Events and calls for input

ESPC4 and PERM5, Vienna, 20-22 June 2022

The 4th European Sustainable Phosphorus Conference (ESPC4) will be the biggest phosphorus stakeholder meeting globally for 4 years (since ESPC3 Helsinki, with 300 participants from 30 countries, see SCOPE Newsletter n°127).

ESPC4, Monday 20th and Tuesday 21st June 2022, will be followed by **PERM5, the 5th Phosphorus in Europe Research Meeting**, Wednesday 22nd June 2022 (summary of PERM4, June 2021, online, coming soon here).

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 summarising, currently being updated (see below).

ESPC4 - PERM5 will be both physical and accessible online.
Updated outline programmes of ESPC4 and PERM5, and a call for abstracts for presentations and posters for ESPC4 are now online https://phosphorusplatform.eu/espc4

Phosphates 2022

7 – 9 March 2022, Tampa, Florida. 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.

CRU Phosphates 2022:
https://events.crugroup.com/phosphates/home

PhD / Masters school on wastewater circular economy

22-26 November 2021, Cracow, Poland. The MonGOS Winter School enables 25 young researchers (Masters, PhD) to explore wastewater resource, water and energy recovery and circular economy indicators and practices. The School will be led by experts from the MonGOS project partner institutes in Belgium, Finland, Latvia, Lithuania and Poland and will be based on targeted teaching and workshops, group projects and case studies.

***Applications are open to 17th October 2021**. In English. Free. MonGOS Winter School 2021 : https://mon-gos.eu/winter-school-2021/*

Update and new entries for Catalogue of Nutrient Recovery Technologies

ESPP, DPP and NNP are updating the Catalogue of Nutrient Recovery Technologies summarising processes for recovery of nutrients from sewage, manure or other sources. Information is invited on technologies to be added. To be included, technologies should be operational or demonstrated at full-scale or pilot scale, and should recover phosphorus, nitrogen, potassium and/or micro-nutrients. The catalogue provides practical data and information on: technology supplier(s) (website, contact), process input materials (sewage sludge, ash, manure, etc.), output products (nutrient content, organic carbon content and other properties), process description (in particular indicating fate of contaminants), current operating status (number and capacity of plants operating, capacity of pilots and duration of continuous operation) and photos of installations.

***To include further technologies in the Catalogue**: send information, as specified above and if possible in the format of (column titles) the Catalogue as currently online here to info@phosphorusplatform.eu*
ESPP - DPP - NNP Catalogue of Nutrient Recovery Technologies: http://www.phosphorusplatform.eu/p-recovery-technology-inventory

Call for abstracts: "Legacy Phosphorus" in agricultural soils

ESPP, with BOKU, are organising a webinar 2nd February 2022, 13h – 17h CET, on relationships between draw-down of "Legacy P", crop yield and P losses, see below. Abstracts are invited by 30th November 2021

Webinar website, call for abstracts, registration www.phosphorusplatform.eu/LegacyP

Call for abstracts: ESPC4, Vienna 2022

A new call for abstracts for presentations and posters is now open for the 4th European Sustainable Phosphorus Conference, Vienna 20-22 June 2022. Deadline 30th November 2021. Proposed presentations should address the conference parallel session themes (see updated programme here): Policy tools and business models, Climate change links to phosphorus management, New fertilisers for nutrient sustainability, P-recycling R&D and new technologies, Regions in action for phosphorus sustainability. Posters can address any theme relating to phosphorus sustainability. Abstract submission instructions are on the conference website here.

ESPC4 – PERM5 website: https://phosphorusplatform.eu/espc4

EU consultations

EU public consultations open

Marine Strategy Framework Directive (MSFD). "Protecting the marine environment – review of EU rules". **Open to 21st October 2021**. See details in ESPP eNews n°58. Consultation.

Water pollutants. "Integrated water management – revised lists of surface and groundwater pollutants". **Open to 1st November 2021.** See details in ESPP eNews n°58. Consultation.

Air quality. Revision of EU rules**. Open to 16th December 2021.** Consultation**.**

Pharmaceuticals: Revision of the EU general pharmaceuticals legislation. Open to 21st December 2021. Consultation.

ESPP input made on EU "Taxonomy" criteria

These criteria will define which economic activities under what conditions, will be eligible for EU Green Deal investment funding and other eco-incentives. Phosphorus recovery from sewage is listed as one of the 100 activities.

ESPP input suggested that the item P-recovery from sewage treatment should be widened to cover P-recovery from other waste streams, and also to cover recovery of other nutrients, in particular N-recovery. ESPP suggested that the two items on agriculture (livestock, crops) should include Phosphorus Use Efficiency in criteria, in addition to Nitrogen Use Efficiency as proposed. ESPP also input on tourism (include environmental impact of restaurant menus), food industry (promote nutrient circularity, water treatment, bio-waste and solid waste).

Consultation closed 28th September 2021, documents online here See ESPP eNews n°58 and ESPP input here

ESPP input on End-of-Waste

ESPP and Eureau, with participation from stakeholders, have input to the EU JRC consultation on selecting priority materials for definition of EU End-of-Waste Criteria, suggesting different recovered materials from wastewaters.

The process for obtaining EU End-of-Waste status for use in fertilisers is ensured by the EU Fertilising Products Regulation 2019/1009. ESPP and Eureau made input concerning non-fertiliser applications of the following materials: minerals recovered from ashes (e.g. recovery of phosphoric acid from sewage sludge incineration ash), minerals recovered from wastewater (e.g. recovered struvite or vivianite as a flame retardant, recovery of iron or aluminium compounds for use as coagulants, etc.), recovery of nitrogen salts for use as a commodity chemical, algae grown in wastewater, bioplastics (PHA, PLA), cellulose (crude, fluff, pellets), "Kaumera" biopolymer.

Consultation closed 10th October 2021, documents online here See ESPP eNews n°57 and ESPP input here

"Legacy Phosphorus"

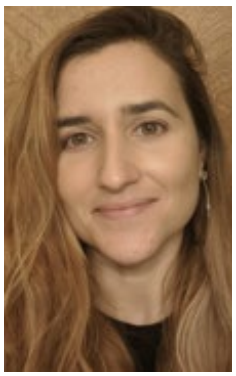
SPA webinar on "Legacy Phosphorus"

80 participants listened to the three speakers on phosphorus accumulation in agricultural soils, soil P chemistry and actions to reduce P runoff. Online questions focussed on whether soil P could be reduced without losing crop yield.

The webinar was introduced by **Matt Scholz, US Sustainable Phosphorus Alliance (SPA)** who pointed to a global "legacy P problem", where phosphorus from past applications of fertilisers and manure overwhelms soil P storage capacity and leaks into surface waters. He referred to Wironen 2018 (see SCOPE Newsletter n°128) who showed how Vermont continues to accumulate > 5 kgP/ha/y in soil, despite improvements in phosphorus use efficiency, and despite significant reconversion of agricultural land back to woodland, because of increasing and increasingly concentrated dairy livestock production.

Jean-Olivier Goyette, University Laval, cited a number of studies indicating that P accumulated in watersheds (soils and water sediments) from past activities can represent a significant part of current P loads to surface waters (McCracklin 2018 DOI: 50% to the Baltic, Meng 2021 DOI: 50- 80% for China upland rivers), and that a drawdown of this legacy P pool could take decades to centuries (McDowell 2020 DOI, Goyette 2018 DOI, Carpenter 2005 DOI). He suggested that this accumulation of P is related to the low phosphorus efficiency (PUE) of food production, which has fallen from 35% around 1900 to 6% today, largely because livestock production and fertiliser use (crop PUE: 30%, conversion vegetal-animal 10%; see Liu 2016 DOI, Suh 2011 DOI). He underlined that studies have shown that once soil reaches around 20% "P saturation" (saturation of mineral binding ions such as Fe, Al, Ca) losses to surface waters begin to occur, that is a "breakpoint" (Nair 2014 DOI). At the watershed scale, this can occur after accumulation of just 21 kgP/ha (Goyette 2018 DOI). It remains to be clarified however how this P-loss "breakpoint" relates to agronomically recommended soil P levels and to crop yields.

Dean Hesterberg, Brazilian Synchrotron Light Laboratory (LNLS/CNPEM), discussed soil phosphorus chemistry and the complexity of relations between "labile" phosphorus (i.e., which can be released from mineral binding sites in soil) and plant-available phosphorus. Roots only directly take up the orthophosphate in soil pore water, which is typically less than 0.1% of average total phosphorus in the top 20 cm of soil, i.e., >99.9% resides in the soil solids. Plants have mechanisms to mobilize solid-phase soil P, although a significant portion of inorganic P tends to become less plant available over time by mechanisms that are not fully understood. Also, (micro)biological mechanisms convert organic forms of phosphorus into more plant-available forms. Complexity results from the very wide variability in soil properties and soil biology, including between different soil depths in the same soil, variation with climate, and different plant species' ability to access phosphorus.



Isis S. P. C. Scott, University of Maryland/Hydrology and Remote Sensing Laboratory (USDA-ARS) outlined different techniques to reduce P losses to water bodies: prevention of legacy-P sources = balanced nutrient application and animal diet, manure export; containment = tillage practices aimed at reducing particle detachment, soil amendments, buffer zones and wetlands; and remediation, namely soil P drawdown by crops and phosphorus removal structures, also known as P traps. These remediation practices work across different temporal scales: Draw-down is a long-term remediation strategy, while P traps are an immediate practice targeting dissolved P in runoff, drainage, or wastewater. Phosphorus traps are systems containing PSMs (phosphorus sorption materials) installed in both urban or rural hotspots, promoting P removal before discharge into rivers or lakes. For information on how to design P removal structures, see the USDA P-trap app. See also SCOPE Newsletter n°138.

Discussion in the webinar chat asked what is the definition of "Legacy phosphorus". Does the term refer to any levels of soil P higher than natural or background levels? Or does it mean soil P levels higher than agronomic recommended indexes defined to enable optimum crop productivity? This was also reflected in the question: **to what extent can "Legacy P" be drawn down without significantly reducing crop yield?**.

US Sustainable Phosphorus Alliance (SPA) webinar "A Legacy of Phosphorus", 30th September 2021.
Watch the webinar on SPA's YouTube channel
A follow-up webinar addressing the question of links between "Legacy P", crop productivity and P losses to watersheds will is organised by ESPP 2nd February 2022, 13h – 17h CET. If you wish to present at this webinar, contact info@phosphorusplatform.eu

Review paper on "Legacy Phosphorus"

Accumulation of P in soils in the US is considered to mainly result from mineral fertiliser application, not manure, and to result in increases in mineral forms of P in soils, not organic P. The abstract states that accumulation of "Legacy P" in soils can increase nutrient runoff leading to eutrophication, but with little supporting evidence (only one study cited, not apparently relevant). The review itself suggests that inorganic P applied to soil is absorbed or reacted with a wide range of minerals in soil, and the bio-availability of this mineral phosphorus pool depends mainly on soil pH. P in organic forms in soils is mainly as monoesters or diesters. Some field studies suggest that annual application of manure (e.g. 30 kgP/ha/y) did not lead to an accumulation of soil organic P. Also, native organic P forms in soils appear to be relatively stable, and may not be reduced even after fertiliser application is stopped. Plants can access non-soluble soil phosphorus by extending root structure, or by releasing acids or enzymes from roots. Tests suggest that changes in root architecture and release of enzymes are more effective than release of organic acids (this despite the importance of soil pH indicated above). The paper does not explore to what extent 'mining' of soil P by plants by such mechanisms could impact crop productivity.

"Review. Accessing Legacy Phosphorus in Soils", S. Doydora et al., Soil Syst. 2020, 4, 74; LINK.

"Legacy Phosphorus", crop productivity and P-losses

ESPP will host a webinar to discuss how "Legacy P", and proposals to "draw down Legacy P", are related to agronomic recommended soil P indexes and crop yield, and to P losses to watershed: 2nd Feb. 2022, 13h – 17h CET.

With Achim Doberman, Chief Scientist, International Fertilisers Association (IFA); Jim Elser, University of Montana, USA; Phil Haygarth, University of Lancaster, UK; Andrew Sharpley, University of Arkansas, USA.

This ESPP webinar will follow on from the SPA (US) *webinar* "A Legacy of Phosphorus", 30th September 2021 (see above) and from the Frontiers in Earth Science *special* on 'Legacy Phosphorus' summarised in *ESPP eNews n°56*

A *SCOPE Newsletter* special issue will summarise this ESPP webinar and the SPA webinar, and will also include selected abstracts submitted to the ESPP webinar as well as a selection of c. 20 relevant recent scientific publications.

Call for presentations and posters, open to 30th November 2021 *www.phosphorusplatform.eu/LegacyP*
Organised with BOKU Austria. Preference for results from field, pot or lysimeter studies (i.e., "real data"), but interesting modelling studies will also be considered. Selected submissions not accepted for presentations will be made available to participants and then published in the SCOPE Newsletter Special Issue.

Policy

Urgent need for conformity assessment bodies for fertilising products

Industry concerned that the lack of Conformity Assessment Bodies (CAB) may prevent products from obtaining access to the market under the new EU Fertilising Products Regulation (FPR).

The new FPR (EU) 2019/1009 (FPR) is set to apply from 16 July 2022 and requires third party certification for many products covered by this regulation. Accreditation of Conformity Assessment Bodies (CABs) is required so that fertilising and plant biostimulant products are able to gain access to the EU Single Market. So far, very few CABs have applied for accreditation across EU member states to date. We are concerned that the lack of CABs will prevent products covered by the FPR from accessing the Single Market, which will be detrimental to industries and farmers alike.

In this context, EBIC, ECOFI, Fertilizers Europe and IVA are urging all concerned parties to reach out to organisations qualified and eligible to act as Conformity Assessment Bodies immediately and encourage them to apply without further delay for notification. To demonstrate the potential demand for CABs, these four associations reached out to their members to make a preliminary, joint estimate of how many products are expected to be submitted for certification under the FPR in the next two years. The data was collected by a third party in full compliance with competition rules and the resulting aggregated figures were made available to the European Commission. To gain access to the data and for further information, please contact Jessica@prospero.ag .

The European Commission is organising a virtual info session for certification companies interested in becoming conformity assessment bodies/notified bodies entitled "Conformity assessment of EU fertilising products: WHY and HOW to become a notified body?". Interested parties can register for this on-line event by sending an e-mail to DG GROW.

Article provided by ECOFI, with thanks: www.ecofi.info
For further information, please contact Jessica@prospero.ag

Post-processed digestates and composts excluded from EU fertilising products

The European Commission has replied to ESPP that post-processing of digestates and composts (e.g. solid-liquid separation, stabilisation …) is not at present covered by the EU Fertilising Products Regulation (FPR) CMC criteria.

ESPP raised this question to DG GROW some time ago, because such post-processing will often be implemented to condition and prepare products to place on the European market, especially digestates. The Commission's reply also confirms that processing additives used downstream of the anaerobic digester / composter are not considered as "composting/digestion additives" (as cited in CMCs3 and 5), e.g. polymers for solid-liquid separation, pH adjusters, granulation aids etc. It is in ESPP's view preferable to resolve such questions now, rather than have them being brought up during a control of a product already on the market after implementation of the FPR from June 2022.

The Commission has indicated to ESPP that amendment of CMCs 3-5 (Annex II of the FPR) could be considered to include (certain) post-processing routes, and that this will be discussed in the next EU Fertilisers Expert Group (of which ESPP is a member) in November 2021.

ESPP will work with relevant federations and operators, to prepare a list of process routes and of additives used for post-processing of composts and digestates, and collate information for each one on how widespread is application and market relevance, product benefits, additives used, extent to which compost/digestate is or is not chemically modified by the process, etc.

EU Fertilising Products Regulation (FPR) 2019/2009

UK requires "nutrient neutrality" for developments near protected habitats

The UK is now requiring "no increase in nutrient emissions" for housing projects impacting Natura 2000 protected areas, to respect the European Court of Justice "Dutch case" ruling.

The Government body Natural England has issued detailed Guidance (60 pages) on how to calculate net nutrient emissions for new developments, for local planning authorities. The Guidance specifically targets the Solent and the Stour catchment, upstream of the Stodmarsh designated wetland sites, Kent, but is being seen as applicable in principle to the catchments of other Natura protected areas. The overall validity of this Guidance has been upheld by the UK High Court, 28th May 2021, in a judgement concerning two housing applications under Fareham Borough Council. The UK requirement for "nutrient neutrality" for protected habitat areas follows the European Court of Justice decision of 7 November 2018 (C-293/17 and C-294/17) stating that "grazing of cattle or application of fertiliser" in the vicinity of a Natura 2000 site may be classified as a "project" (under Directive 2011/92) so requiring demonstration "that there is no reasonable scientific doubt as to the lack of adverse effects" on the Natura site (see ESPP eNews n°35).

The Natural England Guidance defines how to calculate "nutrient neutrality" for housing development, change of agricultural land use, etc. For new housing, is assumed that all residents will be new residents, coming from outside the catchment, so generating additional wastewater: additional nutrient input to the catchment is calculated by multiplying the estimated number of residents in the housing x average water use per person x total P and total N discharge per litre (estimated as 100% of the waste water treatment plant consent limit TN/l and 90% of the consent limit TP/l). Nutrient loss from changes in agricultural land use is estimated from data for average farm N and P loss (kg/ha) compared to average losses from e.g. green space. The numbers used are specific to the local catchment. To achieve "nutrient neutrality", mitigation actions must be planned to compensate for nutrient loss increases, such as interceptor wetlands, planting of woodland, upgrading of sewage works.

Natural England, July 2020 "Advice on Nutrient Neutrality for New Development in the Stour Catchment in Relation to Stodmarsh Designated Sites - For Local Planning Authorities. July 2020" LINK.

Erratum: EU Member States derogatory cadmium limits

The article in ESPP eNews n°57 specifying derogations accorded to certain Member States for fertiliser cadmium limits lower than the EU Fertilising Products Regulation limit of 60 mgCd/kgP_2O_5 (which will apply to EU fertilisers from July 2022) contained two errors:

- The limit in Finland is 22 mgCd/kgP_2O_5 (not 50 as indicated because the Finland regulation is 50 mgCd per kg P not P_2O_5)
- The Swedish request to apply a national limit of 20 mgCd/kgP_2O_5 in 2012 was rejected by the European Commission decision 2012/D0719 because the Commission considered that Sweden "*has not provided new scientific evidence relating to the protection of the environment or working environment demonstrating that there is a specific problem within its territory … which makes it necessary to introduce the notified national measures.*" The national limit of (equivalent) 44 mgCd/kgP_2O_5 (COM decision 2002/399) therefore remains in force today in Sweden.

The corrected list of Member States with derogations for national fertiliser cadmium limits lower than 60 mgCd/kgP_2O_5 is therefore as follows:

- Denmark (COM decision 2020/1178) = equivalent to 48 mgCd/kgP_2O_5
- Finland (COM decision 2006/D0348) = 22 mgCd/kgP_2O_5
- Hungary (COM decision 2020/1184) = 20 mgCd/kgP_2O_5
- Slovak Republic (COM decision 2020/1205) = 20 mgCd/kgP_2O_5
- Sweden (COM decision 2002/399) equivalent to 44 mgCd/kgP_2O_5

EU partly lifts ban on feeding processed animal protein (PAP) to animals

It is now legal to feed processed animal protein (PAP) to non-ruminants (pigs, poultry), but the ban on feeding PAP of one species to the same species remains in place (intra-species). The PAP feed ban was put in place in 1994, in response to the 'mad cow disease' (bovine spongiform encephalopathy - BSE), which is thought to have been spread by the practice of supplementing feed for cattle with meat-and-bone meal which was not sufficiently sterilised to inactivate prions (the novel agent which causes BSE and is not a pathogen but a badly-folded brain protein, capable of causing other brain proteins to refold). Millions of cattle were culled because of BSE, and nearly 200 people died of the version transmissible to humans (a variant of Creutzfeldt-Jakob disease), whereas it was initially feared that thousands or millions of people could be at risk. The European Commission justifies the decision to partially lift the PAP feed ban by the fact that other countries worldwide do not apply this, so that imported meat is unfairly advantaged compared to EU producers, and that 24 of the 26 EU Member States today have "negligible" BSE status (the UK's last case of BSE was in 2016). The Commission states that the current ban causes some 100 000 tonnes/year of processed animal protein to be disposed as waste. The EU farmers' federation COPA-COGECA states that PAP is an important source of phosphorus and highly digestible protein. The partial lift of the ban is expected to benefit insect protein. The published regulation runs to 17 pages of small print detailing production, use and transport conditions for PAP.

"EU lifts ban on feeding livestock processed animal protein (PAP)", 1st September 2021
EU Regulation 2021/1372 "amending Annex IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council as regards the prohibition to feed non-ruminant farmed animals, other than fur animals, with protein derived from animals"

Nutrient recycling

N2 Applied on the world's radio

"Firing a bolt of plasma at slurry to break up toxic ammonia and climate-heating methane". The BBC has featured (2 items) ESPP member N2 Applied's innovative process to reduce manure emissions and improve nitrogen recycling. The report by BBC environmental analyst Roger Harrabin features an N2 installation at a dairy farm in Buckinghamshire UK, includes sniffing manure 'before plasma' "typically pungent" and 'after plasma' "uplifting smell of the seaside". The N2 Applied process prevents ammonia and climate emissions from the manure, instead converting N into stable forms which are valuable fertiliser. N2 Applied has recently received 15 million € EU investment funds for roll out of its process.

"Artificial lightning zaps farm stink", BBC 8th October 2021 https://www.bbc.com/news/business-58795272
BBC News, 7th October 2021, N2 Applied @ c. 42 mins.
BBC World Service News, 7th October 2021, N2 Applied @ c. 19 mins.
Video clip of the N2 Applied installation at Holly Green farm (Arla Innovation Farm) in UK https://www.youtube.com/watch?v=P76DMaldbuk
"N2 Applied gets $17m to turn livestock slurry into sustainable fertilizer", 14th October 2021.

Glatt & Seraplant commission 30 000 t(ash)/y P-recycling plant

The PHOS4Green process reacts phosphoric acid with sewage sludge incineration ash to render the P in ash more plant available, combines with other nutrients, then produces granulated fertilisers, with part-recycled P content. The 20 million € plant commissioned at Haldesleben (between Hannover and Berlin, Saxonly-Anhalt) will take 30 000 t/y ash as input and produce 60 000 t/y fertiliser. Heavy metals, iron, aluminium, silica and other minerals present in the sewage sludge remain in the final product. The process generates no waste streams. the final product is compliant with the German fertiliser ordinance (DüMV)

"Produktion in erster deutscher PHOS4green-Anlage für Recyclingdünger ist gestartet", 8th June 2021
Details of PHOS4Green process: http://www.phosphorusplatform.eu/p-recovery-technology-inventory

Técnicas Reunidas announces contract for 40 000 t(ash)/y P-recycling plant

Following demonstration pilot trials, the Técnicas Reunidas Phos4Life technology has been selected by ZAR, Switzerland, to recover and recycle P from sewage sludge incineration ash at KEBAG's site, Zuchwil, near Soluthurn. KEBAG AG Zuchwil collects and manages waste from half a million inhabitants in the cantons of Bern and Soluthurn. ZAR is the Foundation for Sustainable Waste and Resource Use. The Phos4Life process leaches ash with sulphuric acid, followed by filtration and separation of iron, aluminium and heavy metals by solvent extraction, to generate technical-grade phosphoric acid. The 40 000 t(ash)/y plant is planned for commissioning in 2026.

"Técnicas Reunidas wins two contracts in Switzerland for the use of proprietary technologies in circular economy projects.", 21st June 2021
Details of Phos4Life process: http://www.phosphorusplatform.eu/p-recovery-technology-inventory

25 million US$ for P sustainability research centre: STEPS

The US Sustainable Phosphorus Alliance will help lead a major phosphorus research centre, with 9 US research institutes, to accelerate fundamental science and develop technologies and practices for sustainable P management. "Science and Technologies for Phosphorus Sustainability", STEPS, is one of six new science and technology centres "to address vexing societal problems" announced by the US National Science Foundation and will receive a total of 25 million US$ in NSF funding over five years, with the possibility of a 5-year renewal. STEPS stems in part from the network of researchers launched in 2011 with the NSF P Sustainability Research Coordination Network RCN (SCOPE Newsletter n°125) and the practitioner network of the Sustainable Phosphorus Alliance (SPA), with strong involvement of Jim Elser and Matt Scholz of SPA.

STEPS research is structured across three themes:

1: Human Technology Scale: physico-chemical materials and biologic material design to develop processes for capturing and releasing phosphorus species;

2: Regional and Global Scale: incorporation of these materials into structures and processes;

3: Convergence Informatics: modelling of phosphorus flows and management scenarios.

STEPS will include education - awareness and research – training actions.

STEPS is led by researchers from North Carolina State University, Arizona State University, the University of Illinois, Marquette University, RTI International, Appalachian State University, and the Joint School of Nanoscience and Nanoengineering.
"Alliance Helps Lead Major P Research Center", 8 September 2021 LINK.
US National Science Foundation announcement.
STEPS: https://steps-center.org

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