Events

Members webinar: regulatory aspects of recycled fertilisers, 25th February 10h00 CET

Webinar for ESPP and national nutrient Platform members. Wednesday 25th February 10h00 CET. With Roland De Bruijne, Global Regulatory Affairs Manager Crop Protection, Crop Nutrition, Knoell and ESPP.

This webinar will provide an overview of the different regulations applicable when placing a recycled nutrient fertiliser on the market in the EU and will allow questions and discussion: national and EU fertilisers regulations, waste regulations and End-of-Waste, REACH, Animal By Products, site authorisations, transport, Health & Safety.

Wednesday 25th February 10h00 CET. To obtain the participation link, staff or members of ESPP and of National Nutrient Platforms wishing to participate must register here https://us02web.zoom.us/meeting/register/U6jXtK0JQuimrGUNQgXV3w

18th CRU Phosphates & Potash 2026, Paris, 13-15 April 2026

This is "the" annual world P and K industry & technology meeting place, covering the whole industry value chain: mining and resources, beneficiation, fertilisers – feed and industrial applications, environmental aspects of production management, sustainability.

For ESPP, Robert van Spingelen, ESPP President, and Willem Schipper, Willem Schipper Consulting, will present on "Elemental Phosphorus (P4) Markets: End-Uses, Supply Bottlenecks, and European Project Pathways".

18th CRU Phosphates & Potash 2026, Paris (Paris Marriott Rive Gauche Hotel), 13-15 April 2026. http://events.crugroup.com/phosphates/home
Conference discount code available on request from ESPP for ESPP members.

16th April 16h00-18h00 CET (online): climate emissions from phosphate fertiliser use

How does use of P fertilisers in the field impact climate emissions, e.g. via eutrophication effects or mitigation, crop carbon and soil carbon cycling. Online workshop will input to the Low Carbon Roadmap for the phosphate industry (see ESPP eNews n°103). Nitrogen fertilisers' climate emissions impacts are widely investigated, but do phosphate fertilisers have significant 'Scope3' greenhouse impacts? Are these positive (increased carbon fixation by crops or in soil, or in surface waters due to runoff …) or negative (methane emissions related to eutrophication)? Discussion and conclusions will input into the Low Carbon Roadmap for phosphate fertilisers, under development by ERM consultants, supported by Systemiq consultants, for EBRD (European Bank for Reconstruction and Development) and IFA (International Fertilizer industry Association), to be presented at the IFA Cultivating Tomorrow Conference (June 2026).

Online workshop, 16th April 16h00-18h00 CET. Registration on Eventbrite. ***If you wish to present, please contact info@phosphorusplatform.eu***

ESNI-NERM 2026: the flagship event on nutrient research, Brussels, 28-29 April 2026

ESNI-NERM is the joint European conference on nutrient research, organised by the Biorefine Cluster and ESPP, addressing the scientific issues, developments and challenges of nutrient management and nutrient recycling.

NERM-ESNI Tue. 28th April 2026 12h00 – Wed. 29th April 16h30
https://www.biorefine.eu/esni-nerm-2026/

Implementation of EU UWWTD art. 20 P reuse and recycling rates, Madrid 8-9 June


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DIRECTIVE (EU) 2024/3019 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 27 November 2024

concerning urban wastewater treatment

(recast)

ESPP workshop to input to the development of proposals for phosphorus "reuse and recycling rates" from sewage, update on P-recover, with participation of the European Commission Joint Research Centre (JRC). This workshop follows JRC's first draft report on current sludge processing and destinations, and on phosphorus recycling technologies. It will include presentation and discussion of the Eunomia study on questions for policymakers for possible 'quotas' for recycled P in fertilisers (see below). Site visits to P-recovery and P-removal operations and research.

Workshop on phosphorus reuse and recycling from urban wastewater, Madrid, Monday 8th June 14h00 – Tuesday 9th June 12h30. Site visits 9th afternoon. https://www.phosphorusplatform.eu/WorkshopMadridArt20

Chemistry of industrial organophosphorus products and P_4

Call for abstracts for ESPP joint session on organophosphorus and P_4 chemicals at 25th ICPC International Conference on Phosphorus Chemistry conference, Montpellier, 5-8 July 2026. ICPC is the world's phosphorus chemistry event for now 60 years, covering all aspects of phosphorus chemistry: biology, health and nutrition, medicine, materials sciences and applied industrial chemistry.

The ESPP joint session will look at chemical routes to key industrial chemicals: fire safety, silicon doping for PV and electronics, battery electrolytes catalysts, phosphonates … Are there industrially feasible routes to some organophosphorus chemicals without thermal P4? What perspectives and opportunities for industrial phosphorus chemistry?

If you would be interested in sponsoring or presenting at this P_4 session, please contact ESPP rapidly so that we can define with the organisers the content and organisation and timing.

25th ICPC Phosphorus Chemistry Conference, Montpellier (at ENSCM Ecole Nationale Supérieure de Chimie de Montpellier), 5-8 July 2026. Conference website: https://icpc25.sciencesconf.org/?lang=en

Policy and regulation

ESPP work underway

Over the last several weeks, ESPP has prepared input to a number of regulatory dossiers relevant to nutrient recycling:

- **Detailed comments (19 pages) submitted to the draft European Commission JRC report to support implementation of the revised EU Urban Waste Water Treatment Directive 2024/3019 (UWWTD), art. 20** (definition of combined minimum phosphorus reuse and recycling rates). This draft is not public and comments could only be made by members of the UWWTD Expert Group (includes ESPP) The draft for comment concerned routes for sewage sludge management at present in Europe, and catalogues and assesses existing and potential phosphorus recovery techniques. Further parts of the report will concern risks from substances in sewage sludge applied to agricultural land, market viability of recovered phosphates and the waste hierarchy. The report will input to the definition of EU phosphorus reuse and recovery rate requirements. On this, see ESPP workshop in Madrid 8-9 June, above https://www.phosphorusplatform.eu/WorkshopMadridArt20
- **Continuing input to the EU Fertilising Products Regulation.** Preparation of a joint industry position calling to resolve the current slow, complex and ineffective process for considering new input materials (CMCs), to take account of innovation, recycled and bioeconomy materials. Preparation of the next EU Fertilising Products Expert Group, in particular the NMI report assessing some candidate materials or processes for new CMCs, Animal By-Products. Input to European Parliament concerning proposed amendments to the Chemicals Omnibus to facilitate consideration of new materials as CMCs.
- **Detailed input to the SCRREEN3 draft Factsheets, which will provide a basis for updating of the EU Critical and Strategic Raw Materials lists**. The documents are not publicly available (only SCRREEN3 registered experts, including ESPP). This concerns both 'Phosphorus' (P_4) and 'Phosphate Rock'. ESPP and other experts in our members and network will participate at the SCRREEN3 workshop in February.
- **Input to EU public consultations:** Battery Labelling. The proposed Regulation update confirms the obligation to declare Critical Raw Materials present at > 0.1% w/w (so includes the element P). Revision of EU rules on Public Procurement. ESPP suggests that consideration of environmental aspects be no longer an option subject to difficult conditions, but be required wherever feasible.
- **Input on final proposals for new materials/processes in the EU Fertilising Products Regulation (FPR)**. Work underway. This is the second 180-page NMI report on work which started in 2022. Current proposals are to continue to exclude from the FPR: vivianite, algae grown in wastewaters, ammonium salts from fire extinguisher recycling, pyrolysis (biochar) from sewage sludge, and others, mainly because of "inadequate data". This is despite EU funding of successful pilot projects, full scale operation or authorisation under national regulations in some cases. A few materials or CMC changes are recommended for implementation, including some processes using source-separated urine. ESPP considers that this very slow process, resulting mostly in rejections for "inadequate data", illustrates the need for a more responsive, criteria-based system to enable the FPR to adapt to innovation in circularity and the bioeconomy.
- **R&D offer**. The several national Nutrient Platforms, with ESPP, are preparing a short summary presentation document on how we can together contribute to Research and Innovation projects, to bring competence on nutrients either to directly targeted projects or to wider projects (circular economy, bioeconomy).

Questions on possible phosphorus 'quotas' for fertilisers

Eunomia study, for ESPP, proposes 40+ questions which policymakers should take into account if considering possible 'quotas' for recycled phosphorus in fertilisers (minimum recycled content). The 10-page study, intended as a briefing tool for policy makers, has been developed through research and an engagement process undertaken by Eunomia on behalf of ESPP; it is not an ESPP position. The document summarises Eunomia's review of literature and stakeholder consultation with experts and practitioners, including fertiliser producers, the water and waste industries, recycling technology companies, research. The questions are intended to provide practical perspectives on the potential effectiveness, fairness, feasibility and possible co-benefits or unintended consequences of a possible a quota system for recycled phosphorus in fertilisers. The identified questions show the complexity of defining a workable system: which types of fertilisers? Phosphorus from sewage only or also from e.g. manure? How to ensure quality of recycled phosphorus materials if their uptake is 'obligatory'? At what point in the fertiliser production – distribution – use chain could quotas be applied? Geographical scope (how to consider regional phosphorus surpluses, how to deal with imports and exports…)? Would quotas be tradeable? What would be the administrative and cost burdens? Eunomia conclude that "Some of these questions could be difficult, if not impossible, to answer. Nonetheless, mapping out the key uncertainties and trade-offs is important for identifying practical pathways and avoiding unintended consequences."

"Questions on Possible Phosphorus Quotas for Fertilisers", Eunomia, January 2026, commissioned by ESPP.

Public consultation on draft standards for fertilising products

The European standardisation Organisation CEN has opened for comment 35 draft standards for testing methods to support the EU Fertilising Products Regulation (Standardization Request M/564 and its amendments). An list of the 35 standards can be found here. At the current stage, both technical and editorial comments can be accepted by CEN. However, at the future Formal Vote stage, only editorial comments can be accepted. As with all European standards processes, the consultation is not publicly accessible. The draft standards cannot be found on the CEN website but status information can be found under CEN/TC 223 'Soil improvers and growing media' and CEN/TC 260 'Fertilizers and liming materials'. You might also find some of the draft standards elsewhere on the web (at a price). The CEN Technical Committees (TC) invite interested stakeholders to contact their national standardisation bodies to be able to review the draft standards and to submit comments by the deadlines set at national levels. Comments can only be submitted via the national standardisation bodies. If a stakeholder is unsure whom to contact to consult the standards and to submit comments, they may reach out to Lara.vanderWoude@nen.nl for the standards under CEN/TC 223 and sophie.dithmer@din.de for the standards under CEN/TC 260.

CEN: https://www.cencenelec.eu/

List of standards open for comment: https://circabc.europa.eu/ui/group/36ec94c7-575b-44dc-a6e9-4ace02907f2f/library/1e048e21-77b1-4929-b66a-784653cef888

Questionnaire for companies for Evaluation of EU Fertilising Products Regulation (FPR)

Based on operating experience applying the FPR, fertiliser companies, distributers, material suppliers and farmers are asked if they consider that the FPR is supporting circularity and innovation and what are challenges to its application. Deadline Friday 13th February. This survey is organised by consultants CSES as part of the official European Commission Evaluation of the FPR. Questions concern points such as FPR criteria, product safety, contaminants, compliance and test method standards, production and distribution, relevance to end-users, economic- innovation- and competitiveness impacts, market access for fertilising products, trade, impacts on company activities and on the supply chain, product reformulations, interactions with National Fertiliser Regulations. Challenges with the conformity assessment modules, CE Certification processes and Notified Bodies are particularly addressed, as are compliance and implementation costs and administrative burdens for companies. Companies are asked to compare FPR compliance costs to those of National Fertilisers Regulations. Proposals for simplification of the FPR and of its implementation are requested.

"Targeted consultation - Evaluation of the EU Fertilising Products Regulation (Regulation (EU) 2019/1009)", CSES for the European Commission – open to 13th February 2026 https://eu.mar.medallia.com/?e=100005097&d=e&h=EDB26B998FC4339&l=en

See also ESPP's input (19_9_25) to the previous public consultation for the FPR Evaluation www.phosphorusplatform.eu/regulatory

EU 'Critical Chemicals Alliance' (CCA) launched, open to join

ESPP was represented by Vincent van der Meijden, Filo Chemical, at the launch meeting of the EU Critical Chemicals Alliance 13th January 2026. The Alliance brings together industry and experts to define which chemicals and which production sites are essential foundations for the EU chemicals industry, and for manufacturing industries dependent on chemicals. The Alliance has set up four working groups: Critical Chemicals and Critical Sites, Trade, Chemical production Modernisation and Investments in Europe, Lead Markets (meaning low-carbon and sustainability). The aims of the WG 'Critical Chemicals and Critical Sites' are to define methodologies for identifying critical chemical molecules and chemical sites ("around 10 EU-wide criteria"), to propose a matrix of critical molecules x sites and recommendations for how to support these molecules and sites, all by June 2026. This will draw on existing frameworks, including the EU Critical Raw Materials Act 2024/1252 (CRM Act), recognising that the challenge is not resource scarcity but production competitivity. As in the CRM Act, a subset of the 'Critical' molecules and sites will be identified as 'Strategic', that is key to the green and digital transitions and to defence. The WG 'Trade' aims to develop early warning systems on trade distortions and propose improvements to trade defence instruments, including looking at raw material access and EU chemicals industry opportunities.

Application to joint this EU Alliance remains open for any organisation with activities in the chemicals industry, including companies, associations, investors, research and civil society. https://ec.europa.eu/eusurvey/runner/CCA_apply

EU Critical Chemicals Alliance (CCA) website https://single-market-economy.ec.europa.eu/sectors/chemicals/critical-chemicals-alliance_en

German water organisation calls to postpone implementation of P-recovery Regulation

ESPP, DPP (German Phosphorus Platform) and stakeholders suggest that the German P-recovery deadline should not be postponed. This would be contrary to the EU objective of rolling out phosphorus recovery and reuse.

The German Association for Water, Wastewater and Waste (DWA) has written to the German Federal Environment Minister on 19th December 2025. DWA opens by underlining their support for the objectives of the German P-recycling Regulation* because phosphorus is a Critical Raw Material and P-recovery will make an "essential contribution to resource security". The Federation estimates that P-recovery installations will be operational in 2029 for only one third of German sewage sludge mono-incineration ash (SSIA), and that significant investment is also needed to install mono-incinerators where sewage sludge currently goes to other destinations. DWA says that despite considerable technological progress in P-recovery and numerous successful pilot installations, scale up to full-scale operation remains a challenge, and that lack of experience of operational full-scale P-recovery means a lack of information to support water industry investment decisions. DWA also suggests concerns about the

market for recycled phosphates because of a lack of legal classification or quality requirements. DWA strongly rejects the option of temporarily storing SSIA in separate landfill for later retrieval for P-recovery (when capacity is available) as costly, legally uncertain and non-feasible in the timeline (difficulties to find a landfill site, permitting). DWA also opposes the proposal for a 'Fund' mechanism whereby water operators not achieving P-recovery by the Regulation deadline would pay into a fund to finance P-recovery investments, because this would not resolve the issues of technological scale-up, market uptake or legal uncertainties. DWA calls to legally clarify that water operators can recoup all preparation, investment and operating costs for P-recovery through user water fees (see UBA report in ESPP eNews n°100).

** The German national P-recycling Regulation (AbfKlärV, 27/9/2017) requires (simplified summary) that from 2029 large sewage treatment plants, where the sewage sludge phosphorus content is higher than 20 g P/kg dry matter, must carry out phosphorus recovery (2029 for wwtps > 100 000 p.e., 2032 for wwtps > 50 000 p.e.). There are three options for P-recovery: recover 50% of P from sludge, recover P from sludge sufficiently to reduce below 20 gP/kgDM, or mono-incinerate sludge. For all wwtps where sludge is incinerated, 80% of P must be recovered from the ash. From 2029 the Regulation requires ALL wwtps with sludge >20 gP/kgDM to either recover P or use sludge in agriculture. Because very few wwtps > 50 000 p.e. do send to agriculture they will have to recover P from 2029, as will smaller wwtps not sending to agriculture.*

DPP (the German Phosphorus Platform) has published a detailed argument as to why postponing the German Regulation deadlines is not necessary and counter-productive to the objective of rapidly implementing P-recovery, rolling out P-recycling technologies and developing a market for recycled phosphates.

ESPP has written to the German Minister emphasising that Phosphate Rock is an EU Critical Raw Material, phosphate fertilisers are non-replaceable and essential to ensure food production and farmer incomes, and the EU is 90% dependent on imports. This dependency means that the EU continues today to import fertilisers from Russia, directly contributing to fund the war of aggression against Ukraine. Phosphate recycling from sewage could replace imports of Russian phosphates. ESPP underlines that several full-scale P-recovery plants are already operational in Germany or under construction and will be operational by the 2029 deadline (e.g. AshDec R-Rhenania, Altenstadt, operational, 50 000 t/y dried sewage sludge ESPP eNews n°102 ; EasyMining Ash2Phos, Schkopau,, under construction, 30 000 t/y SSIA by 2027 ESPP eNews n°100 - and others) and that postponing deadlines will result in postponement of investment decisions and of roll-out or full-scale operation implementation of other technologies. ESPP notes that recovered phosphorus products already today have a market when of appropriate quality, either for use as fertiliser (struvite and phosphorus from thermal oxidation processes are already authorised as EU-fertilisers: FPR CMCs 12 and 13) or in industry. ESPP supports DWA's call to ensure legal clarification that full costs of P-recycling can be recouped by operators in water fees.

DWA letter to the German Federal Ministry, 19th December 2025, public documents register SG2601200011,"Zu Regelungsvorhaben:Rahmenbedingungen Phosphorrückgewinnungskapazitäten bis 2029 gem. Verpflichtungen der Klärschlamm" https://www.lobbyregister.bundestag.de/inhalte-der-interessenvertretung/stellungnahmengutachtensuche/SG2601200011

DPP (German Phosphorus Platform) position, 20th January 2026, "No deadline extension – create a transitional solution": https://www.deutsche-phosphor-plattform.de/dpp-fordert-umsetzung-der-phosphorrueckgewinnungspflicht-ab-2029-keine-fristverschiebung/

Nutrient stewardship

Phosphorus needs of Organic Farming in Europe

Data analysis suggests that Certified Organic Farming offtakes an average 5.6 kgP/ha in crops, less than half that in crops on conventional farms. Around 2.1 kgP/ha is input to Organic Farming from mineral fertiliser (ground phosphate rock is authorised for use in Organic Farming in some countries, but crop availability of P is low, except in acidic soils*). The analysis uses FADN (Farm Accountancy Data Network) data analysed by NUTS2 regions. Organic Farming crop P offtake varies considerably between NUTS2 regions (from near zero to >35 kgP/ha). This analysis does not take into account P losses (soil erosion, runoff) nor offtake in crop residues but considers that 90% of P offtake in Organic Farming is in crops, as soil P losses are low and residues are generally recycled. The analysis concludes that around 20% of P offtake in crops is in fodder crops, whereas this P is probably being fed to Organic Livestock, and then recycled back to Organic Farming in manure. Organic Farms use a range of other P inputs (in addition to phosphate rock), including e.g. manure from non-Organic farming (manure from "factory farming" cannot be used), composts from food wastes. Previous studies indicate that EU Organic Farming often has a P deficit or to avoid this uses a range of external P inputs such as composted municipal solid waste, municipal biogas digestate, commercial fertilisers derived from organic wastes, non-Organic livestock manures (see Reiner et al. 2023, Barbieri et al. 2021, in **SCOPE Newsletter n°149**).

** This paper wrongly states "phosphate rock efficiency is limited to soils with pH > 6" referring to a reference to Cooper 2018 (the link given is incorrect: DOI link is https://doi.org/10.1007/s10705-017-9894-2). As is well known, P availability decreases with increasing pH, and the Cooper paper cited states "Phosphate rocks can be very inefficient P sources in soils with a pH > 6.0". ESPP also notes bad practice in that this Cooper paper is a secondary reference – Cooper 2018 provides no data and simply refers to original data in Fardeau 1998.*

"Phosphorus removal and use in organic crop farming in the EU", S. Magaya et al., Nutr Cycl Agroecosyst (2025) 130:91–110 https://doi.org/10.1007/s10705-024-10379-0

STOWA report on TTBS Rubiphos trials

Report of 12.5 kg/h ash input testing of the TTBS Rubiphos process to recovery phosphorus by sulphuric acid leaching of sewage sludge incineration ash by sulphuric acid followed by membrane and nanofilter purification. The 65-page report is published by STOWA, the Netherlands water industry joint research organisation. The test unit at HVC's site in Dordrecht, The Netherlands, was operated during working hours for several days with the membrane units operating continuously, for several runs on 2024, treating a total of around 2 tonnes of input ash. Up to 97% of the phosphorus was extracted from the ash to the phosphoric acid by leaching with 96% concentrated sulphuric acid. The resulting phosphoric acid purified using nanofiltration and Diffusion Dialysis membranes, resulting in a dilute purified acid (2-3 % P_2O_5) and a waste acid stream. Production of phosphate fertiliser from the purified acid was model simulated not tested, as this is well-known, market-available technology. Treatment of this waste acid stream, which contains most of the heavy metals from the ash, is not addressed in this report. Because of water input to the process, 1 tonne of ash generates around 2 tonnes of leached ash filter cake ("Rubicas") with dry weight 0.7 – 0.8 tonnes. Around 60% of iron from the ash remains in this cake and around 35% of aluminium, the remainder going to the output (purified phosphoric acid or phosphate fertiliser). Around 50% of zinc and less that 10% of copper from the ash end up in the purified phosphoric acid / phosphate fertiliser. Lead levels in the "Rubicas" cake were too high for its use as fertiliser. The report also summarises other technologies currently available for P-recovery from ashes: EasyMining, Remondis, Susphos, Spodophos, ICL.

"Pilotonderzoek fosfaatterugwinning uit as van zuiveringsslib met het Rubiphos process" (pilot research phosphate recovery sewage sludge incineration ash by the Rubiphos process), STOWA report n° 2025-30, 19th November 2025, 65 pages, in Dutch (without English summary)
https://www.stowa.nl/publicaties/pilotonderzoek-fosfaatterugwinning-uit-van-zuiveringsslib-met-het-rubiphos-proces

Planetary boundaries

What Planetary Boundaries indicators for nutrients ?

Update paper on 'Planetary Boundaries' suggests increasing ecological overshoot for P and N. But this is based only on fertiliser use, not environmental risks, contradicting messages on food security. In their 2025 analysis, Fanning & Raworth present the "Doughnut" concept, combining 35 ecological indicators of planetary overshoot with indicators of social deprivation. Their results point to improvements in some human welfare indicators, such as a decline in global undernourishment from 13% in 2000 to 10% in 2021, but a simultaneous increase in food insecurity, from 23% to 29% of the world population. Nearly all ecological indicators show deterioration over the past two decades, including nutrient pollution. For phosphorus and nitrogen, the paper indicates that between 2000 and 2022, phosphorus overshoot rose from +123% to +273% (over 2x planetary capacity), while nitrogen overshoot rose from +116% to +273% (nearly 3x planetary capacity). These values are based on planetary boundaries of 6.2 MtP/y and 62 MtN/y (Richardson, Rockström et al., 2023, see below). The overshoot calculation, however, is based solely on fertiliser applied to land. For phosphorus, the 23 MtP/y used in the calculation corresponds roughly to total global phosphate rock extraction (the 23 MtP/y indicated as phosphorus fertiliser application to land for 2022 is approximately the total P extracted from phosphate rock, see ESPP Phosphorus Fact Sheet).
This reliance on fertiliser tonnage leads to two main issues:

- Firstly, it produces contradictory messages concerning food security. In regions such as Africa, current fertiliser use is far below agronomic needs, contributing to depleted soils, low crop productivity, declining soil carbon and persistent rural poverty (see e.g. Lomé Declaration on Fertilizers and Soil Health in West Africa and the Sahel, African Union, 2023).
- Secondly, it conflicts with scientific analyses indicating that the primary environmental limit for phosphorus is loss to freshwater and marine environments, not fertiliser use or phosphate rock mining. Eutrophication results from phosphorus losses linked to soil erosion and management practices, not from total quantities applied. This perspective is consistent with the UN Biodiversity Convention and the EU Green Deal goal to reduce nutrient losses by 50% (ESPP eNews n°74).

These are not new questions, and discussion on how to define planetary boundaries for phosphorus and nitrogen is ongoing since Rockström et al. 2019 first launched the concept. **We summarise below how the definition and estimation of planetary boundaries for P and N have evolved over time and questions outstanding today.**

Evolution of how planetary boundaries for phosphorus are defined

The definition of planetary boundaries for nutrients has changed considerably since the concept was introduced. Rockström et al. 2009 initially proposed a phosphorus boundary based on avoiding large-scale anoxia in the oceans, setting the limit at 11 MtP/y, calculated as 10x estimated natural background P-release from soil weathering, indicating that P emissions were still 15-25% below this boundary at the time. Concerns were also raised about the long-term loss of non-renewable phosphate rock. This 2009 paper also proposed a boundary of 35 MtN/y human-induced nitrogen fixation. Schlesinger 2009 criticised this figure as too generous and suggested that boundaries should be defined according to the need to prevent eutrophication in coastal waters.

Carpenter & Bennett 2011 reframed the boundary in terms of eutrophication risks in freshwater and marine systems. They noted that although freshwater eutrophication is a local problem, with locally specific causes and effects, it is widespread globally. Their proposal focused on phosphorus applied to erodible agricultural soils and identified 6.2 MtP/y as the global limit

compatible with avoiding widespread eutrophication. They estimated that global P flows to oceans are three times higher than pre-industrial flows (from Carpenter 2001) and underlined "contrast between large amounts of P needed for food production and the high sensitivity of freshwaters to pollution by P runoff". This is based on Bennet et al. 2001 which explained that phosphorus losses and so eutrophication risks are mainly related to particulate P losses linked to soil erosion, and so increase with phosphorus accumulation in agricultural soils and with land management and agricultural practices which accentuate eutrophication. On these premises, they proposed a planetary boundary of 6.2 MtP/y of phosphorus added to erodible agricultural soils (*suggesting that this means fertilised arable cropland soils prone to P-losses to freshwaters, so presumably not including permanent pastures or managed forests: NOTE: Sattari, Bouwman et al. 2016 estimate global fertiliser use on grasslands as significantly < 1 MtP/*y). They concluded that P flows to freshwaters exceed planetary boundaries by 3 – 20 x (with target freshwater P concentrations of 160 -24 µgP/l) and exceed the boundary for flows to oceans by around +50%.

Subsequent studies reinforced this assessment. Kahiluoto et al. 2014 (see SCOPE Newsletter n°103) concluded that global phosphorus use exceeds sustainable levels by roughly eightfold, while nitrogen use exceeds limits by around twofold. Steffen et al. 2015 (DOI) also adopted the 6.2 MtP/y threshold, to also avoid widespread freshwater eutrophication resulting from mineral P fertiliser application to erodible soils. They discuss regional differences in P application and eutrophication consequences, stating that "addition of P to regional watersheds is almost entirely from fertilizers" (*ESPP comment: this is arguably incorrect, in that many high P-loss regions are manure hotspots*) and suggest that a redistribution of P from intensive P-use regions to regions with low soil P could both increase global food production and reduce ecological boundary transgression.
Richardson, Rockström et al. 2023 maintained this boundary in their update, estimating that global flows of phosphorus from rivers to the oceans amount to 22 MtP/y (*ESPP note: this number is nearly the same as the estimate of total mined P used in Fanning & Raworth 2025 above*), compared to a boundary of 11 MtP/y, and that phosphorus applied to cropland exceeds the sustainable limit by almost 200%.

Li et al. 2019 propose a different approach termed "**Phosphorus Exceedance Footprint**" (PEF), which incorporates trade flows by calculating exceedance above a sustainable application rate (4.1–7.5 kg P/ha/y) and allocating part of the impact to imported or exported products. Their results suggest that all countries exceed sustainable phosphorus use levels and that around 30% of global exceedance is embodied in traded goods from New Zealand, China and Brazil.

The planetary boundaries for P and N are further discussed, with **graphs showing development of planetary overshoot over the last hundred years**, in Sandström, Kahiluoto et al. 2023.

Nitrogen boundaries have followed a similar trajectory. Rockström et al. (2009) originally proposed a boundary of 35 MtN/y, estimated as 25% of calculated total anthropogenic N fixation at the time. De Vries et al. 2013 revised this upward to 62 MtN/y, a value considered to avoid major environmental risks. This number is maintained in the 2023 update, which concludes that nitrogen fixation now exceeds the boundary more than threefold.

Peñuelas & Sardans et al. 2022 showed the need to address the increasing global imbalance in the nitrogen to phosphorus (N:P) ratio driven by anthropogenic activities because of its implications for ecosystem health, food security, and social equity. They suggest that the N:P balance warrants inclusion as a distinct planetary boundary.

Outstanding questions

ESPP notes that the question of how to define planetary boundaries for nutrients remains unresolved. The main challenge is that phosphorus impacts are highly local and depend strongly on soil conditions, land use and hydrology. Phosphorus inputs on depleted soils may pose almost no environmental risk and are essential for maintaining soil fertility, whereas the same level of application in a phosphorus-saturated watershed may cause significant eutrophication. Scientific publications repeatedly point to the need for multi-indicator approaches that consider freshwater and marine impacts, soil erosion, agricultural management and regional nutrient balances.

Also, impacts of changes in diet (higher animal protein consumption) are often flagged. But this does not generally impact the planetary boundary calculation model, because P in manure is taken to be recycled back to soil, in an agricultural internal loop without changing the quantitative flow from phosphate mine to oceans. The P in livestock manure originally came (nearly all) from mined P-rock. However, higher livestock numbers may increase the rate of loss of P from agriculture to surface waters, for example if intensive fodder crop production replaces uncultivated land or extensive pasture. This may or may not be accentuated if livestock are regionally concentrated (manure hotspots) but only if this leads to increased overall P losses to surface water, that is overall net loss from the system leading to increased demand for phosphate rock mine extraction.

Different methods for calculating "phosphorus use" further complicate matters, whether based on mineral P fertiliser use, phosphate rock extraction or more detailed assessments of fertiliser applied to erodible soils – but in fact this makes little difference, as non-fertiliser uses of phosphate rock and fertiliser application to 'non-erodible' soils (permanent pastures, forests …) probably represent only 20% of global P use, so not significant compared to overall 'planetary boundary' estimates. Despite these differences, the global threshold of 6.2 MtP/y has remained largely unchallenged since 2011.

Some proposals could however be made:

- **Exclude from the 'use' calculation fertiliser application in regions where P-fertiliser application is inadequate**. In that such regions use low quantities of P-fertiliser, this might not significantly modify outcomes, but it would clearly show that planetary boundary objectives are not contradictory to food security,

- **Add a 'multiplying factor' to reflect unsustainable concentrations of P in regional nutrient hotspots, combining high P use (often via livestock) and eutrophication.** This could contribute to taking into account impacts of changing diet / increased livestock numbers, see above.
- **Develop regional nutrient "boundaries", as a tool to identify overall policy distance from environmental objectives (including the UNEP -50% nutrient loss reduction target).** Such regional boundaries can contribute to phosphorus management, awareness and governance and enable identification of import dependency. For example, Liu et al. 2024 defined differentiated thresholds for the safe and just regional phosphorus boundaries for China's river basins considering Chinese water quality standards and P fertilizer use.
- **Interactions between different planetary boundary factors**. Analysis in Lade et al. 2019 showed that interactions between factors tends to further shrink the estimated safe operating space, compared to analysis of each factor separately, because of cascade and feedback. We would suggest that in particular interactions between phosphorus and nitrogen and with climate change should be considered (see SCOPE Newsletter n°137 – science summary of phosphorus – climate change interactions).

Invitation for contributions

ESPP would welcome short expert perspectives or comments on how planetary boundaries for nutrients should be interpreted or improved. Please send, by end of March 2026, text of up to 200 words, including references, for possible publication in a future ESPP eNews (115 000 email circulation worldwide) to info@phosphorusplatform.eu.

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