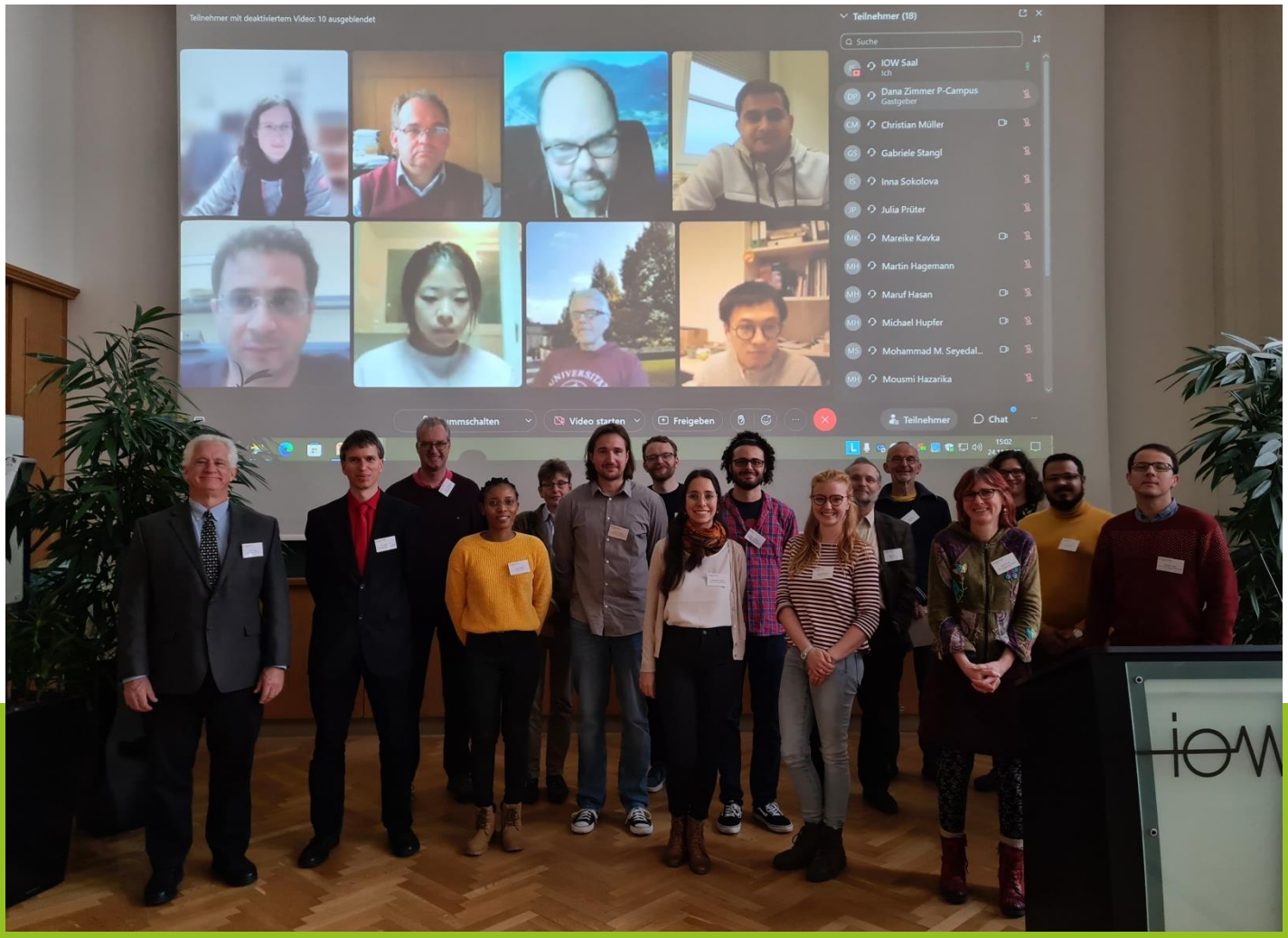
LEIBNIZ SCIENCE CAMPUS
PHOSPHORUS RESEARCH
ROSTOCK




# Activity Report 2022


Katalysis LIKAT Leibniz-Institut für Katalyse e.V.
INP FROM IDEA TO PROTOTYPE
Leibniz Institute for Baltic Sea Research Warnemünde IOW
IPK LEIBNIZ INSTITUTE
FBN RESEARCH INSTITUTE FOR FARM ANIMAL BIOLOGY
Universität Rostock Traditio et Innovatio

## Content

# 1 Development of the Leibniz ScienceCampus Phosphorus Research Rostock (Introduction)

The Leibniz ScienceCampus Phosphorus Research Rostock (P-Campus) is linking the phosphorus research of currently (December 2022) 93 scientists from six research institutes in different disciplines working in 22 third-party funded projects (including PGS2). It focuses on three main areas in the support of phosphorus research by its members: strengthening of **networking**, **internationalization** and funding of **graduate students**.

Although still limited by the Corona pandemic, events of various formats were held in 2022 by the P-Campus to promote **networking** at all levels. Internal meetings and workshops serve the intensive networking of the scientists of the P-Campus and the further thematic development. Special events for the PhD students in the P-Campus within the framework of the **P-Campus Graduate School** (PGS), such as the P Breakfast, specific workshops and the lecture series, serve in particular to promote networking and professional exchange among PhD students. Further details can be found in chapter 3.3 P-Campus Graduate School.

Due to the visibility of the P-Campus research, the Coordination Office was contacted in 2020 and 2021 by a scientist from the **ZALF** (Leibniz Centre for Agricultural Landscape Research, www.zalf.de/en/) and a scientist from the **Roman-Germanic Commission** of the German Archaeological Institute (www.dainst.org/en/). It was possible in both cases to successfully establish contact with several scientists in the P-Campus. Further details can be found in chapter 4 Networking.

The **Leibniz Innovation Farm for Sustainable Bioeconomy**, initiated by ATB (Leibniz Institute for Agricultural Engineering and Bioeconomy, www.atb-potsdam.de/en/), started in 2021 (www.atb-potsdam.de/en/news-and-press/). Members of the P-Campus (from UR, IOW, FBN) are involved in the project proposal development workshops that have been ongoing since 2021.

As an event for **internationalization** for all members of the P-Campus (and external interested parties), the **International P-Campus Symposium** with participation of the International Advisory Council of the P-Campus can be highlighted. The symposium was held as a hybrid event on November 24-25, 2022 with a total of 40 participants.

Furthermore, the P-Campus is an active member of the **German Phosphorus Platform** (DPP) and the **European Sustainable Phosphorus Platform** (ESPP). Further networking activities are e.g. the integration of further PhD students of partner institutes with topics in the field of phosphorus research from various sources of funding. In addition, members of the P-Campus are internationally active throughout the year. The P-Campus contributes to the financial support of young scientists in their **international activities** and co-finances the participation in conferences and research stays. This allows PhD students to travel and present their findings in this way. This was also only possible to a limited extent in 2022.

In spring 2021, the **18th European Workshop on Phosphorus Chemistry (EWPC-18)** should take place in Rostock. Unfortunately, the on-site conference had to be cancelled; a very well-attended online conference was held instead. EWPC-18 was held as a face-to-face event from 14 to 16 September 2022 (https://www.ewpc18.uni-rostock.de/). Further details can be found in chapter 5 Events.

The **Graduate School Phosphorus Research** is the core of the graduate concept of the P-Campus and has the overarching goal of an excellent graduate education. Thematic training and the lively exchange of information among PhD students are supported by different events such as thematic workshops, professional training and informal meetings. The start workshop "P analytics" for the new PhD students of the P-Campus at the Biological Station Zingst in November (CW 48) 2019 was organized and co-supervised by the P-Campus coordinator. Due to Corona restrictions, no workshops could be organized in 2020 and 2021, and a workshop was only possible again in 2022. From September 6 to 9, the summer school "Scientific Writing and Successful Publishing" could be held as an on-site event. Moreover, a lecture series was again organized in 2022 (Table 6).

By March 2021, six PhD theses from PGS1 had been successfully defended. In summer 2021, the first PhD student of PGS2 successfully defended her PhD thesis. In September 2022, the second PhD thesis from PGS2 was submitted (defended on 23.01.2023) and in October 2022, the seventh PhD thesis from PGS1 was successfully defended.

In 2022, 22 **third-party funded projects**, which can be thematically assigned to the P-Campus, were running (Table 1).

To continue the successful concept of the **seed projects**, the first six seed projects have been granted as of June 2019. Due to Corona restrictions, two projects (P-CAT and Pro-Cycle) had to be extended in a cost-neutral manner. They were successfully completed until the end of 2021. Thus, all project reports can now be made available since 2022. In 2022, two calls for seed projects with regard to the continuation of the P-Campus after 2023 were initiated by the P-Campus. A total of eleven seed projects were approved following both calls for proposals.

In 2022, three publications received the **P-Campus Publication Award** (see chapter 3.4 Publications).

The **public relations work** of the P-Campus included, besides text writing, publishing and presentations, also the maintenance of the website. The "Long Night of the Sciences" took place in 2022 with restrictions, however, it was not possible for the P-Campus to participate.

The P-Campus will run until 30 November 2023, including a cost-neutral extension. **Continued funding of the P-Campus after 2023** is currently being worked out under the organization of the coordination office. Two funding lines are being pursued, on the one hand the organization of a Leibniz Research Alliance and on the other hand a DFG Research Training Group.

Leibniz Research Alliances are alliances between thematically focused, nationwide collaborating Leibniz institutes and universities in which joint doctorates are sought. Funding is provided for a maximum of three times four years; in addition to the Leibniz Association's funding, the participating institutes must also contribute their own funds. **The Leibniz Research Network "P Health – Phosphorus in Agriculture, Environment and Nutrition: Ecological Consequences and Societal Challenges"** (working title) is to consist of four main research areas (I. P in Agriculture and Nutrition, II. P in the Environment, III. P Recycling, IV. P-Resources, P-Governance) and a cross-sectional topic (Transfer and Education).

A DFG Research Training Group is designed to promote young researchers and, in addition to a research program at a high scientific level, also includes a study program with

innovative teaching and supervision elements. The maximum funding period is two times four and a half years. The envisaged **DFG Research Training Group "PhAMoS - Phosphorus Acquisition, Metabolism and Signaling in aquatic and terrestrial organisms"** has been heavily revised and now contains two overarching themes ("T1 Interactions between organisms/cells and the environment: regulatory mechanisms of P uptake, storage and release" and "T2 Role of biological P forms in the coordination of signaling pathways and metabolic cycles in the cell"). Six subprojects can be assigned to topic T1, three subprojects to topic T2, and another three subprojects can be assigned to both topics.

Both funding lines are developed with delimited but complementary research questions, so that collaborations between the projects and researchers (mainly PhD students) are possible. In addition to funding research and graduate training in the P-Campus, both funding lines also maintain the interdisciplinary networking of the P-Campus members and at the same time extend the network to other (Leibniz) institutes and thus also new partners.

# 2 Goals and Concept

The overarching goal of interdisciplinary cooperation at the Leibniz ScienceCampus Phosphorus Research Rostock is, through a thematically oriented integrated network, to explore options for the more sustainable management of phosphorus. Further focuses of the P-Campus, in addition to the sufficient and efficient use and recycling and recovery of phosphorus, are phosphorus cycles and fluxes in the environment and the environmental problems, in particular in aquatic systems, caused by inefficient phosphorus use or a lack of phosphorus recycling. Research is also conducted on the catalysis and synthesis of phosphorus-containing organocatalysts in chemical processes and medicine.

Expertise in various aspects of research into the essential and irreplaceable element phosphorus, diverse phosphorus-containing chemical compounds, and specific modes of action of phosphorus in agricultural and environmental systems as well as in technical and industrial processes are brought together at the P-Campus. In addition to fundamental and applied research, the aim is to contribute to economic development through the simultaneous development and transfer of technologies. Moreover, cooperation and research are intensified, and strong national and international networks are being established.

**The following institutes are partners of the P-Campus:**

- Leibniz Institute for Catalysis (LIKAT) at the University of Rostock
- Leibniz Institute for Baltic Sea Research (IOW), Warnemünde
- Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Satellite Collections North, Groß Lüsewitz
- Leibniz Institute for Plasma Science and Technology (INP), Greifswald
- Research Institute for Farm Animal Biology (FBN), Dummerstorf
- University of Rostock (Faculty of Agricultural and Environmental Sciences, Interdisciplinary Faculty, Faculty of Law, Faculty of Mathematics and Natural Sciences, Rostock University Medical Centre)

# 3 Research

## 3.1 Research Foci

The research foci of the P-Campus are:

- Cluster I: P in the Environment
- Cluster II: Sufficiency and Efficiency of P Utilization, P Recycling
- Cluster III: P in Synthesis and Catalysis
- Cluster IV: Molecular Biology of P
- Cluster V (cross-topic): P Governance

Table 2a (for PGS 1) and 2b (for PGS 2) list the exact research topics in each research cluster. It should be noted that in the following listings, some publications may be assigned to more than one research cluster.

### 3.1.1 Cluster I: P in the Environment

Phosphorus ends up in the environment through open-ended industrial cycles and along river flows, reaching the sea. The aim is a better understanding of P fluxes and cycles in the environment in order, on the one hand, to analyze the effects of high P inputs and, on the other, to enable discussion of protection and/or rehabilitation measures. This starts at the "sources", for example with the application of fertilizer on agricultural land and the effects of artificial drainage (drain systems), but also at the river outlets of small and large wastewater treatment plants. And it continues through phosphorus fluxes in different ecosystems, from special soil crusts to coastal waters and into the large Baltic Sea basin. Methodological approaches in Cluster I include measurements on the smallest scale up to the Baltic Sea ecosystem modellings over a wide range of scales and instrumentation. Within the graduate school, research is being conducted on coastal wetland rewetting, P pools and their mobilization in coastal soils and sediments, and glyphosate and its degradation products in seawater. In “Cluster I: P in the environment”, six publications (including one dissertation) were published. For 2022, the following publication can be highlighted in particular, as it was developed by a PhD student of the P-Campus as part of her dissertation and deals with the influence of sample preparation on the analytical results.

Prüter, J., Hu, Y., Leinweber, P. (2022) Influence of sample pretreatment on P speciation in sediments evaluated with sequential fractionation and P K-edge XANES spectroscopy. Communications in Soil Science and Plant Analysis 53, 1712-1730, DOI: 10.1080/00103624.2022.2063317

### 3.1.2 Cluster II: Sufficiency and Efficiency of P Utilization, P Recycling

The goal is to formulate a scientific basis with which to derive the necessary legal framework and policy recommendations for the sustainable management of regional and global closed P-fluxes in accordance with the principles of sufficiency and efficiency (see also Cluster V. P-Governance). Sufficiency means to limit the application rates of P for the production of plant and animal foods to the level actually required. This requires critical evaluations of existing P-fertilization and feed recommendations with the aim of reducing P-use in agriculture. The following research topics are elaborated in the second funding period within the framework of PhD projects in PGS 2: P recycling in animal husbandry, efficiency of recovered phosphorus for monogastric animals and P efficiency of forage legumes. The economic efficiency of the processes will also be investigated. Research in

Cluster II thus covers all sub-areas of the agricultural P cycle (soil, plant, animal, water, process engineering, ...).

In 2022, 13 publications were published in "Cluster II: Sufficiency and Efficiency of P Utilization, P Recycling". Two publications were selected for the P-Campus Publication Award 2022. Both publications were published by PhD students of the P-Campus:

Hu, Y., Jarisch, K.A., Kavka, M., Eichler-Löbermann, B. (2022) Fate of P from organic and inorganic fertilizers assessed by complementary approaches. Nutr Cycl Agroecosyst 124, 189–209, DOI: 10.1007/s10705-022-10237-x

Seyedalmoosavi, M. M., Mielenz, M., Görs, S., Wolf, P., Daş, G., & Metges, C. C. (2022) Effects of increasing levels of whole Black Soldier Fly (Hermetia illucens) larvae in broiler rations on acceptance, nutrient and energy intakes and utilization, and growth performance of broilers. Poultry Science 101, 12, DOI: 10.1016/j.psj.2022.102202

### 3.1.3 Cluster III: P in Synthesis and Catalysis

Cluster III is concerned with research into fundamental questions relating to the structure and reactivity of phosphorus-containing compounds. Due to the extraordinary variability of phosphorus with respect to its oxidation states (-3 to +5) and coordination numbers, phosphorus-containing compounds of various structures and properties are known.

They are used in almost all areas of chemistry. In organometallic and coordination chemistry, phosphorus-containing compounds play a central role as ligands, for example in transition metal complexes. Both in research and in industry, many of these complexes find application in catalysis. These complexes give access to numerous products and enable reactions in the first place. In terms of sustainable chemistry, these catalysts make a major contribution to the development of energy and resource-efficient processes.

Phosphorus-containing compounds also play a central role as organocatalysts and, above all, as reagents in organic synthesis. Without them, the production of natural substances and new pharmacological agents, e.g. in medicinal chemistry, would often not be possible. Even today, we encounter products containing the element phosphorus in many areas of daily life, such as plant protection agents, flame retardants and light-emitting diodes.

In PGS 2, issues related to the synthesis of P-based ligands, the application of P-based organocatalysts, the synthesis of antitumor compounds and P-based methods for the activation of N-H bonds are addressed.

Twelve publications were published in "Cluster III: P in Synthesis and Catalysis". At this point, the following publication can be highlighted:

Dankert, F., Siewert, J.-E., Gupta, P., Weigend, F., Hering-Junghans, C. (2022) Metal-free N-H Bond Activation by Phospha-Wittig Reagents. Angew. Chem. Int. Ed. 2022, 61, 32, DOI: 10.1002/anie.202207064

In this publication, Mr Hering-Junghans' group reported on the metal-free activation of N-H bonds using phospha-Wittig reagents. These represent masked phosphinidene in which the P atom is in the +1 oxidation state. The phosphinide-like reactivity towards $NH_3$ and other amines could be shown for the first time and a variety of secondary aminophosphanes could be synthesised. This work paves the way for the use of phospha-Wittig reagents only for selective NH and OH bond activation and thus for the preparation of P-chiral phosphines.

### 3.1.4 Cluster IV: Molecular Biology of P

The overarching goal is to unravel the central role of P as a metabolic, signaling and regulatory molecule from molecular to ecosystem levels. In fact, P acquisition, mobilization and assimilation involve various molecular mechanisms in microorganisms, plants and animals. Moreover, P plays a key role in signaling at the level of ecosystems, organisms and cells. Projects in this cluster aim to analyze the molecular mechanisms related to the uptake of P from the environment into the organism, the distribution, storage and mobilization of P within the organisms and its essential roles in the cellular metabolism as well as in the crosstalk of microorganisms, cells and tissues. The PhD students of PGS 2 are working on the following topics: Gene expression in biological soil crusts, candidate genes for P production in potatoes, phosphate availability and the development of cyanobacterial blooms in the Baltic Sea, P during environmental stress in mollusks like mussels, and molecular mechanisms of P homoeostasis in birds (domestic chicken) and mammals (domestic pig). Ten publications could be assigned to "Cluster IV: Molecular Biology of P". One of the publications in Cluster IV was selected for the P-Campus Publication Award 2022:

Hasan, M., Oster, M., Reyer, H., Ponsuksili, S., Murani, E., Wolf, P., Fischer, D.-C., Wimmers, K. (2022) Tissue-Wide Expression of Genes Related to Vitamin D Metabolism and FGF23 Signaling following Variable Phosphorus Intake in Pigs. Metabolites 12, 729, DOI: 10.3390/metabo12080729

### 3.1.5 Cluster V (cross-topic): P Governance

Cluster V of the P-Campus aims at possible policy instruments to strengthen P-recycling (consistency), efficiency and sufficiency in the use of P-fertilizers and deals with their implementation in society and agricultural practice through effective legal frameworks. The aim of the subproject is to deepen the analysis and further development of agricultural, fertilizer, water, soil protection, waste and recycling legislation and to develop concrete governance options for closed P cycles at different legal levels. Natural scientific findings generated within the framework of the P-Campus will be included as well as current political and legal developments. A current priority is the monitoring and further development of the EU Common Agricultural Policy for the 2021-2027 funding phase. This topic (Governance options for closed P cycles - the CAP 2020 revision) is addressed in the context of PGS 2. In Cluster V, nine publications were published in 2022. In particular, the article published in the journal Natur und Recht

Heyl, K., Ekardt, F., Roos, P., Garkse, B. (2022) Digitalisierte Präzisionsdüngung und EU-Agrarsubventionen im deutschen Recht: Ökologisch effektive Umsetzung von Farm-to-Fork-Strategie und Umweltvölkerrecht? Natur und Recht 44, 837–846, DOI: 10.1007/s10357-022-4114-5

can be hightlighted. The article deals with digitalisation (in agriculture) and how it is promoted alongside sustainable farming practices through the national implementation of the CAP in Germany.

## 3.2 Research Projects

Within the research clusters, 22 disciplinary and interdisciplinary, third-party funded projects (including PGS 2) were thematically assigned to the P-Campus in 2022 (Table 1). Four of these projects started newly in 2022 and nine projects ended in 2022.

**Table 1.** Third-party funded research projects thematically assigned to the P-Campus (status as of December 2022; *in italics: phosphorus not a subject of the total project or members of the P-Campus only active in parts of the project*)

| Project Name | Term | Sponsor | Participating Partners of the P-Campus | Cluster |
|---|---|---|---|---|
| *AC/DC-weeds: Applying and combining disturbance and competition for an agro-ecological management of creeping perennial weeds* | *04/2019-03/2022* | *DFG* | *University of Rostock (AUF)* | *I* |
| *Baclofen: Entwicklung effizienter Produktionsverfahren für die Darstellung von Baclofen und hiermit verwandter pharmazeutischer Produkte* | *10/2020-09/2023* | *BMWi, AIF* | *University of Rostock (MNF)* | *IV* |
| *Baltic Transcoast* | *01/2016-12/2024* | *DFG* | *University of Rostock (AUF, MNF), IOW* | *I* |
| Crustfunction III – Landnutzung als Treiber der Struktur und Funktionalität biologischer Bodenkrusten | 08/2020-12/2023 | DFG | University of Rostock (AUF, MNF) | I |
| DiveCropS: Diversifying cropping systems - Traditional knowledge and innovative approaches | 01/2019-12/2022 | DAAD | University of Rostock | II |
| Graduate School II: Leibniz ScienceCampus Phosphorus Research Rostock | 07/2019-11/2023 | WGL | FBN, IOW, INP, IPK, LIKAT, University of Rostock | I, II, III, IV, V |
| InFertRes: Innovative Fertilizers and Resource Efficiency in Agriculture | 03/2018–04/2024 | BMBF | University of Rostock (AUF) | II |
| InnoSoilPhos III: Innovative solutions to sustainable soil phosphorus management | 05/2021 – 04/2024 | BMBF | University of Rostock (AUF) | I, II, Q |
| *Innovationsraum: BaMS-RüBio - Blaue Bioökonomische Kreislaufwirtschaft für Rügen (Teilprojekt 3) - Umsetzungsphase. "Welsaquaponik am Standort Bergen auf Rügen"* | *01/2022-12/2024* | *BMBF* | *University of Rostock (AUF), FBN* | *II* |
| *Kombination von Biokatalyse und Kristallisation für die Synthese chiraler Amine* | *04/2019-03/2022* | *BMWi* | *University of Rostock (MNF)* | *III* |
| MikroMais: Verbundvorhaben: Reduzierung des Grundwasser-relevanten Stickstoff- und Phosphor-Überschusses durch kombinierte Mikrogranulat-Mikroorganismen- Ausbringung auf Gärrest-gedüngten Flächen im Energiemaisanbau; Teilvorhaben 2: Nährstoffverfügbarkeit und Nährstoffverlagerung im Boden | 04/2021-03/2024 | BMEL | University of Rostock (AUF) | II |
| *MitoBOX: The mitochondrial basis of hypoxia tolerance in marine mollusks* | *02/2019-03/2022* | *DFG* | *University of Rostock (MNF)* | *IV* |
| P-FOWL: Characterization of mineral utilisation by functional genomics in two contrasting high-yielding laying hen strains | 09/2022-08/2025 | DFG | FBN | IV |

| Project Name | Term | Sponsor | Participating Partners of the P-Campus | Cluster |
|---|---|---|---|---|
| P-FOWL: Data integration to derive biological networks of host gut expression and microbiota variation related to inositol phosphates, myo-inositol and P utilization in laying hens and quails, Teilprojekt in FOR 2601 | 10/2018 – 05/2022 | DFG | FBN | IV |
| P-FOWL: Epigenetics, molecular pathways, and data integration to derive biological networks related to myo-inositol and P utilization in two contrasting high-yielding laying hen strains | 10/2022-09/2025 | DFG | FBN | IV |
| P-FOWL: Characterizing endocrine and transcriptional determinants of P utilization mediated by the environment-host-microbiota interaction in laying hens and quails, sub-project in FOR 2601 | 06/2018 – 11/2021 | DFG | FBN | IV |
| PNC-Processing: Stoffkreisoptimierung durch Fraktionierung von Gülle in Phosphor, Stickstoff und organischen Kohlenstoff | 07/2019-06/2022 | BMBF | University of Rostock (AUF) | II |
| **PROCESSOR: Phosphorus recycling from complex scarcely soluble societal resources – letting the soil do the work* | *2021-2024* | | *University of Rostock (AUF)* | *II* |
| Verbundvorhaben: Züchterische Verbesserung der Phosphor-Aneignungseffizienz von Stärkekartoffeln und eine ressourcenschonende Rohstoffproduktion; Teilvorhaben 1 | 03/2019-12/2022 | BMEL | IPK | II |
| Verbundvorhaben: Züchterische Verbesserung der Phosphor-Aneignungseffizienz von Stärkekartoffeln und eine ressourcenschonende Rohstoffproduktion; Teilvorhaben 2 | 03/2019-12/2022 | BMEL | University of Rostock (AUF) | II |
| Verbundvorhaben: Selektion und Züchtung nährstoffeffizienter, *Phytophthora*-resistenter Kartoffelzuchtstämmen für einen nachhaltigen ökologischen Landbau | 03/2020-10/2022 | BMEL | IPK | II |
| Verbundvorhaben: Erhöhung der Anbauwürdigkeit von Luzerne (*Medicago sativa* L.) als Futterpflanze - Neue Impulse für die Königin der Futterpflanzen | 04/2021-04/2024 | BMEL | IPK | II |
| VitD-Pig: Functional signals for vitamin D-mediated mineral utilization and related physiological determinants in pigs | 11/2022-10/2025 | DFG | FBN | IV |

* Project PROCESSOR: A project of the associated partner WG Soil Fertility (Prof. J. Magid) at the University of Copenhagen; Prof. P. Leinweber (University of Rostock, WG Soil Science) and Prof. E. Frossard (ETH Zurich, Professor of Plant Nutrition at the Institute of Agricultural Sciences, member SAC of the P-Campus) function as co-supervisors for chemical analysis, e.g. isotope, XANES and NMR analyses.

The Graduate School 1 (**PGS 1**) consisted of eleven sub-projects (Table 3a in chapter 3.3). Two projects were discontinued for personal reasons by the PhD students and the projects were finished by the supervisors. Six dissertations were successfully completed by the end of 2021. In October 2022, the seventh dissertation was successfully defended. For the remaining two projects, which were completed by the PhD students and from which results were published and presented at conferences, the submission of the dissertation is still planned. The second P-Campus Graduate School (**PGS 2**) consists of 15

sub-projects (Table 3b in Chapter 3.3), which all started by October 2020. Further details on the projects are presented in Chapter 3.3.

In order to continue the successful concept of the **seed projects**, the first six seed projects were approved in June 2019. Most of the projects were finished in 2019. The last two projects (ProCycle and P-CAT) ended in December 2020 and 2021, respectively, so all respective summary reports of the completed projects (green) are now available upon request. In May (deadline in August) and in September (deadline in October) 2022, two calls for seed projects were initiated by the coordination office of the P-Campus. The projects are to be aligned as preliminary work to the envisaged Leibniz Research Alliance "P-Health - Phosphorus in agriculture, food and environment: Ecological consequences and societal challenges" and the DFG Research Training Group "PhAMoS - Phosphorus acquisition, metabolism and signaling in aquatic and terrestrial organisms". Six projects were submitted and approved for the summer call and five for the fall call. As usual, all seed projects are designed as collaborative projects between at least two partners.

**Table 2.** Seed projects of the P-Campus 2019-2022, funded by WGL grant of the P-Campus (finished projects with final report available in green, projects starting in 2022 in orange, projects starting in 2023 without colour highlighting)

| Project | Participating Partners |
|---|---|
| Funding period 2, call for proposals 1 (2019) | |
| Phosphor - Protein - Interaktionen in der Quervernetzung (P-ChemBind) | LIKAT, UR |
| Phosphorus as a cue regulating microbial $N_2O$ production (PQ4N) | UR, IOW |
| Plasmainduzierte Abbaureaktionen in Glyphosat-haltigen Substraten (PIAG) | UR, INP |
| Die Rolle von Protisten im Phosphorkreislauf biologischer Bodenkrusten (ProCycle) | UR, IOW |
| Dietary effects on DNA methylation in porcine parathyroid glands (EpiPTG) | FBN, UR, UMR |
| Entwicklung enantioselektiver katalytischer Wittig Reaktionen basierend auf chiralen Phosphorverbindungen als Katalysatoren (P-CAT) | UR, LIKAT |
| Funding period 2, call for proposals 2 (August 2022) | |
| 2022-01 Recht und Governance der Gewässer – international, europäisch, national (Governance-Wasser) | UR/FNK, IOW |
| 2022-02 Die neuen Phosphor-Bodenfertilitätsklassen und ihre Beziehungen zu Phytodiversität und Vegetationstypen (PhosPhyDiv) | UR: LÖ, Grünland |
| 2022-03 Methodische Voruntersuchungen für die Analytik von MPn (MPn-Analytik) | IOW, UR |
| 2022-04 Plasmaunterstützte Behandlung von Biomasse und Klärschlämmen für die Phosphorrückgewinnung (PlaBiPhos) | INP, UR |
| 2022-05 Development of an ELISA for quantification of FGF23 as a marker of phosphate homeostasis in pigs (porcine FGF23, ELISA)) | FBN, UMR |
| 2022-06 Gennetzwerke des Phosphormetabolismus von Fischen und fakultativ anaeroben Invertebraten (GePFI) | FBN, UR |
| Funding period 2, call for proposals 3 (October 2022) | |
| 2022-07 Plasmaunterstützte Oxidation von Phosphonsäureabfällen für die Phosphorrückgewinnung (Plasma) | INP, UR |
| 2022-08 Erfassung der Kulturpflanzen-Wurzelarchitektur in Medium Size-Rhizotronen (MedRhizo) | INP, UR |
| 2022-09 Root exudations and root architecture in mixed crops (MixedRoots) | UR, INP |
| 2022-10 Untersuchung ausgewählter Antikörper für die immunhistochemische Analyse der Nebenschilddrüsen von Schweinen (histoNSD) | UMR, FBN |
| 2022-11 Cultivation of bone-forming cells and analysis of respective expression profiles (CULTIVATE) | FBN, UMR |

Abbreviations: FBN= Research Institute for Farm Animal Biology, FNK = Research Unit Sustainability and Climate Policy, INP = Leibniz Institute for Plasma Research and Technology, IOW = Leibniz Institute for Baltic Sea Research Warnemünde, LIKAT = Leibniz Institute for Catalysis, UMR = Rostock University Medical Center, UR = University of Rostock

## 3.3 Graduate School Phosphorus Research

The structured training concept of the P-Campus (see Figure 1) is realized by graduate studies at the Graduate School of Phosphorus Research and the involvement of other young scientists (BSc and MSc students, PhD students, and postdocs) whose thesis or project concerns phosphorus research. Special events, inclusion in the information and notification mailing lists, participation in P-Campus events, financial support for internationalisation (travel, publications and guest researchers/stays) and active participation in scientific and thematic networks (e.g. DPP, ESPP) are offered.

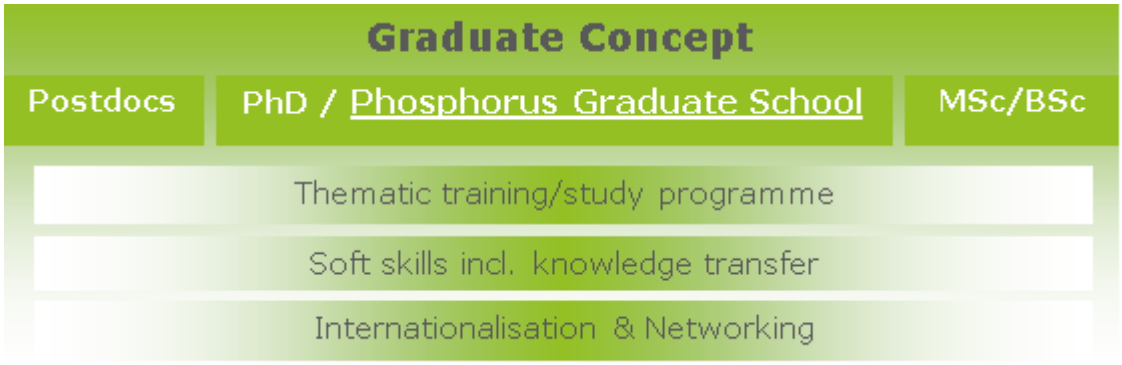



**Figure 1.** Graduate Concept of the Leibniz ScienceCampus Phosphorus Research Rostock

The Graduate School of Phosphorus Research is the core of the graduate concept of the P-Campus. Its overall objective is to provide excellent graduate education, to encourage new and innovative phosphorus research topics, and to foster networking among partners. The 11 PhD projects of the first period and the 15 PhD projects of the second period cover important areas of knowledge and research (Table 3a + 3b).

All PhD students are supervised by a committee of scientists from at least two partner organizations of the P-Campus. The students present their work at the annual P-Campus Symposium, usually held in November. Lively exchanges of information between PhD students are promoted through various events, such as workshops and the regularly held P-Breakfast (could not take place since 2020). Positive support for these activities has come from opening the events to other PhD students with thesis topics in phosphorus-related research.

On 30 August 2022, a P breakfast for the PhD students could finally be held again. This on-site event at the IOW was attended by eight PhD students, three of whom presented their scientific work. This event finally allowed the PhD students to have a relaxed, informal exchange about the challenges and problems they face in their work.

In the fourth quarter of 2019, a start workshop "P-Analytics" was successfully conducted with the first PhD students of PGS2 of the P-Campus. A second start workshop "P-Analytics" for PhD students starting in 2020 (originally planned for summer 2020, then considered for 2021) at the Biological Station Zingst could not take place so far due to the Corona restrictions. This **P analytics workshop** was then planned to take place in 2022 as part of a summer school in May 2022. Due to far too few registrations, the event

was cancelled. However, from 6 to 9 September 2022, the summer school "Scientific Writing and Successful Publishing", originally planned for autumn 2021, could finally be held as an on-site event. Nine PhD students took part in this summer school, including five P-Campus PhD students and four external PhD students from the University of Rostock.

For 2022, a **lecture series** with six lectures was also organized by the P-Campus coordination office. The lecture series also serves the interdisciplinary knowledge transfer of the PhD students. Scientists from outside the P-Campus presented their research at the lecture series. (Table 6 in chapter 5 Events).

At the **P-Campus Symposium** on November 24-25, 2022, 13 PhD students presented their work in the form of talks (10) or posters (3) (Table 5 in chapter 5).

By the end of 2021, six PhD students of the first graduate school (PGS1) had successfully completed their dissertation. The seventh dissertation ("Mechanisms of P mobilization in the rhizosphere involving weeds and crop plants") was successfully defended in October 2022. The successfully defended dissertations are listed in green font in table 3a. The submission of the remaining two dissertations of PGS1 is still planned by the PhD students (marked in orange). Thus, of the original eleven projects, only two dissertations were cancelled for personal reasons and the projects were completed by the supervisors (marked in red).

**Table 3a.** Subprojects of the Graduate School 1 (PGS 1; 2015-2019, financed by the Leibniz Association) (green: project and dissertation fully completed, orange: project completed and dissertation still planned, red: dissertation discontinued, project terminated by supervisor)

| Project | Participating Partners | Research Focus |
|---|---|---|
| Quality, quantity and transformation of P losses from diffuse sources to the Baltic Sea | IOW, UR | I |
| Phosphatases – Development of new quantitative assays along terrestrial-aquatic gradients | UR, IOW | I |
| Natural and anthropogenic organic P compounds – inositol-phosphates, phospholipids and glyphosate | IOW, UR | I, II, Q |
| Mechanisms of P mobilization in the rhizosphere involving weeds and crop plants | UR, IPK | II |
| Genetic regulation of phosphatase production and activity to increase P uptake from deficient soils | UR, IPK | II |
| Genetic and nutritional effects on the efficiency of P use of monogastric animals | FBN, UR | II |
| The P cycle and its application in land-based integrated aquaculture systems | UR, FBN | II |
| Political-legal P governance by means of certificate markets and charges | UR, IOW | II |
| Processing of alternative P sources for fertilization in agriculture | INP, UR | II, III |
| Synthesis of new heterocyclic ring systems containing P | LIKAT, UR | III |
| Large scale application of P based organocatalysts in batch and flow for the synthesis of fatty acid derived cyclic carbonates | LIKAT, UR | III |

In PGS 2, all 15 PhD projects started by November 2020. Since some PhD students did not start until third or fourth quarter 2020 (delays due to Corona restrictions), PGS 2 was cost-neutrally extended from May 2023 to November 2023. The PhD students presented their results at (international) conferences with posters or talks (see chapter 6).

The **project I.1 Risks and benefits of rewetting coastal wetlands after agricultural use (P-Risk)** had to be partly redesigned with regard to the project objectives, as the author passed away in May 2020. With 13 months remaining, Dr. Sate Ahmad conducted work on the risk of phosphorus discharge from coastal sites in accordance with the original objectives. Essentially, he has developed an estimation method to quantify phosphorus and nutrient discharge risk based on land use and groundwater levels along the coast. In addition, he has dealt with the renaturation of coastal wetland sites, looking at different ecosystems (literature study). A draft manuscript is available for each of the two areas of work (as of November 2022). Both articles are expected to be submitted over the next three months. In addition, a comprehensive final report on the project was submitted in November 2022.

The **project I.2 P Pools and mobilization potential in lowlands and coastal regions (P-Pools)** ended in September 2022 after an extension of funding by the P-Campus. In that month, the PhD student (J. Prüter) also submitted the dissertation; the defence was on 25 January 2023. J. Prüter is the first author of the following publications:

**Prüter, J.**, McLaren, T.I., Pätzig, M., Hu, Y., Leinweber, P. (2023) Phosphorus speciation along a soil to kettle hole transect: sequential P fractionation, P XANES, and $^{31}$P NMR spectroscopy. Geoderma 429, 116215 DOI: 10.1016/j.geoderma.2022.116215

**Prüter, J.**, Yongfeng Hu, Leinweber, P. (2022) Influence of sample pretreatment on P speciation in sediments evaluated with sequential fractionation and P K-edge XANES spectroscopy. Communications in Soil Science and Plant Analysis 53, 1712-1730, DOI: 10.1080/00103624.2022.2063317

**Prüter, J.**, Strauch, S.M., Wenzel, L.C., Klysubun, W., Palm, H.W., Leinweber, P. (2020) Organic matter composition and phosphorus speciation of solid waste from an African Catfish recirculating aquaculture system. Agriculture MDPI 10, 466; DOI: 10.3390/agriculture10100466 (open access)

**Prüter, J.**, Leipe, T., Michalik, D., Klysubun, W., Leinweber, P. (2019) Phosphorus speciation in sediments from the Baltic Sea, evaluated by a multi-method approach. Journal of Soils and Sediments, DOI: 10.1007/s11368-019-02518-w

The **project I.3 Analysis of glyphosate and glufosinate in sea water and as indicator compounds for industrial cropping (Glyphosate)** started in January 2020 with a PhD student (M. Wirth) who was already working with another funding since October 2017 on the topic of detection of glyphosate and similar compounds in sea water. She was able to successfully contribute her previous experience and results to the project and defended her dissertation in the summer of 2021. In 2022, further work on the development of a method for the determination of particulate glyphosate was carried out as part of a research internship. M. Wirth is first or co-author of the following publications:

**Wirth, M.A.**, Longwitz, L., Kanwischer, M., Gros, P., Leinweber, P., Werner, T. (2021) AMPA-$^{15}$N – Synthesis and application as standard compound in traceable degradation studies of glyphosate. Ecotoxicology and Environmental Safety 225, 1-8, DOI: 10.1016/j.ecoenv.2021.112768

**Wirth, M.A.**, Schulz-Bull, D.E., Kanwischer, M. (2021) The challenge of detecting the herbicide glyphosate and its metabolite AMPA in seawater - Method development and application in the Baltic Sea. Chemosphere 262 (2021) 128327, DOI: 10.1016/j.chemosphere.2020.128327

Gros, P., Meissner, R., **Wirth, M.A.**, Kanwischer, M., Rupp, H., Schulz-Bull, D.E., Leinweber, P. (2020) Leaching and degradation of 13C2-15N-glyphosate in field. Environ Monit Assess 192: 127, DOI: 10.1007/s10661-019-8045-4

Lohrer, C., Cwierz, P., **Wirth, M.A.**, Schulz-Bull, D., Kanwischer, M. (2020) Methodological aspects of methylphosphonic acid analysis: Determination in river and coastal water samples. Talanta, DOI: 10.1016/j.talanta.2020.120724

**Wirth, M.A.**, Sievers, M., Habedank, F., Kragl, U., Schulz-Bull, D.E., Kanwischer, M. (2019) Electrodialysis as a sample processing tool for bulk organic matter and target pollutant analysis of seawater. Marine Chemistry 217, DOI: 10.1016/j.marchem.2019.103719

The three publications highlighted in purple were honored with the P-Campus Publication Award.

The **project II.1 P recycling in animal husbandry (P-Recycling)** started in October 2019. The PhD student terminated the contract in fall 2021 due to another job opportunity. A new project worker was hired in January 2022 who completed the work in the project by September 2022. Due to the short processing time, a doctorate on this topic is not possible for the second processor. Two manuscripts emerged from the work in the project. After preliminary rejection of one manuscript, both are still/again in revision. The manuscript "Enhanced chemical recovery of phosphorus from residues of recirculating aquaculture systems (RAS)" (working title) is to be submitted in Q1 2023. The second will be further revised in 2023 and will be submitted later.

The project **II.2 Efficiency of recovered phosphorus for monogastric animals (Monogastric)** started in November 2019 and ended on December 31, 2022. The submission of the dissertation is planned for 2023. The FBN extended the employment contract until 28.02.2023 to allow the PhD student to complete and submit the dissertation. The PhD student is the first author of the following publications:

**Seyedalmoosavi, M. M.**, Dannenberger, D., Pfuhl, R., Görs, S., Mielenz, M., Maak, S., Wolf, P., Daş, G., & Metges, C. C. (2022) Lipid metabolism, fatty acid composition and meat quality in broilers supplemented with increasing levels of defrosted black soldier fly larvae. Journal of Insects as Food and Feed. (accepted)

**Seyedalmoosavi, M. M.**, Mielenz, M., Görs, S., Wolf, P., Daş, G., & Metges, C. C. (2022) Effects of increasing levels of whole Black Soldier Fly (*Hermetia illucens*) larvae in broiler rations on acceptance, nutrient and energy intakes and utilization, and growth performance of broilers. Poultry Science 101, 12, 1-15, DOI: 10.1016/j.psj.2022.102202

**Seyedalmoosavi, M.M.**, Mielenz, M., Veldkamp, T., Daş, G., Metges, C.C. (2022) Growth efficiency, intestinal biology, and nutrient utilization and requirements of black soldier fly (*Hermetia illucens*) larvae compared to monogastric livestock species: a review. Journal of Animal Science and Biotechnology 13, 1-20, DOI: 10.1186/s40104-022-00682-7

The **project II.3 P efficiency of forage legumes and their capacity to utilize P from recycled products (P-Legumes)** started in November 2019 and will end on July 31, 2023 after a Corona-related extension. PhD student Yue Hu is the first author of the following publication, which has received the P-Campus 2022 Publication Award at the International P-Campus Symposium 2022. Another publication is in progress.

**Hu, Y.,** Jarisch, K.A., Kavka, M., Eichler-Löbermann, B. (2022) Fate of P from organic and inorganic fertilizers assessed by complementary approaches. Nutr Cycl Agroecosyst, DOI: 10.1007/s10705-022-10237-x

The **project III.1 Synthesis of novel P-based ligands for complexes to activate small molecules (P-Cord)** started in October 2020 and will end after a cost-neutral extension in November 2023. For the PhD student Jan-Erik Siewert, who is employed in the project, the Kekulé fellowship was obtained in summer 2021. The WGL and LIKAT funds thus freed up were then used to hire an additional *project researcher*. The following publications were published in the project:

*Dankert, F.*, Fischer, M., Hering-Junghans, C. (2022) On the ambiphilic character of phosphanylidenephosphoranes and manipulation of phosphinidenoid reactivity with Lewis acids. DOI: 10.26434/chemrxiv-2022-drdkg (working paper)

*Dankert, F.*, Hering-Junghans, C. (2022) Heavier group 13/15 multiple bond systems: synthesis, structure and chemical bond activation. Chem. Commun. 2022, 58, 1242-1262, DOI: 10.1039/D1CC06518A

*Dankert, F.*, **Siewert, J.-E.**, Gupta, P., Weigend, F., Hering-Junghans, C. (2022) Metal-free N-H Bond Activation by Phospha-Wittig Reagents. Angew. Chem. Int. Ed. 2022, 61, 1-6, DOI: 10.1002/anie.202207064

Gupta, P., Täufer, T., **Siewert, J.-E.**, Reiß, F., Drexler, H.-J., Pospech, J., Beweries, T., Hering-Junghans, C. (2022) Synthesis, Coordination Chemistry, and Mechanistic Studies of P,N-Type Phosphaalkene-Based Rh(I) Complexes. Inorg. Chem. 2022, 61, 30, 11639–11650, DOI: 10.1021/acs.inorgchem.2c01158

Gupta, P., **Siewert, J.-E.**, Wellnitz, T., Fischer, M., Baumann, W., Beweries, T., Hering-Junghans, C. (2021) Reactivity of phospha-Wittig reagents towards NHCs and NHOs. Dalton Trans. 50, 1838-1844, DOI: 10.1039/D1DT00071C

Nees, S., Fantuzzi, F., Wellnitz, T., Fischer, M., **Siewert, J.-E.**, Goettel, J. T., Hofmann, A., Härterich, M., Braunschweig, H., Hering-Junghans, C. (2021) Cyclo-Dipnictadialanes. Angew. Chem. Int. Ed., 60, 24318–24325, DOI: 10.1002/anie.202111121

**Siewert, J.-E.**, Schumann, A., Hering-Junghans, C. (2021) Phosphine-catalysed reductive coupling of Dihalophosphanes. Dalton Transactions 42, 15111-15117, DOI: 10.1039/D1DT03095G

**Siewert, J.-E.**, Schumann, A., Fischer, M., Schmidt, C., Taeufer, T., Hering-Junghans, C. (2020) Terphenyl(bisamino)phosphines: electron-rich ligands for gold-catalysis. Dalton Trans. 49, 12354-12364, DOI: 10.1039/D0DT02435J

Schumann, A., Reiß, F., **Siewert, J.-E.**, Jiao, H., Rabeah, J., Krummenacher, I., Braunschweig, H., Hering-Junghans, C. (2019) A selective route to aryl-triphosphiranes and their titanocene-induced fragmentation. Chem. Sci. 10, 7859-7867, DOI: 10.1039/C9SC02322D

Täufer, T., *Dankert, F.,* Michalik, D., Pospech, J., Bresien, J., Hering-Junghans, C. (202?) Photochemical Formation and Reversible Base-Induced Cleavage of a Phosphagallene. (in revision)

The **project III.2 Application of P-based organocatalysts and biocatalysts for the resolution of racemic carbonates (P-RaceCar)** started in February 2020 and will last after an extension until April 2023. The submission of the dissertation is planned for summer 2023. The PhD student is the first author of the following publication:

**Terazzi, C.,** Laatz, K., von Langermann, J., Werner, T. (2022) Synthesis of Cyclic Carbonates Catalyzed by CaI2–Et3N and Studies on Their Biocatalytic Kinetic Resolution. ACS Sustainable Chem. Eng. 10, 40, 13335–13342, DOI: 10.1021/acssuschemeng.2c03210

The **project III.3 Synthesis of potential anti-tumor and adhesion-promoting agents by P-based organocatalysis for oncology and biomedical engineering (P-Med)** started in January 2020 and ended on December 31, 2022. The submission of the dissertation is planned for summer 2023. The PhD student is first or co-author of the following two publications:

**J. Tönjes**, L. Longwitz and T. Werner (2021) Poly(methylhydrosiloxane) as a reductant in the catalytic base-free Wittig reaction. Green Chem. 23, 4852-4857. DOI: 10.1039/D1GC00953B

Liu, X., Longwitz, L., Spiegelberg, B., **Tönjes, J.**, Beweries, T., Werner, T. (2020) Erbium-Catalyzed Regioselective Isomerization–Cobalt-Catalyzed Transfer Hydrogenation Sequence for the Synthesis of Anti-Markovnikov Alcohols from Epoxides under Mild Conditions. ACS Catal. 2020, 10, 13659–13667, DOI: 10.1021/acscatal.0c03294

The **project IV.1 Gene expression in biogeochemical cycling of phosphorus in biological soil crusts of sand dunes of the Baltic Sea (Soil Crust)** started in June 2019 and ended on September 30, 2022, after a Corona-related extension. The PhD student plans to submit the dissertation in 2023. A first manuscript was published at the turn of the year 2022/2023.

**Kammann, S.,** Schiefelbein, U., Dolnik, C., Mikhailyuk, T., Demchenko, E., Karsten, U., Glaser, K. (2023) Successional development of the phototrophic community in biological soil crusts on coastal and inland dunes. MDPI Biology, 12, 58, DOI: 10.3390/biology12010058

Two further manuscripts are in progress (working title).

**S. Kammann**, K. Glaser, U. Karsten, U. Schiefelbein, C. Dolnik, T. Mikhailyuk, E. Demchenko, P. Leinweber (202?) Successional development of the phototrophic community in biological soil crusts and soil development on Holocene deposits at the Baltic Sea coast.

**S. Kammann**, K. Glaser, C. Hassenrück, U. Karsten, M. Labrenz (202?) Bacterial diversity in biocrusts of sand dunes following a succession gradient.

The **project IV.2 Sustainability of potato production: cloning and sequencing of candidate genes improving P acquisition efficiency to reduce fertilizer inputs (P-Stop)** started in May 2020. Due to a prolonged illness of the PhD student, the project was extended by the P-Campus for 3 months until July 31, 2023. The PhD student is the first author of the following publication:

**Kirchgesser, J.,** Hazarika, M., Bachmann-Pfabe, S., Dehmer, K. J., Kavka M., Uptmoor, R. (2023) Phenotypic variation of root-system architecture under high P and low P conditions in potato (*Solanum tuberosum* L.). BMC Plant Biology, DOI: 10.1186/s12870-023-04070-9

The **project IV.3 The role of inorganic phosphate supply on the development of cyanobacterial summer blooms in the Baltic Sea (Cyanoblooms)** started in November 2019 and will end after a Corona-related extension on March 31, 2023. The submission of the dissertation is planned for 2023. The PhD student is the first author of the following publication:

**Santoro, M.**, Hassenrück, C., Labrenz, M., Hagemann, M. (2022) Acclimation of Nodularia spumigena CCY9414 to inorganic phosphate limitation - Identification of the P-limitation stimulon via RNA-seq. Front. Microbiol. 13:1082763, DOI: 10.3389/fmicb.2022.1082763

The **project IV.4 Phosphorus as a metabolic regulator during environmental stress in animals (MetaPhos)** started in August 2020 and is expected to end on August 12, 2023. The PhD student is first or co-author of the following publications:

**Adzigbli, L.**, Sokolov, E. P., Ponsuksili, S., Sokolova, I. M. (2022) Tissue- and substrate-dependent mitochondrial responses to acute hypoxia–reoxygenation stress in a marine bivalve (*Crassostrea gigas*). J Exp Biol 225 (1), DOI: 10.1242/jeb.243304

Sokolov, E. P., **Adzigbli, L.**, Markert, S., Bundgaard, A., Fago, A., Becher, D., Hirschfeld, C., Sokolova, I. M. (2021) Intrinsic mechanisms underlying hypoxia-tolerant mitochondrial phenotype during hypoxia-reoxygenation stress in a marine facultative anaerobe, the blue mussel *Mytilus edulis*. Frontiers in Marine Science 8:773734, DOI: 10.3389/fmars.2021.773734

The **project IV.5 Molecular mechanisms of phosphate homeostasis and osteo-immunological processes and their consequence for health and welfare (P homeostasis)** started in October 2020 and will end on October 1, 2023. The PhD student is the first author of the following publication, which has received the publication award of the P-Campus in 2022.

**Hasan, M.**, Oster, M., Reyer, H., Ponsuksili, S., Murani, E., Wolf, P., Fischer, D.-C., Wimmers, K. (2022) Tissue-wide expression of genes related to vitamin D metabolism and fgf23 signaling following variable phosphorus intake in pigs. Metabolites 12, 729, DOI: 10.3390/metabo12080729

The **project V. Governance options for closed P cycles - the GAP 2020 revision (P-Governance)** started in July 2019 and ended after a Corona-related extension on September 30, 2022. The submission of the dissertation is planned for 2023.
The PhD student is first author (7) or co-author (6) of the following publications:

Garske, B., **Heyl, K.,** Ekardt, F. (202?) The EU Communication on ensuring availability and affordability of fertilisers – a milestone for EU food security or a missed opportunity? Environmental Research Letters (submitted)

**Heyl, K.,** Ekardt, F., Roos, P., Garske, B. (2023) Achieving the nutrient reduction objective of the farm to fork strategy. an assessment of CAP subsidies for precision fertilization and sustainable agricultural practices in Germany. Frontiers in Sustainable Food Systems. 7: 1088640; DOI:10.3389/fsufs.2023.1088640

**Heyl, K.** (202?) Combatting eutrophication in the Baltic Sea – An assessment of the updated Baltic Sea Action Plan and the Common Agricultural Policy. Ambio (submitted)

**Heyl, K.,** Ekardt, F., Sund, L., Roos, P. (2022) Potentials and limitations of subsidies in sustainability governance: the example of agriculture. Sustainability 14, 15859, DOI: 10.3390/su142315859

**Heyl, K.**, Ekardt, F., Roos, P., Garkse, B. (2022) Digitalisierte Präzisionsdüngung und EU-Agrarsubventionen im deutschen Recht: Ökologisch effektive Umsetzung von Farm-to-Fork-Strategie und Umweltvölkerrecht? Natur und Recht 44, 837–846, DOI: 10.1007/s10357-022-4114-5

Ekardt, F., Bärenwaldt, M., **Heyl, K.** (2022) The Paris Target, Human Rights, and IPCC Weaknesses: Legal Arguments in favour of Smaller Budgets. Environments, 9(9), 112, DOI: 10.3390/environments9090112

Ekardt, F., **Heyl, K.** (2022) The German constitutional verdict is a landmark in climate litigation. Nature Climate Change, 12, 697–699, DOI: 10.1038/s41558-022-01419-0

**Heyl, K.**, Ekardt, F. (2022) Barriers and methodology in transitioning to sustainability: Analysing web news comments concerning animal-based diets. Journal of Cleaner Production 330, 129857, DOI: 10.1016/j.jclepro.2021.129857

**Heyl, K.**, Ekardt, F., Roos, P., Stubenrauch, J., Garske, B. (2021) Free Trade, Environment, Agriculture, and Plurilateral Treaties: The Ambivalent Example of Mercosur, CETA, and the EU–Vietnam Free Trade Agreement. Sustainability 13, 3153, DOI: 10.3390/su13063153

Garske, B., **Heyl, K.**, Ekardt, F., Weber, L.M., Gradzka, W. (2021) Lebensmittelverluste als Governance- und Rechtsproblem. NuR 43, 168-179, DOI: 10.1007/s10357-021-3814-6

Stubenrauch, J., Ekardt, F., **Heyl, K.**, Garske, B., Schott, V.L., Ober, S. (2021) How to legally overcome the distinction between organic and conventional farming - Governance approaches for sustainable farming on 100% of the land. Sustain. Prod. Consum. 28, 716-725, DOI: 10.1016/j.spc.2021.06.006

**Heyl, K.,** Döring, T., Garske, B., Stubenrauch, J., Ekardt, F. (2020): The common agricultural policy beyond 2020: A critical review in light of global environmental goals, RECIEL, DOI: 10.1111/reel.12351

Garske, B., **Heyl, K.**, Ekardt, F., Weber, L.M., Gradzka, W. (2020): Challenges of food waste Governance: An Assessment of European legislation on food waste and recommendations for improvement by economic instruments. Land 2020, 9, 231. DOI: 10.3390/land9070231

The PhD student presented her results at the ESPC in Vienna in June 2022 ("Sustainable phosphorus management under the future Common Agricultural Policy").

**Table 3b.** Subprojects of the Graduate School 2 (PGS 2, 2019-2023, financed by the Leibniz Association), color marking as follows: defended dissertation in green, submitted dissertation in orange, projects finished by December 31, 2022 at the latest with upcoming submission of the dissertation in purple, finished projects without dissertation in blue (as of December 2022)

| Project | Participating Partners | Research Focus |
|---|---|---|
| I.1 Risks and benefits of rewetting coastal wetlands after agricultural use | UR, IOW | I |
| I.2 P Pools and mobilization potential in lowlands and coastal regions | UR, LIKAT | I |
| I.3 Analysis of glyphosate and glufosinate in sea water and as indicator compounds for industrial cropping | IOW, UR | I |
| II.1 P recycling in animal husbandry | UR, IOW, FBN | II |
| II.2 Efficiency of recovered phosphorus for monogastric animals | UR, FBN | II |
| II.3 P efficiency of forage legumes and their capacity to utilize P from recycling products | IPK, UR | II |
| III.1 Synthesis of novel P-based ligands for complexes to activate small molecules | LIKAT, UR | III |
| III.2 Application of P-based organocatalysts and biocatalysts for the resolution of racemic carbonates | UR, LIKAT | III |
| III.3 Synthesis of potential anti-tumor and adhesion-promoting agents by P-based organocatalysis for oncology and biomedical engineering | LIKAT, UMR, INP | III |

| Project | Participating Partners | Research Focus |
|---|---|---|
| IV.1 Gene expression in biogeochemical cycling of phosphorus in biological soil crusts of sand dunes of the Baltic Sea | UR, IOW | IV |
| IV.2 Sustainability of potato production: Cloning and sequencing of candidate genes improving P acquisition efficiency to reduce fertilizer inputs | UR, IPK | IV |
| IV.3 The role of inorganic phosphate supply on the development of cyanobacterial summer blooms in the Baltic Sea | UR, IOW | IV |
| IV.4 Phosphorus as a metabolic regulator during environmental stress in animals | UR, IOW, FBN | IV |
| IV.5 Molecular mechanisms of phosphate homeostasis and osteoimmunological processes and their consequence for health and welfare | FBN, UMR | IV |
| V. Governance options for closed P cycles - the CAP 2020 revision | UR, IOW | V |

The Winter School "Scientific Writing and Successful Publishing" was first planned for Fall 2021 and then for February/March 2022. This event was to take place on-site over four days (https://wissenschaftscampus-rostock.de/winter-school-2022.html). Since it was mandatory that the winter school be held as a face-to-face event, it was postponed to September 2022 (September 6-9, 2022) due to the pandemic circumstances and could then be successfully held on-site (**Summer School "Scientific Writing and Successful Publishing"**). The summer school should provide the PhD students with the appropriate basics for the successful publication of their research results in peer-reviewed journals. After the summer school, the PhD students should thus be able to write and submit a well-structured manuscript and master the review process. The following topics were discussed or practiced during the summer school:

- Concepts and mechanisms of scientific writing
- Good scientific practice
- DFG guidelines
- Selection of the journal
- Review process and reviewers' perspective
- Copyright and Open Access

Nine PhD students participated in the Summer School Publishing for four days. Lectures on the topics were offered, but also group work and detailed discussions about the revised manuscript parts of the PhD students.

One more one-week **summer school on P analysis and research** at the various institutes was planned to take place in May 2022. In the fall of 2021, members and institutes of the P-Campus have agreed to provide rooms for this summer school or scientists have agreed to organize the corresponding lectures/seminars. As too few PhD students had registered for the summer school on phosphorus analysis, it was cancelled.

Despite still existing restrictions, in 2022 some PhD students had the opportunity to **co-supervise** students for their term papers or theses (BSc, MSc) and were thus able to gain valuable **teaching experience**.

## 3.4 Publications

The following three publications were honored with the **Publication Award 2022** because authors from at least two partner institutions were involved in the peer-reviewed key publications (P-Campus members in **bold**, (former) PhD students also in ***italics***). PhD students from the P-Campus were the first authors of all 3 publications:

***Hasan, M.*, Oster, M.**, Reyer, H., Ponsuksili, S., Murani, E., Wolf, P., **Fischer, D.-C., Wimmers, K.** (2022) Tissue-wide expression of genes related to vitamin D metabolism and fgf23 signaling following variable phosphorus intake in pigs. Metabolites 12, 729, DOI: 10.3390/metabo12080729

***Hu, Y.*,** Jarisch, K.A., **Kavka, M., Eichler-Löbermann, B.** (2022) Fate of P from organic and inorganic fertilizers assessed by complementary approaches. Nutr Cycl Agroecosyst, Doi 10.1007/s10705-022-10237-x

***Seyedalmoosavi, M. M.*,** Mielenz, M., Görs, S., **Wolf, P.**, Daş, G., **Metges, C. C.** (2022) Effects of increasing levels of whole Black Soldier Fly (*Hermetia illucens*) larvae in broiler rations on acceptance, nutrient and energy intakes and utilization, and growth performance of broilers. Poultry Science 101, 12, 1-15, DOI: 10.1016/j.psj.2022.102202

In the following, all publications from phosphorus research of the members of the P-Campus from the year 2022 are listed here:

Adzigbli, L., Sokolov, E. P., Ponsuksili, S., Sokolova, I.M. (2022) Tissue- and substrate-dependent mitochondrial responses to acute hypoxia–reoxygenation stress in a marine bivalve (Crassostrea gigas). J Exp Biol 225 (1), DOI: 10.1242/jeb.243304

Adzigbli, L., Sokolov, E.P., Wimmers, K., Sokolova, I.M., Ponsuksili, S. (2022) Effects of hypoxia and reoxygenation on mitochondrial functions and transcriptional profiles of isolated brain and muscle porcine cells. Sci Rep 12(1): 19881, DOI: 10.1038/s41598-022-24386-0

Avilés-Tamayo, Y., Guarda-Puebla, Y., Valdesiguirre, L., Arias, Q., López, R., Morscheck, G., Eichler-Löbermann, B. (2022) Comparative characterisation of humic substances obtained from anaerobic digestate of horticultural residues. Tropentag 2022, Book of abstracts, p. 40.

Bullaín Galardis, M.M., López Sánchez, R.C., Fall, F., Eichler-Löbermann, B., Pruneau, L., Bâ, A.M. (2022) Growth and physiological responses of ectomycorrhizal Coccoloba uvifera (L.) L. seedlings to salt stress. Journal of Arid Environments 196, art. no. 104650, DOI: 10.1016/j.jaridenv.2021.104650

Bullaín, M., López, R., Fall, F., Eichler-Löbermann, B., Pruneau, L., Séne, S., Ba, A.M. (2022) Diversity and role of ectomyccorhizal fungi in improving teh tolerance of see grape to salt stress. 19th Int. Conference of the Biological Nitrogen Fixation, Senegal, Book of abstracts

Chiba, A., Peine, M., Kublik, S., Baum, C., Schloter, M., Schulz, S. (2022) Complete Genome Sequence of Psychrobacillus sp. Strain INOP01, a Phosphate-Solubilizing Bacterium Isolated from an Agricultural Soil in Germany. Microbiol. Resour. Announc. 11, 4, DOI: 10.1128/mra.00207-22

Dankert, F., Fischer, M., Hering-Junghans, C. (2022) Modulating the reactivity of phosphanylidenephosphoranes towards water with Lewis acids. Dalton Trans. 51, 11267-11276, DOI: 10.1039/D2DT01575G

Dankert, F., Gupta, P., Wellnitz, T., Baumann, W., Hering-Junghans, C. (2022) Deoxygenation of chalcogen oxides EO2 (E = S, Se) with phospha-Wittig reagents. Dalton Trans., 51, 18642-18651, DOI: 10.1039/D2DT03703C

Dankert, F., Hering-Junghans, C. (2022) Heavier group 13/15 multiple bond systems: synthesis, structure and chemical bond activation. Chem. Commun. 2022, 58, 1242-1262, DOI: 10.1039/D1CC06518A

Dankert, F., Siewert, J.-E., Gupta, P., Weigend, F., Hering-Junghans, C. (2022) Metal-free N-H Bond Activation by Phospha-Wittig Reagents. Angew. Chem. Int. Ed. 2022, 61, 1-6, DOI: 10.1002/anie.202207064

Eichler-Löbermann, B., Koal, P., Hu, Y., Dehmer, K.J. (2022) Nachhaltiges und effizientes Phosphor-Management im Pflanzenbau. In: Kinder haften für ihre Eltern – Impulse aus dem Ökolandbau. KTBL-Tagung 2022, S. 94-109

Ekardt, F., Bärenwaldt, M., Heyl, K. (2022) The Paris Target, Human Rights, and IPCC Weaknesses: Legal Arguments in favour of Smaller Budgets. Environments, 9(9), 112, DOI: 10.3390/environments9090112

Ekardt, F., Heyl, K. (2022) The German constitutional verdict is a landmark in climate litigation. Nature Climate Change, 12, 697–699, DOI: 10.1038/s41558-022-01419-0

Falfushynska, H., Khatib, I., Kasianchuk, N., Lushchak, O., Horyn, O., Sokolova, I.M. (2022) Toxic effects and mechanisms of common pesticides (Roundup and chlorpyrifos) and their mixtures in a zebrafish model (Danio rerio). Science of the Total Environment 833, 155236, DOI: 10.1016/j.scitotenv.2022.155236

Fornara, D., Ball, E. M., Mulvenna, C., Reyer, H., Oster, M., Wimmers, K., Poulsen H.D., Rosemarin, A. (2022) Soil and Plant Responses to Phosphorus Inputs from Different Phytase-Associated Animal Diets. Agronomy, 12(1), 130, 1-16, DOI: 10.3390/agronomy12010130

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Gupta, P., Täufer, T., Siewert, J.-E., Reiß, F., Drexler, H.-J., Pospech, J., Beweries, T., Hering-Junghans, C. (2022) Synthesis, Coordination Chemistry, and Mechanistic Studies of P,N-Type Phosphaalkene-Based Rh(I) Complexes. Inorg. Chem. 2022, 61, 30, 11639–11650, DOI: 10.1021/acs.inorgchem.2c01158

Hasan, M., Oster, M., Reyer, H., Ponsuksili, S., Murani, E., Wolf, P., Fischer, D.-C., Wimmers, K. (2022) Tissue-Wide Expression of Genes Related to Vitamin D Metabolism and FGF23 Signaling following Variable Phosphorus Intake in Pigs. Metabolites 12, 729, DOI: 10.3390/metabo12080729

Heyl, K., Ekardt, F. (2022) Barriers and methodology in transitioning to sustainability: Analysing web news comments concerning animal-based diets. Journal of Cleaner Production 330, 129857, DOI: 10.1016/j.jclepro.2021.129857

Heyl, K., Ekardt, F., Roos, P., Garkse, B. (2022) Digitalisierte Präzisionsdüngung und EU-Agrarsubventionen im deutschen Recht: Ökologisch effektive Umsetzung von Farm-to-Fork-Strategie und Umweltvölkerrecht? Natur und Recht 44, 837–846, DOI: 10.1007/s10357-022-4114-5

Heyl, K., Ekardt, F., Sund, L., Roos, P. (2022) Potentials and limitations of subsidies in sustainability governance: the example of agriculture. Sustainability 14, 15859, DOI: 10.3390/su142315859

Hu, Y., Jarisch, K.A., Kavka, M., Eichler-Löbermann, B. (2022) Fate of P from organic and inorganic fertilizers assessed by complementary approaches. Nutr Cycl Agroecosyst 124, 189–209, DOI: 10.1007/s10705-022-10237-x

Iqbal, M.A., Reyer, H., Oster, M., Hadlich, F., Trakooljul, N., Perdomo-Sabogal, A., Schmucker, S., Stefanski, V., Roth, C., Camarinha Silva, A., Huber, K., Sommerfeld, V., Rodehutscord, M., Wimmers, K., Ponsuksili, S. (2022) Multi-Omics Reveals Different Strategies in the Immune and Metabolic Systems of High-Yielding Strains of Laying Hens. Frontiers in Genetics 13, 1-20, DOI: 10.3389/fgene.2022.858232

Jarosch, K., Hu, Y., Kavka, M., Eichler-Löbermann, B. (2022) Phosphorus fractions and availabilities in different soil depths after 20 years of continuous soil P management. 22nd World Congress of Soil Science, Glasgow, August 2022

López, R., Medina, J., Eichler-Löbermann, B. (2022) Phenotypic plasticity of Anacardium occidentale seedlings to salt stress based on physiological indicators. Tropentag 2022, Book of abstracts, p. 86.

Mulvenna, C.C., McCormack, U.M., Magowan, E., McKillen, J., Bedford, M.R., Walk, C.L., Oster, M., Reyer, H., Wimmers, K., Fornara, D.A., Ball, M.E.E. (2022) The Growth Performance, Nutrient Digestibility, Gut Bacteria and Bone Strength of Broilers Offered Alternative, Sustainable Diets Varying in Nutrient Specification and Phytase Dose. Animals 12, 1669, DOI: 10.3390/ani12131669

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Pham, D. N., Sokolov, E. P., Falfushynska, H., Sokolova, I. M. (2022) Gone with sunscreens: Responses of blue mussels (Mytilus edulis) to a wide concentration range of a UV filter ensulizole. Chemosphere 309: 136736, DOI: 10.1016/j.chemosphere.2022.136736

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Rojas, R., Fundora, O., Eichler-Löbermann, B., Gálvez, G. (2022) Weed control using environmentally friendly alternatives in smallholder agriculture in Cuba. Tropentag 2022, Book of abstracts, p. 90.

Seyedalmoosavi, M. M., Mielenz, M., Görs, S., Wolf, P., Daş, G., & Metges, C. C. (2022) Effects of increasing levels of whole Black Soldier Fly (Hermetia illucens) larvae in broiler rations on acceptance, nutrient and energy intakes and utilization, and growth performance of broilers. Poultry Science 101, 12, 1-15, DOI: 10.1016/j.psj.2022.102202

Seyedalmoosavi, M.M., Mielenz, M., Veldkamp, T., Daş, G., Metges, C.C. (2022) Growth efficiency, intestinal biology, and nutrient utilization and requirements of black soldier fly (Hermetia illucens) larvae compared to monogastric livestock species: a review. Journal of Animal Science and Biotechnology 13, 1-20, DOI: 10.1186/s40104-022-00682-7

Shaheen, S.M., Wang, J., Baumann, K., Ahmed, A.A., Hsu, L.-C., Liu, Y.-T., Wang, S.-L., Kühn, O., Leinweber, P., Rinklebe, J. (2022) Stepwise redox changes alter the speciation and mobilization of phosphorus in hydromorphic soils. Chemosphere 288, DOI: 10.1016/j.chemosphere.2021.132652

Steinfurth, K., Börjesson, G., Denoroy, P., Eichler-Löbermann, B., Gans, W., Heyn, J., Hirte, J., Huyghebaert, B., Jouany, C., Koch, D., Merbach, I., Mokry, M., Mollier, A., Morel, C., Panten, K., Peiter, E., Poulton, P. R., Reitz, T., Rubæk, G. H., Spiegel, H., van Laak, M., von Tucher, S., Buczko, U. (2022) Thresholds of target phosphorus fertility classes in European fertilizer recommendations in relation to critical soil test phosphorus values derived from the analysis of 55 European long-term field experiments. Agric. Ecosyst. Environ. 332, DOI: 10.1016/j.agee.2022.107926

Stubenrauch, J. (2022) Innovative phosphorus governance: How to address recurring regulatory shortfalls - The example of Germany, Costa Rica and Nicaragua. In: Ginzky, H. et al. (eds.) International Yearbook of Soil Law and Policy 2020/2021, 435-462, DOI: 10.1007/978-3-030-96347-7_17

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Suhrbier, T., Bresien, J., Villinger, A., Schulz, A. (2022) A four-membered heterocyclic prevented biradical that can be described as a zwitterion or masked N-heterocyclic phosphinidene. Cell Reports Physical Science 3, 100777, DOI: 10.1016/j.xcrp.2022.100777

Terazzi, C., Laatz, K., von Langermann, J., Werner, T. (2022) Synthesis of Cyclic Carbonates Catalyzed by CaI2–Et3N and Studies on Their Biocatalytic Kinetic Resolution. ACS Sustainable Chem. Eng. 10, 40, 13335–13342, DOI: 10.1021/acssuschemeng.2c03210

Wu, F., Sokolov, E. P. , Khomich, A., Fettkenhauer, C., Schnell, G., Seitz, H., Sokolova, I.M. (2022) Interactive effects of ZnO nanoparticles and temperature on molecular and cellular stress responses of the blue mussel Mytilus edulis. Science of the Total Environment 818: 151785, 15 p., DOI: 10.1016/j.scitotenv.2021.151785

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Zerssa, G., Eichler-Löbermann, B. (2022) Combining mineral fertilisers with compost for sustainable maize production and reduction of greenhouse gas. Tropentag 2022, Book of abstracts, p. 29.

Zerssa, G., Kim, D.G., Koal, P., Eichler-Löbermann, B. (2022) Mixed application of compost and inorganic fertilizers increases maize (Zea mays L.) yields, grain minerals, and nutrient use efficiency and mitigates greenhouse gas emissions in Southwestern Ethiopia. Global Symposium on soils for nutrition. FAO. July 2022

## 3.5 Theses

In 2022, one P-Campus PhD student completed her dissertation (Table 4, *italics*). In addition, one more dissertation was supervised by a P-Campus member. P-Campus members also supervised master's and bachelor's theses. Some of the theses were co-supervised by PhD students from PGS2.

**Table 4**. List of theses in the P-Campus

| Thesis | Institution |
|---|---|
| **Dissertations** | |
| Wubuli, A. (2022) Effects of dietary phosphorus on endogenous mechanisms of phosphorus homeostasis in pigs. | UR-MNF/ FBN |
| *Zacher, A. (2022) Zur Rolle von Unkräutern in Mais und Kartoffeln bei der effizienten Nutzung des P-Pools im Boden.* | UR-AUF-SSC / IPK |
| **Master Theses** | |
| Hellige, I. (2022) Development of a fixative for the long-term RNA and DNA preservation of water samples. | HS Bremerhaven + IOW |
| Meyn, A. (2022) Auswirkungen einer langfristigen Düngung mit Gärresten auf die organische Bodensubstanz und die mikrobielle Aktivität. | UR-AUF-AGR |
| Tahar, A. (2022) Comparison of wild and cultivated potato genotypes with regard to their phosphorus utilization efficiency. | Uni Göttingen + IPK |
| **Bachelor Theses** | |
| Engel, A. (2022) Phosphordüngewirkung von Reststoffen in Kombination mit kleinkörnigen Leguminosen. | UR-AUF-AGR |
| Fritzsche, L. (2022) Phosphorverfügbarkeit im Boden in Abhängigkeit von Düngung, Fruchtart und Beprobungstermin. | UR-AUF-AGR |

| Thesis | Institution |
|---|---|
| Helm, G. (2022) Phosphorverfügbarkeit im Boden nach dem Anbau von kleinkörnigen Leguminosen. | UR-AUF-AGR |
| Liermann, R. (2022) Untersuchungen zur Wirkung unterschiedlicher Phosphatdünger auf den Futterwert von Kleegrasmengen. | UR-AUF-GF |
| Ruff, L. (2022) Agroforstsysteme – Auswirkungen auf biologische und chemische Bodeneigenschaften. | UR-AUF-AGR |
| Schiele, W. (2022) Phosphor-Aufnahme von Luzerne und Rotklee nach zweijähriger Wachstumszeit in Abhängigkeit von der Phosphorversorgung. | UR-AUF-AGR |

Abbreviations: AGR = chair of Agronomy, AUF = Faculty of Agricultural and Environmental Sciences, GF = chair of Grassland and Fodder Sciences, IOW = Leibniz Institute for Baltic Sea Research Warnemünde, MNF = Faculty of Mathematics and Natural Sciences, SSC = chair of Soil Science, UR = University of Rostock

# 4 Networking

Besides interactions among its individual scientists and research groups, the P-Campus is a member of the European Sustainable Phosphorus Platform (ESPP) and the German Phosphorus Platform (DPP). In addition, the P-Campus is connected with other Leibniz ScienceCampi as well as through its scientists and their thematic networks.

**German Phosphorus Platform** (DPP) – Participation in the General Assembly (12.10.2022, on site) and the annual DPP forum (13.10.2022, online), Dr. D. Zimmer

**European Phosphorus Platform** (ESPP) - Participation in the General Assembly (28.11.2022, online, Dr. D. Zimmer)

**Associated partnerships** with the:
German Chemical Society, working group Phosphorus Chemistry (Prof. Dr. Evamarie Hey-Hawkins, Prof. Dr. Jan J. Weigand, Prof. Dr. Robert Wolf)
University of Copenhagen, Research Group Soil Fertility (Prof. Dr. Lars Stoumann Jensen, Prof. Dr. Jakob Magid, Prof. Dr. Dorette Sophie Müller-Stöver)

**New collaborations in the P-Campus:**

Due to the visibility of the P-Campus research, the Coordination Office was contacted in 2020 and 2021 by a scientist from ZALF (Leibniz Centre for Agricultural Landscape Research, www.zalf.de/en/) and a scientist from the Roman-Germanic Commission of the German Archaeological Institute (www.dainst.org/en/). In both cases, it was possible to successfully establish contact with several scientists in the P-Campus.

In cooperation with the ZALF, a **concept for a third-party funded project** was developed in 2020 and 2021, in which the mutual influence of the (bio)availability of **Si and P** from the soil via groundwater to surface waters (limnic and marine) will be investigated. In addition to ZALF, the University of Rostock and IOW, the IGB (Leibniz Institute of Freshwater Ecology and Inland Fisheries: https://www.igb-berlin.de/en) is also involved in the intended cooperation. The project application has been drafted as far as possible. Unfortunately, it has not yet been possible to find a suitable call for proposals from the BMBF, BMEL or similar for the project application in the course of 2022.

A **research collaboration** was initiated with scientists from the Roman-Germanic Commission to evaluate **soil phosphorus** and **vegetation** in the context of **archaeological research**. For this purpose, two student research projects started in the winter semester 2021/22, one with the working group (WG) Soil Science, the other with the WG Landscape Ecology at the Faculty of Agricultural and Environmental Sciences of the University

of Rostock. The archaeologists' question was whether the speciation of P compounds in soil samples from excavation sites could provide information about the land use and way of life of the populations at that time. To this end, samples were taken from two different excavations in south-eastern Europe and carried out investigations of the P fractions as part of a small student project in the WG Soil Science during a semester work. Although it has not yet been possible to process a sufficiently large set of samples, initial hypotheses about the (historical) introduction of P-containing materials into the soils can be derived from sample analyses together with a very extensive data set already available. This is to be seen as a "proof of concept" and encourages further work in this direction. In parallel, vegetation surveys were to be carried out in the area under the supervision of the Landscape Ecology working group and evaluated with regard to the archaeological findings. Since neither in 2021 nor in 2022 a student could be found at the University of Rostock or the University of Greifswald who was interested in such a thesis, the work on the vegetation could not be carried out.

The **Leibniz Innovation Farm for Sustainable Bioeconomy**, initiated by the ATB (Leibniz Institute of Agricultural Engineering and Bioeconomy, https://www.atb-potsdam.de/en/), started in 2021 (https://www.atb-potsdam.de/en/news-and-press/). Members of the P-Campus (from UR, IOW, FBN, and from the Sustainability and Climate Policy Research Unit) are involved in the workshops (animal husbandry, agronomy, systems analysis) that have been ongoing since 2021 for the development of project proposals. Due to the link to the Leibniz Innovation Farm, scientists from the ATB are involved in the envisaged Leibniz Research Network.

P. Leinweber's participation in the "PROCESSOR" project at the University of Copenhagen (Prof. J. Magid, Department of Plant and Environmental Sciences) includes participation in the selection of the scientific staff to be recruited (including Dr. Wakene Negassa, a PhD student in the WG Soil Science, University of Rostock) as well as in the discussion of the first scientific results and planning of further experimental work. In particular, by means of an application to the Canadian synchrotron CLS, measurement time was obtained for samples from the PROCESSOR project and extensive investigations with P-XANES were carried out, initially by sending in the samples and in December also with the personal presence of P. Leinweber at the CLS. A member of the project team from the University of Copenhagen was trained in the P-XANES technique, so that in future the Copenhagen working group will be able to carry out the P-XANES measurements increasingly independently. At least one joint publication will result from these investigations.

# 5 Events

The P-Campus has organized and hosted or supported several external and internal events, which are listed in the following.

## 5.1 Public Events

The **International P-Campus Symposium 2022** of the Leibniz ScienceCampus Phosphorus Research Rostock took place on November 24/25, 2022 as a hybrid conference at IOW. Thirteen presentations and six posters demonstrated the research results as well as the networking and cooperation within the P-Campus and with scientists outside the P-Campus. P-Campus PhD students presented nine lectures and three posters. The five members of the International Scientific Advisory Council (SAC) of the P-Campus also attended the symposium.

**Table 5.** Presentations at the International P-Campus Symposium 2022 on 24/25 November 2022: presentations by P-Campus PhD students in green, presentations by scientists who are not members of the P-Campus are marked with an "E" for external in the column Cluster

| Name of the speaker | Presentation | Cluster |
|---|---|---|
| **Oral presentations** | | |
| Maruf Hasan (FBN) | Tissue-wide expression of genes related to vitamin D metabolism and FGF23 signaling in response to variable phosphorus intake in pigs (online) | IV |
| Linda Adzigbli (FBN) | Mitochondrial responses of marine bivalves to hypoxia-reoxygenation stress (IOW) | IV |
| Kay Sowoidnich (FBH) | Shifted Excitation Raman Difference Spectroscopy for molecule-specific analysis of fluorescent animal bones (IOW) | E |
| Jan-Erik Siewert (LIKAT) | Mimicking enzymes in molecular P-containing systems, novel ligand framework of Bis(NHC)Phosphinidines (IOW) | III |
| Constanza Terazzi (LIKAT) | Phosphonium salt catalyzed synthesis of cyclic carbonates and their kinetic resolution (IOW) | III |
| Jan Tönjes (LIKAT) | P(III)/P(V) Redox Cycling Catalysis: Development and Outlook on New Methods for the Synthesis of Active Compounds (IOW) | III |
| Michael Hupfer (IGB) | Spontaneous eutrophication of Lake Stechlin: Which external and internal mechanisms control phosphorus increase in the water body? (online) | E |
| Ashour Ahmad (UR) | Advances in understanding the P binding in soil: A computational chemistry perspective (IOW) | I |
| Sandra Kammann (UR) | Succession of the phototrophic community composition in biological soil crusts on the temperate coastal dunes: Implications for P cycling (IOW) | IV |
| K. Heyl, F. Ekardt (FNK/UR) | P Governance, Oceans, and Precision Farming (online) | V |
| Mariano Santoro (IOW) | Blooms in the Baltic Sea: insights into acclimation strategies of toxic diazotrophic cyanobacteria to limiting nutrients (IOW) | IV |
| Julia Prüter (UR) | Phosphorus speciation in soil and sediment indicating transformation processes from terrestrial to aquatic ecosystems | I |
| Mareike Kavka standing in for Julian Kirchgesser | Phenotypic and genotypic variation of root-system architecture under high P and low P conditions in potato (*Solanum tuberosum* L.) (online) | IV |
| **Posters** | | |
| Yue Hu (IPK) | Phosphorus utilisation capacity of forage legumes from recycling products | II |
| Volker Brüser (INP) | Hydrogen evolution from biomass by combined ultrasound-plasma treatment | II |
| Torsten Müller (Uni Hohenheim) | Confocal Raman Microscopy for the Detection of Calcium Phosphates in Fluorescent Soil Matrices | E |
| Felix Gumpert (UR) | Phosphorus recovery from residues of recirculating aquaculture systems | II |
| Mousumi Hazarika (IPK) | Genome-Wide Association Studies (GWAS) in *Solanum tuberosum* | II |
| Richard Thiem (UR) | MikroMais - Reduction of groundwater-relevant nitrogen and phosphorus surplus by combined microgranule-microorganism application in maize cultivation | II |

The **P-Campus Lecture Series** in 2022 took place online (Table 6). Prof. Wellmer's lecture was held as a hybrid event. The online offer once again resulted in a higher number of participants and the participation of more external interested parties, as no travel was necessary as with the previous attendance-only events. Scientists working in the field of P-research, who are not members of the P-Campus, were invited to give the lectures. Between 6 and 30 people took part in the lectures. Between 32% and 58% of

the participants were members of the P-Campus and the remaining participants were external interested parties.

**Table 6.** Topics, lecturers and participants (NP) of the lecture series 2022

| Date | Topic | Lecturer | NP[a] |
|---|---|---|---|
| 05.05.2022 | Steuerung des Phosphor-Haushaltes in Seen durch externe und interne Managementmaßnahmen | Dr. Michael Hupfer (IGB) | 22 |
| 02.06.2022 | Die facettenreiche Chemie der aromatischen Phosphor-Heterocyclen | Prof. Christian Müller (FU Berlin) | 13 |
| 23.06.2022 | Schwimmende Pflanzeninseln als Multitalent in Küstengewässern | Svenja Karstens (EUCC) | 13 |
| 30.06.2022 | Phosphorrückgewinnung aus Abwasser | Prof. Heidrun Steinmetz (TU Kaiserslautern) | 6 |
| 29.09.2022 | Die zukünftige Verfügbarkeit von Phosphat | Prof. Friedrich-Wilhelm Wellmer (ehem. Präsident BGR) | 30 |
| 20.10.2022 | Targeting Management Practices to Mitigate Phosphorus Losses from Agricultural Fields in Regions with Cold Climates | Dr. Merrin Macrae (University Waterloo) | 9 |

[a] Notice: The number of participants (NP) is the number of people who actually participated, usually about ¼ more people had registered.

The **18th European Workshop on Phosphorus Chemistry (EWPC 18)** was supposed to take place in Rostock in spring 2021. The EWPC was started to be organized in 2020 by members of LIKAT, the Institute of Chemistry of the University of Rostock and the coordination office of the P-Campus. The EWPC is a very important conference in phosphorus chemistry especially for young scientists and is therefore a great opportunity to present the research location Rostock and to highlight the diverse research taking place in the P-Campus. Unfortunately, the on-site conference had to be cancelled in 2021; a very well-attended online conference was held instead. However, EWPC 18 could then be held in 2022 as an on-site event at the University of Rostock (https://www.ewpc18.uni-rostock.de/) from September 14 to 16. The organization was done by the same organizing committee as originally. In addition to 31 international presentations from the field of chemistry, three presentations in a special P-Campus session demonstrated the multifaceted P-research in the P-Campus.

The following talks were presented in the P-Campus session:

Dana Zimmer (IOW) The Leibniz ScienceCampus Phosphorus Research Rostock.

Ashour Ahmad (UR) Advances in understanding of P binding in soil: A molecular modeling perspective.

Yue Hu (IPK) Effects of recycling products on P efficiency of forage legumes in a two-year field trial.

Moreover, a P-Campus PhD student presented his research findings in a talk:

Jan Tönjes (LIKAT) Polymthylhydroxsiloxane as green reductant in the catalytic basefree Wittig-reaction via PIII/PV redix cycling.

## 5.2 Internal Meetings and Workshops

Internal meetings and workshops facilitate intensive networking and thematic exchanges between scientists of the P-Campus. In addition to various events for graduate/PhD students, an annual campus symposium is held in which all scientists introduce their new

projects, present their work, and discuss the results. The Steering Group of the P-Campus meets roughly every two to four months to discuss overarching issues as well as the strategic orientation and further development of the P-Campus. In 2022, most of the meetings took place online. In addition, meetings of selected members of the steering group (+ partly other scientists) took place for the concept development of a DFG Research Training Group and a Leibniz Research Alliance.

Meetings of the **steering group** of the P-Campus: 27.01.; 30.03.; 28.04.; 25.08.; 17.11

Meeting for **DFG Research Training Group** "P-Metabolism in Land-Sea Gradients": 02.02.; 01.04.; 20.06.

Meeting for the **Leibniz Research Alliance** "P-Health – Phosphorus in Agriculture, Environment and Nutrition: Ecological Consequences and Societal Challenges": 11.03.; 27.06. (workshops) / 05.05.; 11.05.; 19.05.; 25.05.; 10.06.; 23.06.; 05.07.; 25.08.; 31.08.; 04.10.; 24.10. (cluster meetings)

# 6 Public Relations

The P-Campus and the research of its members have been introduced to external research groups, politicians, government and the general public. A selection of the related events is provided below.

## 6.1 Oral Presentations (Selection)

**76th Conference of the Society of Nutrition Physiology, 08. – 10.03.2022, online**

Seyedalmoosavi, S.M.M., Daş, G., Dannenberger, D., Maak, S., Mielenz, M., Wolf, P., Metges, C.C. Whole black soldier fly larvae in broiler rations: impact on carcass characteristics, blood metabolites and fatty acids profiles in plasma, muscle and fat tissues.

Seyedalmoosavi, S.M.M., Daş, G., Maak, S., Mielenz, M., Metges, C.C., Wolf, P. Effects of different levels of whole black soldier fly larvae in broiler rations on bone characteristics.

**Canadian Chemistry Conference and Exhibition, 13. – 17.06.2022, Calgary, Canada**

Hering-Junghans, C. Isolable Pnictaalumenes and -gallenes.

Siewert, J.-E., Hering-Junghans, C., Schumann, A. Phosphine-catalysed reductive coupling of Dihalophophanes.

**18th European Workshop on Phosphorus Chemistry (EWPC-18), 14. – 16.09.2022, Rostock**

Ahmad, A. Advances in understanding of P binding in soil: A molecular modeling perspective.

Hu, Y. Effects of recycling products on P efficiency of forage legumes in a two-year field trial.

Tönjes, J., Longwitz, L., Werner, T. Poly(methylhydrosiloxane) as a Green Reductant in the Catalytic Base-Free Wittig Reaction via P(III)/P(V) Redox Cycling.

Zimmer, D. The Leibniz ScienceCampus Phosphorus Research Rostock.

**Further presentations**

Hasan, M., Oster, M., Reyer, H., Ponsuksili, S., Murani, E., Wolf, P., Fischer, D.-C., Wimmers, K. Tissue-specific expression of genes of the vitamin D and FGF23 signaling pathways at variable phosphorus supply in pigs. DGfZ/GfT-Jahrestagung 2022, 21.-22.09.2022, Kiel

Hering-Junghans, C. Shutteling Phosphinidenes – The chemistry of Phospanylideneph-oranes. First Annual Meeting of the Phosphorus Chemistry Working Group, 20.03.2022, Saarbrücken

Hering-Junghans, C. Isolable Pnictaalumenes and -gallenes. Chemiedozententagung, 21.-23.03.2022, Saarbrücken

Heyl, K. Sustainable phosphorus management under the future Common Agricultural Policy? 4th European Sustainable Phosphorus Conference, 20.-22.06.2022, Wien, Österreich

Reyer, H., Oster, M., Ball, E., Mulvenna, C., Fornara, D., Poulsen, H.D., Rosemarin, A., Arata, L., Sckokai, P., Wimmers, K. PEGaSus - Phosphorus efficiency in Gallus gallus and Sus scrofa – Bridging the gaps in the phosphorus value chain. European Research Area on Sustainable Animal Production (Era-Net SusAn) Final Conference, 25.-26.01.2022, online

Santoro, M., Hassenrück, C., Labrenz, M., Hagemann, M. Blooms in the Baltic Sea: insights into acclimation strategies of toxic diazotrophic cyanobacteria to limiting nutrients. Cyano2022 - 7th Early Career Researcher Symposium on Cyanobacteria, 26.-28.09.2022, Leipzig

Santoro, M., Hassenrück, C., Labrenz, M., Hagemann, M. Blooms in the Baltic Sea: insights into acclimation strategies of toxic diazotrophic cyanobacteria to limiting nutrients. ICYMARE 2022 - International Conference for Young Marine Researchers, 13.-16.09.2022, Bremerhaven

Seyedalmoosavi, S.M.M., Mielenz, M., Daş, G., Metges, C.C. Broiler eating rate suggests preference for black soldier fly larvae (BSFL) over regular feed. 73rd European Federation of Animal Science, 05.-09.09.2022, Porto, Portugal

Sowoidnich, K., Oster, M., Wimmers, K., Maiwald, M., Sumpf, B. Animal Feedstuff Inspection using Shifted Excitation Raman Difference Spectroscopy. 27th International Conference on Raman Spectroscopy (ICORS), 14.-19.08.2022, Long Beach, USA

**Other Events**

On December 5, 2022, the **year-end meeting** between members of the P-Campus and representatives of the Ministry of Agriculture and the Ministry of Science of MV took place as on-site event. In addition to the presentation on the general development and future of the P-Campus, two projects were presented by P-Campus members:

Dr. Dana Zimmer, Prof. Klaus Wimmers. Aktuelle Entwicklungen im P-Campus 2022 und die Zukunft des P-Campus nach 2023

Dr. Simone Tränckner. Phosphor-Stickstoff-Kohlenstoff aus Gülle getrennt nutzen: PNC-Processing

Anika Zacher. Freund oder Feind? - Zur Rolle von Unkräutern im P-Kreislauf

## 6.2 Posters (Selection)

**55th Annual Meeting of German Catalysts, 27. – 29.06.2022, Weimar**

Ren, C., Spannenberg, A., Werner, T. Synthesis of Bifunctional Phosphonium Salts Bearing Perfluorinated Side Chains and Their Application in the Synthesis of Cyclic Carbonates from Epoxides and $CO_2$.

Sebode, H., Schirmer, M.-L., Spannenberg, A., Werner, T. Acid-catalyzed Reduction of Tertiary Phosphine Oxides Giving Facile Access to Phosphine Boranes.

Terazzi, C., Laatz, K., von Langermann, J., Werner T. Cyclic Carbonates Synthesis Catalyzed by CaI2·Et3N.

Tönjes, K., Longwitz, L., Werner, T. Poly(methylhydrosiloxane) as a Green Reductant in the Catalytic Base-Free Wittig Reaction via P(III)/P(V) Catalysis.

**Further posters**

Dankert, F. N-H oxidative addition of $NH_3$ and other small molecules with phospha-Wittig reagents. Wöhler Tagung, 26.-28.09.2022, Marburg

Kirchgesser, J., Kavka, M., Hazarika, M., Bachmann-Pfabe, S., Dehmer K. J., Uptmoor, R. Phenotypic variation of potato root-system architecture in contrasting P environments. GPZ-Tagung 2022, 12.-14.09.2022, Düsseldorf

Reyer, H., Oster, M., Ball, E., Mulvenna, C., Fornara, D., Poulsen, H.D., Rosemarin, A., Arata, L., Sckokai, P., Wimmers, K. Untapped potential – A multifaceted phosphorus management can maintain nutrient balance. European Research Area on Sustainable Animal Production (Era-Net SusAn) Final Conference, 25.-26.01.2022, online

Santoro, M., Hassenrück, C., Labrenz, M., Hagemann, M. A multi level approach to study cyanobacterial summer blooms in the Baltic Sea. Annual Conference of the VAAM 2022 - Vereinigung für Allgemeine und Angewandte Mikrobiologie, 21.-23.03.2022, online

Sebode, H., Schirmer, M.-L., Spannenberg, A., Werner, T. Brønsted acid-catalyzed reduction of phosphine oxides & direct conversion into air-stable borane adducts. 18th European Workshop on Phosphorus Chemistry, 14.-16.09.2022, Rostock

Steinfurth, K., Holton Rubæk, G., Hirte, J., Buczko, U. Yield response of grass and grass-clover leys in crop rotations to phosphorus fertilization. 29th EGF general meeting: Grassland at the heart of circular and sustainable food systems, 26.-30.06.2022, Caen, France

## 6.3 Press

## 6.4 Websites

Project website **InnoSoilPhos** - **Inno**vative solutions to sustainable **Soil Phos**phorus management: https://www.innosoilphos.de/

Project website **PEGaSus** - **P**hosphorus **e**fficiency in ***Ga****llus gallus* and ***Sus*** *scrofa* – Bridging the gaps in the phosphorus value chain: www.pegasus.fbn-dummerstorf.de

Leibniz ScienceCampus Phosphorus Research Rostock: www.wissenschaftscampus-rostock.de (www.sciencecampus-rostock.de | www.p-campus-rostock.de)

Leibniz-Association/ScienceCampi: www.leibniz-gemeinschaft.de/en/research/leibniz-sciencecampi/phosphorous-research

# 7 Structure and Committees

## 7.1 Structure

The Leibniz ScienceCampus Phosphorus Research Rostock is assigned to the University of Rostock's Interdisciplinary Faculty (INF), Department of Maritime Systems.

The organisation of the Leibniz ScienceCampus Phosphorus Research Rostock is as follows:
The **Directorship** is made up of the Directors of the participating Leibniz Institutes and the Rector of the University of Rostock. They can be represented by members of their institutions. Through the **Steering Committee** representatives of the Leibniz Institutes and the University of Rostock assume direct leadership of the P-Campus. They are represented by a **Spokesperson**. A staff scientist, supported by a secretary, carries out direct **coordination**. An international **Scientific Advisory Council** oversees the Leibniz ScienceCampus Phosphorus Research and in addition to advising has the task of evaluating the scientific work of the P-Campus. Currently, more than 70 scientists and more than 15 PhD students from 40 Working Groups are **Members** of the P-Campus. This list is constantly updated on the website.

The Leibniz Institute for Baltic Sea Research Warnemünde acts as beneficiaries and provides the coordination office.

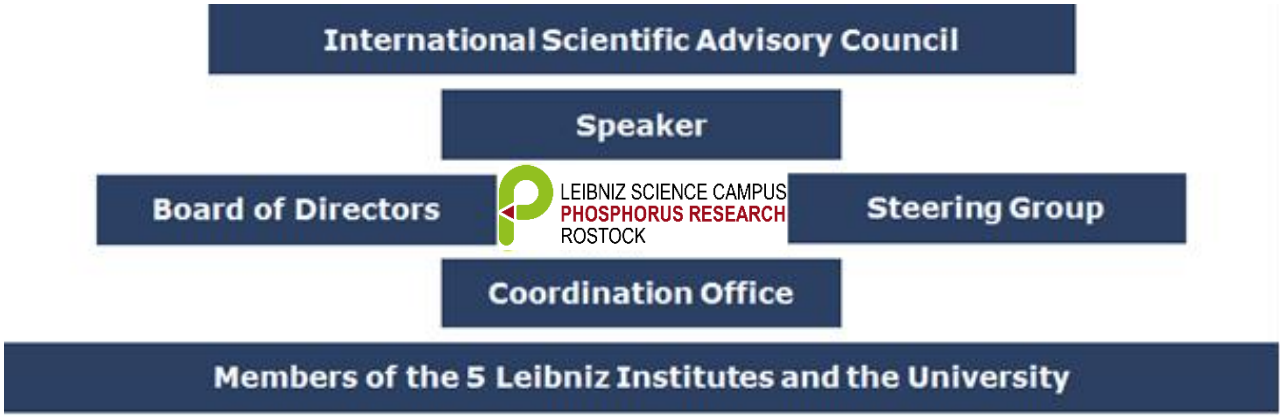


**Figure 4.** Structure of the Leibniz ScienceCampus Phosphorus Research Rostock

## 7.2 Committees

### 7.2.1 Scientific Advisory Council

Prof. Dr. Emmanuel Frossard, ETH Zürich, Switzerland
Prof. Dr. Ellery D. Ingall, Georgia Institute of Technology, USA
Prof. Dr. Helen Jarvie, University of Waterloo, Canada
Prof. Dr. Christian Müller, FU Berlin, Germany
Prof. Dr. Heidrun Steinmetz, TU Kaiserslautern, Germany

### 7.2.2 Directorship

Prof. Dr. Helge Arz, IOW (interim)
Prof. Dr. Matthias Beller, LIKAT
Prof. Dr. Andreas Graner, IPK
Prof. Dr. Wolfgang Schareck, UR

Prof. Dr. Klaus-Dieter Weltmann, INP
Prof. Dr. Klaus Wimmers, FBN

### 7.2.3 Spokesperson / Deputy

Prof. Dr. Ulrich Bathmann, IOW
Prof. Dr. Peter Leinweber, UR (spokesperson of the university)

### 7.2.4 Steering Committee

Prof. Dr. Ulrich Bathmann, IOW
Dr. Volker Brüser, INP
Dr. Klaus Dehmer, IPK
Prof. Dr. Bettina Eichler-Löbermann, UR
PD Dr. Dagmar-Christiane Fischer, UniMed Rostock
Dr. Marion Kanwischer, IOW
Prof. Dr. Ulf Karsten, UR
Prof. Dr. Udo Kragl, UR
Prof. Dr. Peter Leinweber, UR
Prof. Dr. Inna Sokolova, UR
Prof. Dr. Thomas Werner, LIKAT
Prof. Dr. Klaus Wimmers, FBN
Dr. Dana Zimmer, P-Campus

**Substitutes:**
Dr. Christian Hering-Junghans, LIKAT
Dr. Michael Oster, FBN
Prof. Dr. Axel Schulz, UR/LIKAT

### 7.2.5 Coordination Office

(Work and tasks 2022: see appendix)
Dr. Dana Zimmer (Coordinator)
Maxi Hoche (Secretary)

### 7.2.6 Members

(Status: Updated during 2022)

**Leibniz Institute for Catalysis (LIKAT) at the University of Rostock**

| | | |
|---|---|---|
| Prof. Dr. Matthias Beller | Applied Homogeneous Catalysis | Cluster III |
| Prof. Dr. Armin Börner | Asymmetric Catalysis | Cluster III |
| Prof. Dr. Marko Hapke | Cycloadditions and Transition Metal Catalysis | Cluster III |
| Dr. Christian Hering-Junghans | Small Molecule Activation | Cluster III |
| Dr. Yuya Hu | Organocatalysis | Cluster III |
| Dr. Dirk Michalik | Analytical Service | Cluster III |
| Prof. Dr. Uwe Rosenthal | Coordination Chemistry and Catalysis | Cluster III |
| Jan-Erik Siewert | Activation of small molecules | Cluster III |
| Constanza Terazzi | Organocatalysis | Cluster III |
| Jan Tönjes | Organocatalysis | Cluster III |
| Prof. Dr. Thomas Werner | Organocatalysis | Cluster III |

**Research Institute for Farm Animal Biology (FBN), Dummerstorf**

| | | |
|---|---|---|
| Linda Adzigbli | Genome Biology | Cluster IV |
| Christian Gerlinger | Genome Biology | Cluster IV |
| Prof. Dr. Tom Goldammer | Genome Biology | Cluster IV |
| Maruf Hasan | Genome Biology | Cluster IV |
| Prof. Dr. Cornelia Metges | Institute of Nutritional Physiology "Oskar Kellner" | Cluster IV |
| Dr. Michael Oster | Genome Biology | Cluster IV |
| Mohammad Seyed Al-moosavi | Institute of Nutritional Physiology "Oskar Kellner" | Cluster II |
| Prof. Dr. Klaus Wimmers | Genome Biology / Director | Cluster II, IV |
| PD Dr. Siriluck Wimmers | Genome Biology | Cluster IV |

**Leibniz Institute for Baltic Sea Research (IOW), Warnemünde**

| | | |
|---|---|---|
| Prof. Dr. Ulrich Bathmann | Directorate | Cluster I |
| Prof. Dr. Michael Böttcher | Geochemistry and Stable Isotope Biogeochemistry | Cluster I, Q |
| Dr. Philipp Braun | Microbial Processes and Phosphorus Cycle | Cluster I |
| Dr. Marion Kanwischer | Organic Contaminants | Cluster I, Q |
| PD Dr. Matthias Labrenz | Environmental Microbiology | Cluster I |
| Dr. Thomas Neumann | Baltic Sea System Dynamics | Cluster I |
| Dr. Sarah Piehl | Coastal and Marine Management | Cluster I |
| Dr. Hagen Radtke | Baltic Sea System Dynamics | Cluster I |
| Mariano Santoro | Environmental Microbiology | Cluster IV |
| Dr. Oliver Schmale | Biogeochemistry Trace Gases | Cluster I, Q |
| Prof. Dr. Detlef Schulz-Bull | Organic Contaminants | Cluster I, Q |
| Dr. Evgeny Sokolov | Directorate | Cluster IV |
| Dr. Angela Vogts | NanoSIMS Lab | Cluster Q |
| Dr. Dana Zimmer | Coordination Office | Cluster II |

**Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Satellite Collections North, Groß Lüsewitz**

| | | |
|---|---|---|
| Dr. Christine Brandt | Genebank, Satellite Collections North | Cluster II |
| Dr. Klaus J. Dehmer | Genebank, Satellite Collections North | Cluster II |
| Nagarjun Devabhakthini | Genebank, Satellite Collections North | Cluster II |
| Prof. Dr. Andreas Graner | Director | Cluster II |
| Mousumi Hazarika | Genebank, Satellite Collections North | Cluster II |
| Yue Hu | Genebank, Satellite Collections North | Cluster II |
| Dr. Mareike Kavka | Genebank, Satellite Collections North | Cluster II |

**Leibniz Institute for Plasma Science and Technology (INP), Greifswald**

| | | |
|---|---|---|
| Dr. Volker Brüser | Plasma Process Technology | Cluster II |
| Prof. Dr. Klaus-Dieter Weltmann | Director | |

**University of Rostock (UR)**

Faculty of Agricultural and Environmental Sciences

| | | |
|---|---|---|
| Prof. Dr. Christel Baum | Soil Science | Cluster II |
| Dr. Adrian Bischoff-Lang | Aquaculture and Sea-Ranching | Cluster I, II |
| Dr. Uwe Buczko | Landscape Ecology and Site Evaluation | Cluster I |
| Dr. Jörg Burgstaler | Agricultural Technology and Process Engineering | Cluster II |
| Dr. Carsten Croonenbroeck | Agricultural Economics | Cluster II |
| Prof. Dr. Bettina Eichler-Löbermann | Agronomy | Cluster II |
| Dr. Beatrice Garske | Research Unit Sustainability and Climate Policy | Cluster II |
| Prof. Dr. Bärbel Gerowitt | Crop Health | Cluster II |
| Felix Gumpert | Water Resources Management | Cluster II |
| Sebastian Heller | Grassland and Fodder Sciences | Cluster I |
| Katharine Heyl | Research Unit Sustainability and Climate Policy | Cluster V |
| Prof. Dr. Florian Jansen | Landscape Ecology and Site Evaluation | Cluster I |
| Julian Kirchgesser | Agronomy | Cluster II |
| Dipl. Agr.-Ing. Ulrich Knaus | Aquaculture and Sea-Ranching | Cluster I, II |
| Dr. Stefan Koch | Soil Physics | Cluster I |
| Prof. Dr. Peter Leinweber | Soil Science | Cluster II,Q |
| Prof. Dr. Bernd Lennartz | Soil Physics | Cluster I, II |
| Dr. Gert Morscheck | Waste Management and Material Flow | Cluster II |
| Mohsen Morshedizad | Soil Science | Cluster II |
| Dr. Jürgen Müller | Landscape Ecology and Site Evaluation | Cluster I |
| Prof. Dr. Michael Nelles | Waste Management and Material Flow | Cluster II |
| Prof. Dr. Harry Palm | Aquaculture and Sea-Ranching | Cluster I, II |
| Julia Prüter | Soil Science | Cluster I, Q |
| Kristin Steinfurth | Landscape Ecology and Site Evaluation | Cluster I |
| Prof. Dr. Jens Tränckner | Water Resources Management | Cluster II |
| Prof. Dr. Ralf Uptmoor | Agronomy | Cluster II |
| Paul Winklhofer | Crop Health | Cluster II |
| Prof. Dr. Nicole Wrage-Mönnig | Grassland and Fodder Sciences | Cluster II |
| Anika Zacher | Soil Science | Cluster II |

Faculty of Law

| | | |
|---|---|---|
| Prof. Dr. Dr. Felix Ekardt | Research Unit Sustainability and Climate Policy | Cluster V |

Faculty of Mathematics and Natural Sciences

| | | |
|---|---|---|
| Dr. Ashour Ahmed | Institute of Physics, Molecular Quantum Dynamics | Cluster Q |
| Dr. Martin Albrecht | Institute for Biological Sciences, Applied Ecology & Phycology | Cluster I |
| Dr. Maximilian Berthold | Institute for Biological Sciences, Applied Ecology & Phycology | Cluster I, Q |
| Dr. Jonas Bresien | Institute for Chemistry, Anorganic Chemistry | Cluster III |
| PD Dr. Stefan Forster | Institute for Biological Sciences, Marine Biology | Cluster I |
| Dr. Karin Glaser | Institute for Biological Sciences, Applied Ecology & Phycology | Cluster I |
| Prof. Dr. Martin Hagemann | Institute for Biological Sciences, Animal Physiology | Cluster II |
| Sandra Kammann | Institute for Biological Sciences, Applied Ecology & Phycology | Cluster IV |
| Prof. Ulf Karsten | Institute for Biological Sciences, Applied Ecology & Phycology | Cluster I, II |
| Prof. Udo Kragl | Institute for Chemistry, Analytical & Technical Chemistry; Technical Chemistry | Cluster III |
| Prof. Oliver Kühn | Institute of Physics, Molecular Quantum Dynamics | Cluster Q |
| Prof. Dr. Axel Schulz | Institute for Chemistry, Anorganic Chemistry | Cluster III |
| PD Dr. Rhena Schumann | Institute for Biological Sciences, Applied Ecology & Phycology, Biological Station Zingst | Cluster I, Q |
| Prof. Dr. Inna Sokolova | Marine Biology | Cluster II |
| Dr. Jan von Langermann | Institute for Chemistry, Biocatalysis | Cluster III |

Rostock University Medical Center

| | | |
|---|---|---|
| PD Dr. Hugo Murua Escobar | Hematology, oncology and palliative care | Cluster III |
| PD Dr. Dagmar-Christiane Fischer | Pediatric Clinic, Experimental Pediatrics Group | Cluster II |
| Prof. Dr. Christian Junghanß | Internal medicine, haematology, oncology, palliative ward | |
| Dr. Jonas Keiler | Institute for Anatomy | |
| Prof. Dr. Brigitte Vollmar | Institute for Experimental Surgery, University Medicine Rostock | Cluster II |

### 7.2.7 Associated members

**German Chemical Society, Working Group Phosphorus Chemistry**

Prof. Dr. Evamarie Hey-Hawkins
Prof. Dr. Jan J. Weigand
Prof. Dr. Robert Wolf

**University of Copenhagen, Research Group Soil Fertility**

Prof. Dr. Lars Stoumann Jensen
Prof. Dr. Jakob Magid
Prof. Dr. Dorette Sophie Müller-Stöver

# 8 Funding

The financial requirements in 2022 were covered by funding from the Ministry of Science, Culture, Federal and European Affairs Mecklenburg-Vorpommern (SM-MV), funding from the Leibniz Association and considerable contributions from the participating Leibniz Institutes and the University of Rostock. External funding by third parties for phosphorus research at the P-Campus was obtained as well (Table 1).

The coordination office of the P-Campus 2022 was funded by the SM-MV with 109,900 euros. Since 2014, the Coordination Office, located at the IOW, has consisted of two employees: a scientist and a secretary.

Since 2015, the P-Campus had an amount of € 1.2 million at his disposal, provided by the Leibniz Association, to be distributed over a period of four years to i.a. partially fund 11 interdisciplinary PhD projects. From June 2019 on, the Leibniz Association provides a total amount of € 1.13 million within the scope of the second funding period of the P-Campus.

# APPENDIX

## Contents

# Leibniz ScienceCampus Phosphorus Research Rostock

## Tasks of the Coordination Office 2022

In the following, the activities and thematic foci of the Coordination Office of the Leibniz ScienceCampus Phosphorus Research Rostock in 2022 are described. The coordination position has been occupied by Dr Dana Zimmer (scientific coordination) since October 2018 and Maxi Hoche (secretariat) since September 2019. The focus of the Coordination Office's work was, as before, the coordination of the partner institutions and its individual members, research foci and projects and, from June 2019, the organization of the P-Campus Graduate School of the new funding phase of the Leibniz Association (PGS2). Other tasks included i. a. the external representation of the P-Campus (e.g. regular website update), the preparation of reports and emails providing information to interested parties, the organization of other events of different formats (e.g. lecture series) and financial management (together with the administration department of the IOW). The work was carried out in close coordination with the spokesperson and the steering group of the P-Campus.

In the following, the priorities of the Coordination Office, including its function as a contact point, provider of support in the development of research project proposals, coordinator of the graduate school, event organizer as well as its public relations tasks are described in detail.

### Contact point

The Coordination Office of the P-Campus is the linchpin for networking, both within the P-Campus and externally, at national and international levels. In 2022, the Coordination Office continued to serve as a contact for all members of the P-Campus, new members and external persons and handled external inquiries, and forwarded targeted information to the relevant members/member groups. By mediating both internal and external contacts, the office supported networking among scientists.

Due to the visibility of the P-Campus research, the Coordination Office was contacted in 2020 and 2021 by a scientist from the **ZALF** (Leibniz Centre for Agricultural Landscape Research) and a scientist from the **Roman-Germanic Commission** of the German Archaeological Institute. It was possible, in both cases, to successfully establish contact with several scientists in the P-Campus.

In cooperation with the ZALF, a concept for a third-party funded project was developed in 2020 and 2021, in which the mutual influence of the (bio) availability of Si and P from the soil via groundwater to surface waters (limnic and marine) shall be investigated. In addition to the ZALF, the University of Rostock and IOW, the IGB (Leibniz Institute of Freshwater Ecology and Inland Fisheries) is also involved in the intended cooperation. The project application has been largely prepared and is expected to be submitted to the BMBF in the next months. The coordination office organized and documented the online meetings and coordinated the networking of the potential project partners.

For this purpose, two student research projects began in the winter semester of 2021/22, one with the soil science group and the other with the landscape ecology group at the Faculty of Agricultural and Environmental Sciences at the University of Rostock. The question posed by the archaeologists was whether the speciation of P compounds in soil samples from excavation sites can be used to derive information about the land use or way of life of the populations at that time. To this end, samples from two different exca-

vations in Southeast Europe and carried out investigations of the P fractions as part of a small student project in the WG Soil Science were taken during the semester work. Although it has not yet been possible to process a sufficiently large set of samples, initial hypotheses about the (historical) introduction of P-containing materials into the soils can be derived from sample analyses together with a very extensive already existing data set. This can be seen as a "proof of concept" and encourages further work in this direction. The planned work on vegetation under the supervision of the Landscape Ecology group could unfortunately not be carried out, as no student was found who was interested in such a thesis.

If possible, the work should serve as a basis for applications for third-party funded projects. Here, too, the coordination office not only initiated the contacts, but also organised and coordinated the meetings.

Contacts with **external research institutes, ministries and authorities** were regularly maintained (e.g. 05.12.2022 presentation of recent research results of the P-Campus to ministry members).

Furthermore, there are contacts with **other networks**, e.g. the INF (Interdisciplinary Faculty), and the German Phosphorus-Platform (DPP).

**Research topics and initiatives**

The P-Campus thrives on the continuous initiatives of its scientists in developing research themes and ideas and in considering proposals for their realization. The funding of six new **seed projects** could be supported by the P-Campus with the official start of the second funding period in June 2019. All six projects have been successful, and since 2022 all final reports are available in the coordination office. In the summer and autumn of 2022, a call for seed projects was initiated by the coordination office with regard to the envisaged **Leibniz Research Network** "P-Health - Phosphorus in Agriculture, Environment and Nutrition: Ecological Consequences and Societal Challenges" and the **DFG Research Training Group** "PhAMoS - Phosphorus Acquisition, Metabolism and Signaling in aquatic and terrestrial organisms". Eleven seed projects were approved. Both initiatives are to become the successor projects for the current Leibniz Science Campus funding after 2023 at the latest. For this purpose, the P-Campus Coordination Office organized appropriate meetings (online or presence) for both initiatives in 2022 as well. At the **International P-Campus Symposium** (November 24 and 25, 2022), both research initiatives were presented to the Scientific Advisory Council and P-Campus members.

**Structured graduate support**

As young scientists are a significant part of the P-Campus network, a structured framework for their support and encouragement is offered by the P-Campus. The Coordination Office is responsible for the coordination and administration of the new graduate school and will organize several events and other networking opportunities for the PhD students again. Since June 2019, the new PhD students were gradually employed (last employment in October 2020). After the **start workshop P-Analytics** in November 2019 and the **P-Breakfast** in December 2019, no face-to-face events for PhD students could be organised by the coordination office until 2022 due to the restrictions caused by the pandemic. After the **Winter School "Publishing"** for the PhD students of the P-Campus and the University of Rostock had to be postponed several times due to the pandemic, it could finally take place as the **Summer School "Scientific Writing and Successful Publishing"** from 6 to 9 September. In September, a P-Breakfast for the PhD students was organised again, for the first time after December 2019.

In 2022, the annual P-Campus lecture series with a total of six lectures was organised by the P-Campus Coordination Office with five online events and one hybrid event. All lectures were presented by academics outside the P-Campus. The **International P-Campus Symposium** took place in November 2022 as a hybrid event. At this symposium, which was also attended by representatives of the International Scientific Advisory Board, ten P-Campus PhD students presented their research results as lectures and three as posters.

Due to the pandemic, some PhD projects of the PGS2 were not able to carry out their research in 2020, 2021 and partly in 2022 as planned, resulting in time delays. As in 2021, the coordination office also took care of the approval of additional funding for these PhD projects in 2022.

**Event organization**

The events organized and guided by the Coordination Office are an important basis not only for networking but also for the internal and external representation of the P-Campus. In 2022, this included i. a. the organization of the P-Campus **Steering Group** meetings (including the presentation of current developments, taking minutes, etc.), the **International P-Campus Symposium** (hybrid format) in November 2022, the organization of the **annual year-end meeting** (on-site event) between representatives of the P-Campus and the Ministry of Science, Culture, Federal and European Affairs MV and the Ministry for Climate Protection, Agriculture, Rural Areas and the Environment MV, respectively, as well as the organisation of the lecture series, the P-Breakfast and the summer school (see above).

The **18th European Workshop on Phosphorus Chemistry (EWPC 18)** was supposed to take place in Rostock in spring 2021. The EWPC was started to be organized in 2020 by members of LIKAT, the Institute of Chemistry of the University of Rostock and the coordination office of the P-Campus. Unfortunately, the on-site conference had to be cancelled in 2021; a very well-attended online conference was held instead. However, EWPC 18 could then be held in 2022 as an on-site event at the University of Rostock (https://www.ewpc18.uni-rostock.de/) from September 14 to 16. The organization was done by the same organizing committee as originally. In addition to 31 international presentations from the field of chemistry, three presentations in a special P-Campus session demonstrated the multifaceted P-research in the P-Campus.

The following talks were presented in the P-Campus session:

Dana Zimmer (IOW) The Leibniz ScienceCampus Phosphorus Research Rostock.

Ashour Ahmad (UR) Advances in understanding of P binding in soil: A molecular modeling perspective.

Yue Hu (IPK) Effects of recycling products on P efficiency of forage legumes in a two-year field trial.

**Public relations**

The P-Campus is a prominent research network among six partner institutions in Mecklenburg-Vorpommern and is represented not only regionally but also nationally and internationally. The coordination office is responsible for the presentation of the P-Campus at various **events** and in the **media** (articles, interviews).

Together with PhD students of the P-Campus, the P-Campus Coordination used to present different research topics of the P-Campus to a broad public at the "Long Night of Sciences" at the University of Rostock every year. In 2022, this event took place again,

although in a limited way, but still in presence; unfortunately, the P-Campus was not able to participate. However, participation is planned again for 2023.

Moreover, the development and **provision of information** (handouts, posters, presentations) about the P-Campus is part of the tasks of the coordination office. That also means that members of the P-Campus are actively addressed to represent the P-Campus at interesting events (conferences, workshops etc.). Selected workshops and other small events are used to increase the level of awareness of the P-Campus and attract new members by **offering P-Campus advertising material** (writing pads, cloth bags, flyers, etc.). These measures were only possible to a limited extent in 2022. However, the P-Campus Coordination also participated in the organisation of the EWPC in 2022, which took place in presence in September 2022, so that the P-Campus could also present itself by providing promotional material.

The coordination office offers support related to introducing the P-Campus to external scientific groups, policy makers, authorities, and the general public through visual presentations, such as research posters. For this purpose, appropriate **templates** and information are prepared and provided to the members.

Another important task was the design and maintenance of the **website** including content development, in coordination with relevant scientists. The website is updated continuously with new information from the P-Campus (e.g. new publications, P relevant events). Furthermore, the coordination office compiles texts and information that allow the presentation of the P-Campus on other websites (for example, those of the DPP and the ESPP).

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