) registration, so giving USDA Organic compliance for liquid nitrogen fertiliser recovered from anaerobic digestion of chicken manure. The liquid 5-0-0 nitrogen fertiliser provides rapidly plant available, soluble nitrogen in ammoniac form, according to crop demand. The fertiliser is recovered from the chicken litter digestate by ammonia stripping from digestate. Methane production by anaerobic digestion means that the recovered nitrogen fertiliser is climate neutral. A solid organic NPK fertiliser is also under development.

"Ductor's first commercial fertilizer product now available and certified Organic", 6 September 2021 and https://www.ductor.com/fertilizers

Research

Biochar, organic carbon molecules and P-solubilisation

Lab study suggests that organic acids released by ionisation of wood biochar can solubilise P in hydroxyapatite, so potentially improving plant P uptake in soils. The paper by Sacko et al. shows that the ozonisation of pine wood pyrolysis biochar increased oxygen functional groups on the biochar surface and caused release of water-soluble organic acids (probably COOH groups). The filtrate from biochar ionisation significantly released soluble P from hydroxyapatite at its generated pH of around 6, but also when neutralised to pH7: releasing 2 – 9 x more P at pH7 than water. This lower effect at neutral pH is expected from literature (Glaser 2019 cited) but most European soils are slightly acidic at pH6 or lower. It should be noted that humic compounds are considered to also increase crop P uptake by interactions with plant hormones, root membranes and P-mobilising bacteria in the soil (see Jindo 2020).

In a second paper by Tumbure et al., condensate from pyrolysis of maize stover (stem+leaves) was tested for P solubilisation of ground Dorowa phosphate rock. The pyrolysis condensates only solubilised around 14% of the phosphorus in the rock, compared to 46% by oxalic acid, at similar pH of 3 – 3.8. The poor solubilisation by pyrolysis condensates was suggested to be related to low concentrations of chelating and complexing agents and significant calcium in the condensates.

"Sustainable Green Chemistry: Water-Soluble Ozonized Biochar Molecules To Unlock Phosphorus from Insoluble Phosphate Materials", O. Sacko et al., ACS Agric. Sci. Technol. 2022 DOI.
"Phosphorus recovery from an igneous phosphate rock using organic acids and pyrolysis condensate", A. Tumbure et al., Scientific African 15 (2022) e01098 DOI.

Phos4You final project report

The Phos4You Interreg project (ESPP member) has concluded that the tested P-recovery processes are technically feasible and ready for upscaling, and generate P fertilisers corresponding to farmers' or industry requirements.

For the recovery of phosphorus from sewage sludge ashes (SSA), **three different acid-leaching processes** were assessed:

- **REMONDIS TetraPhos®**: phosphoric acid leaching. For information (outside Phos4You project): a full scale 20 000 t/y TetraPhos plant has been constructed and is under commissioning in Hamburg, Germany, following process testing for over two years in a pilot scale plant with a capacity of 50 kg/h (see SCOPE Newsletters n°141 and 129). Within the Phos4You project, several tonnes of three different ashes were treated in the pilot plant.
- **PARFORCE-Technology**: hydrochloric acid leaching. This process was tested in a pilot scale plant with batch acid leaching (150 – 250 kg ash per batch) and semi-continuous purification, using a total of around one tonne of SSA in several campaigns.
- **Phos4Life™**: sulphuric acid leaching. Laboratory proof of concept tests were carried out with several kilograms of SSA to evaluate the leaching properties and impurities removal.

All three of these processes were tested with different qualities of SSA with relatively low P-content between 5 and 6 % (literature range of 6 – 13% P for municipal sewage sludge incineration ash). With all three processes a P- recovery rate over 80 % was achieved, as required by German P-recovery legislation. The technologies were additionally tested for, and managed to cope with SSA with high percentage of industrial sewage sludge (high impurities and P-content around 4%), but for this, process adjustments and/or additional technical steps were required.

The three tested processes were successful in achieving the production of marketable phosphoric acid from SSA.

The technical differences between these three processes, in terms of leaching acid used and of process steps to remove impurities (precipitation steps, membranes, ion exchange and solvent extraction), led to the production of different by-products and residues. The quality of the by-products produced in the pilot scale tests (gypsum, Fe-/ Al-salt solutions, road salt) were compared with standard market products and roughly assessed to be recyclable in existing value chains.

Also, the **EuPhoRe process**, in which sewage sludge is incinerated in a specifically designed kiln with magnesium chloride added to remove (by vaporisation) part of the heavy metals and to improve plant availability of the phosphorus in the ash, was tested with construction of a demonstration scale pilot plant (up to 100 kg/h input dewatered sludge, c. 25% DM) at EGLV's Dinslaken sewage works (see SCOPE Newsletter n°129). Results (p.92 of Phos4You Technical Report) show cadmium, mercury and thallium below detection limits in the treated ash; arsenic < 25% of the EU Fertilising Products Regulation limit [PFC 1(C)(I)]; lead < 13 - 50% of this limit and nickel between 65 - 90% of this limit. Copper, at the tested temperatures (which were below the intended operation temperature), exceeding the EU Fertilising Products Regulation limits. Despite the low operating temperatures, the zinc limit could be achieved by increasing the dosing of magnesium chloride from 3% to 6%. Chromium VI values in the raw material and in the products were always below the detection limit. The analyses of the EuPhoRe-SSA produced with the demonstrator in Dinslaken showed solubility of total P content of 70 % to 90 % with 2 % citric acid and > 60 % with neutral ammonium citrate solubility (NAC), compared to the EU Fertilising Products Regulation specification of > 75% with NAC [Annex II, Part II, PFC1, 4(b)]. Ryegrass pot trials with the resulting ash showed significantly better growth with the ash compared to no P fertiliser (control) but significantly lower growth than with triple super phosphate (c. 1/3 lower biomass dry matter). The EuPhoRe product is considered to provide long-term, slow-release phosphate.

Lab-scale tests showed feasibility of **bio-acidification** of sewage sludge from sewage works using iron or aluminium salts for P-removal, followed by P-recovery by precipitation of calcium phosphate using **Veolia Struvia** technology (see SCOPE Newsletter n°141). The bio-acidification was achieved by endogenous bacteria with dosing only of sugar-rich organic by-products. 55% - 70% of total phosphorus in the sewage sludge was released as soluble phosphorus by bio-acidification upstream of sewage sludge digestion, with slightly higher release from iron phosphate than from aluminium phosphate sludge. Release from iron phosphate sludge (with the same sugar-rich organics dosing) was however considerably lower (only around 20%) for bio-acidification of digested sludge. Bio-acidification upstream of the anaerobic digester significantly increased methane production. The Veolia Struvia reactor, in the tests, was able to recover over 95% of the dissolved phosphorus from bio-acidification as calcium phosphate (hydroxyapatite). The recovered hydroxyapatite is considered to have low economic value, but very low operating costs. Struvite production was not adopted because of high operating costs and insufficient ammonia concentrations.

Other technologies tested at laboratory scale were mineral acid-leaching of phosphorus from (wet) sewage sludge, microalgae bioreactor for treating sewage, Veolia Struvia (hydroxyapatite precipitation) for tertiary P-removal and alkali-activated crab carapace as a phosphorus adsorbent (with Veolia Filtraflo). Summary in SCOPE Newsletter n°141).

The final report also includes assessment of possible value chains and business models, with scenarios for Switzerland (see ESPP eNews n°61). The Netherlands and Germany (Emscher – Lippe region EGLV), a GIS tool, recommendations for EU decision makers

Phos4You Interreg project Final Report (184 pages) and Technical Report (326 pages), edited by Lippeverband water board, Germany, 09/2021 and 12/2021 www.nweurope.eu/phos4you See also summaries in SCOPE Newsletter n°141 (Phos4You final conference)

Science summary on plant phosphorus and use efficiency

The conclusions of the EU Horizon2020 CropBooster-P project give an overview of knowledge and perspectives on crop Phosphorus Use Efficiency. It is underlined that around one third of cultivated soils worldwide have insufficient available phosphorus for optimal plant growth. Knowledge of root architecture, soil biome and plant hormonal phosphorus signalling are summarised. It is noted that addition of mycorrhizal fungi (AMF) to plants (e.g. by inoculation, soil application or seed coating) has shown to be effective in improving plant P uptake in laboratory conditions, but that field experiments have shown little benefits, because the bacterial populations cannot be controlled. The practical, agronomic value of understanding plant P signalling and transport mechanisms is not clear, but may provide routes to early-stage detection of P deficiency. The authors note that work on crop selection should aim not only to increase P uptake, but also to improve overall P utilisation, so increase of harvestable material or of seed P content. Work on plant traits also needs to be combined with referenced soil P analysis (Olsen P is indicated). Development of progressive-release fertilisers and of fertilisers with improved phosphorus plant uptake is recommended. The project report also includes a summary on improving nitrogen uptake and use efficiency.

CropBooster-P, EU Horizon 2020, Deliverable 4.2, November 23rd 2021 "White Paper and Scientific Basis of the Strategic Research Agenda", https://www.cropbooster-p.eu/

Phosphorus levels in Organic and conventional food products

The BfR MEAL study Germany analysed 356 food products and found similar phosphorus (P), potassium (K) and calcium (Ca) levels between Organic and non-Organic (conventional) products. Significant differences showed for olives: lower Ca, maybe due to calcium chloride additive used in non-Organic, higher K, maybe in sea salt used for Organic olives and higher P, attributed by the authors (surprisingly) to higher fertiliser use for Organic olives. Higher phosphorus was also found in certain categories of Organic cereal products, suggested to be because of inclusion of seeds and not only cereals in the Organic products (ESPP note: this would be expected because of phytate content of seeds, but the P in phytate is only partly assimilable by humans). P, K and Ca levels were also similar for foods purchased in different regions of Germany and at different times of the year. The authors conclude that dietary differences in mineral intake would therefore result principally from choice of different categories of food.

"Results of the BfR MEAL Study: The food type has a stronger impact on calcium, potassium and phosphorus levels than factors such as seasonality, regionality and type of production", K. Schwerbel et al., Food Chemistry: X 13 (2022) 100221 DOI.

Elevated CO_2 increases soil P mineralisation but decreases plant-available P

Tests with wheat showed that high atmospheric (eCO_2) increased crop biomass growth, accelerated mineralisation of organic P with increased soil microbial activity, resulting in reduced plant available P, due to plant – microbe competition for P (Jin 2022). The tests were carried out in laboratory growth chambers, with 0.12 x 0.2m area rhizoboxes enabling physical separation of the root growth and rhizosphere compartments (but movement of water, nutrients), with CO_2 at 800 vs. 400 ppm, organic phosphorus added (phytate, 70 mgP.kg soil), in two soils from Victoria, Australia (Chromosol = strong texture difference between surface and subsoil, Vertosol = high in clay) and carbon labelling. Elevated CO_2 (eCO_2) resulted in increased carbon in soil (+60%), transferred by the wheat plants. Mineralisation (conversion to inorganic forms of P) of the phytate (organic P) increased 9% in the Chromosol and 45% in the Vertosol respectively and microbial respiration rate increased significantly in the rhizosphere of both soils. Bacterial species richness increased. The increased mineralisation of organic P was considered to be related to an increased genetic pool of bacteria for glycolysis and for the pentose phosphate pathway, linked to synthesis of nucleotides and ATP. Abundance of the soil bacteria phyla Bacteriodetes and Gemmatimonadetes increased, associated with phytate mineralisation. eCO_2 led to statistically significant reductions in plant available soil P (Olsen-P) and also reduced plant available N. This was considered to be the result of competition between soil microbes and plants for nutrients (indicated by increased microbial C:P ratio). The results of these tests confirm and provide additional insights to the 8-year Free Air CO_2 Enrichment (SoilFACE) experiments reported in Jin 2020 which showed, under eCO_2, increased presence of oligotrophs in the bacterial community and increased mineralisation of soil organic P in surface soils.

"Elevated atmospheric CO2 alters the microbial community composition and metabolic potential to mineralize organic phosphorus in the rhizosphere of wheat", J. Jian et al., Microbiome (2022) 10:12, DOI.
"Long-term CO2 enrichment alters the diversity and function of the microbial community in soils with high organic carbon", J. Jian et al., Soil Biology and Biochemistry, Volume 144, May 2020, 107780 DOI.

Climate variation likely to increase soil phosphorus losses (bis)

Drought – flood abrupt alternation (DFAA) conditions were simulated in field trials, Anhui plain, China, under summer maize, showing reduced plant P storage and increased soil P losses. Using this data in modelling suggested a six-times increase in P losses possible with future climate change. Fifteen field plots of 5.5 x 3.7 m, separated by baffles 1.2m deep, were used for the tests, near Bengbu, 500 km NW of Shanghai. The DFAA test plots were sheltered and subject to artificial rainfall only. DFAA was considered to be dry soil conditions followed within 5 days by rainfall, with testing of three degrees of dryness and rainfall. The plots with DFAA showed nearly 50% lower P-storage in the crop than natural (control) conditions and soil phosphorus losses from 2% to 9%. Modelling suggested that climate change (IPCC RCP 4.5 scenario) could lead to a nearly six-fold increase in soil P loss. This study confirms similar conclusions from laboratory tests carried out in the UK (S. Khan et al. 2021, see ESPP eNews n°62).

"Soil phosphorus loss increases under drought-flood abrupt alternation in summer maize planting area", W. Bi et al., Agricultural Water Management 262 (2022) 107426 DOI.

Misleading research

Erroneous research paper on phosphates in food

An author from Plymouth University, UK, who published an erroneous paper on food phosphates in 2013 has offended again, with a new paper whose conclusions are based on errors, biological misunderstanding and failure to verify data sources. This 2022 paper contains some limited but interesting primary data, but then draws misleading and false conclusions.

The primary data contained in the 2022 paper are the results of a Google Survey, with a smallish sample of 184 useable responses (unbalanced: 142 female, 34 male). The online questionnaire asked people what they would eat on a typical day for breakfast, lunch, dinner, snacks and drinks, and if known to specify "*brands and amounts*". Respondents were asked to classify themselves as meat eaters (83), flexitarians (58), vegetarians (31) and vegans (12). Responses were then combined with the UK Government 2019 food database to estimate daily dietary phosphorus intake. These calculations suggest that meat eaters and flexitarians (meat-flex) have a diet P intake of c. 1.3 gP/day, whereas vegetarians and vegans (veg-veg) have a lower intake (0.8 – 1.0 gP/day). Differences between meat eaters and flexitarians were not statistically significant, nor between vegetarians and vegans, but the difference comparing the groups meat-flex and veg-veg was significant. As indicated in the paper, this result is contrary to the hypotheses of Forber et al. 2020 (see ESPP eNews n°51 and discussion in Metson et al. ESPP eNews n°4). Forber's estimates assumed the same protein intake for vegetarians as meat-eaters, whereas in this 2022 paper veg-veg respondents suggested a lower protein intake than meat-flex. In ESPP's opinion, this interesting result merits further investigation with a larger sample..

However, the paper then draws erroneous conclusions based on various assumptions, unverified secondary data and a significant scientific error concerning phosphorus metabolism.

The paper suggests total average diet P intake of 1.1 – 1.7 gP/day, by multiplying the calculated intakes (based on respondents' answers) by +32% to compensate for the under-declaration of food consumption which is known to generally occur in food questionnaires. This is reasonable, but it is also possible that the degree of under-declaration may be different for veg-veg than meat-flex respondents, as the former may have a more attentive attitude to diet. A higher proportion of the veg-veg respondents are female which may also modify attitudes*. These potential sources of result bias are not considered.

It is stated concerning diet P intake that "*Food containing additives also comprises 70% more P than those without*". The reference given is Winger 2012. But in fact, Winger (secondary source) quotes this number from the abstract of Benini O. et al. J Renal Nutrition 21(4), 2011 (primary source). The original data in Benini actually shows P (total) 57% higher in 60 samples of processed meats (30 with and 30 without P food additives). This would imply a 57% higher diet P intake **for persons eating <u>only</u> processed meat** (for breakfast lunch and tea) and no other foodstuffs, so potentially much less of a difference in a diet including some processed meat along with unprocessed meat, cereals, vegetables, beverages, etc.

It is indicated that the daily minimum requirement of phosphorus in diet is 0.55 gP/day. P excreted from the body (to sewage) is then calculated as the dietary intake (based on the respondents' calculation) minus 0.55 gP – that is, the paper assumes that 0.55 gP/day is accumulated in the body (ignoring losses in sweat, hair growth, skin cell shedding … which are negligible). This is of course balderdash. **If it was true, then at my age I would have accumulated 12 kg of P in my body, that is 70 kg of calcium phosphate (the material of bones), that is more than 100% of my weight (more than two-and-a-half times my body dry weight).** This does not seem to have led the authors to question their conclusions. In reality, the daily excretion of P well known to be approximately the same as the daily intake, with a small net accumulation during childhood. This error leads to considerably overestimate the differences between P excretion to sewage from meat-flex compared to veg-veg (calculated from the results, adjusted), and so leads to misleading conclusions as to a hypothetical reduction in sewage phosphorus levels in case of dietary change.

The paper calculates the reduction in sewage P levels claimed to result from a change of diet by comparing the (erroneous) estimated change in body P excretion (wrongly calculated as indicated above, and based on responses of < 50 veg-veg respondents) to an estimate for total P in UK raw sewage (wwtp influent**)**. This estimate is referenced p.6 to a study by the same author (ref. 44, Comber 2021), which in fact seems to include only wwtp effluent data. In fact, the primary data is probably from UKWIR CIP2 2015-2020 monitoring (cited as ref. 40, p. 5) which show mean P in influent sewage of 8.36 mg/lP-TOTAL (44 UK wwtps). This estimate of the proportion of P in sewage coming from diet involves other errors, for example: part of the P coming from the population does not reach sewage works (households on septic tanks, pipe leakage …). Overall, the authors conclude that "*current diets contribute 45% of the P load to UK wwtps*". This number is unrealistically low, coherent with the incorrect assumption that a half to a third of diet P is retained in the body and does not reach sewage. In 2017, the UK Environment Agency indicated 60% of P in UK sewage from diet, and the % will have increased as phosphates have been banned in household dishwasher detergents since 2017. The authors do not ask themselves the question that if only 45% of P in sewage were to come from human diet, where does the rest come from?

The author, S. Comber, Plymouth University signed in 2013 an erroneous paper in the same peer reviewed journal (Environmental Technology, Taylor & Francis), see SCOPE Newsletter n°103. This 2013 paper estimated the quantities of P from food phosphate additives in the UK diet, with a conclusion which would have meant that half of total EU food phosphate production was consumed in the UK. This result did not lead the author to question the conclusions. The UK Environment Agency on the other hand considered the conclusions as "unrealistic". This error resulted from the same methodological fault as one of the errors of the new 2022 paper: the use of secondary data without going back to the primary source. In the 2013 paper, data from a (dubiously reliable and incorrectly cited) thesis were used, these data having been incorrectly taken from a 1993 UK

Government publication. This non-verified use of secondary data led to confuse grammes of phosphorus with grammes of “food phosphate”, an error of factor at > 4x.

The paper abstract also suggests that more P in sewage “*causes eutrophication*”. This is misleading, in that **increasing P influent to sewage works will often not increase P discharge**, because P-removal is operated to discharge consent level (there will be some increase in P reaching the environment in storm overflows, households not connected to mains sewerage).

** ESPP note: please do not take this as discriminatory, but only as a possible hypothesis.*
“The impact of diet on wastewater treatment works phosphorus loading”, C. Down, S. Comber, Environmental Technology 2022
https://doi.org/10.1080/09593330.2022.2027029

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