LEIBNIZ SCIENCE CAMPUS
PHOSPHORUS RESEARCH
ROSTOCK

Activity Report 2020

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 LEIBNIZ 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 more than 100 scientists from six research institutes in different disciplines working in 19 third-party funded projects. 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 limited by the Corona pandemic, events of various formats were held this year by the P-Campus to promote **networking** at all levels. Internal meetings and workshops took place to intensify both the networking of scientists at the P-Campus and scientific cooperation/exchange among them. Events for the PhD students in the P-Campus and in the P-Campus Graduate School (PGS) such as the P-Breakfast and a second start-workshop P-Analytics (originally planned summer 2020) at the Biological Station Zingst could not take place due to the Corona restrictions. For the winter semester 2020/21 (Oct. 2020 to March 2021), a lecture series as a video colloquium with 10 lectures has been organized by the P-Campus coordination office.

Especially the **International** P-Campus Symposium (16.-17.11.2020), at which the international scientific advisory council of the P-Campus participated, can be highlighted as event for all members of the P-Campus (and external interested parties). This year, the symposium was conducted entirely online. Due to the online format, more external participants (22 external out of a total of 70 participants) were welcomed than in previous years. The personal exchange between the PhD students during the P-Campus Symposium was unfortunately limited by the online format.

Furthermore, the P-Campus is an active member of the 'Deutsche Phosphor Plattform (DPP)' and the European Sustainable Phosphorus Platform (ESPP). Further networking activities were 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. Moreover, the first chapters of the electronic handbook P-Analytics were translated in English in May 2020 (Handbook on the Selection of Methods for Digestion and Determination of Total Phosphorus in Environmental Samples, DOI: 10.12754/misc-2020-0001) and are freely available after registration on the P-Campus website at https://wissenschaftscampus-rostock.de/intern-en.html. The English chapters are also intended to be of help in P analytics to the English-speaking PhD students employed in PGS 2 in the P-Campus. 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 not possible in 2020 as conferences were cancelled and research stays were not possible.

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' at the Biological Station Zingst in November (CW 48) 2019 was organized and co-supervised for the new PhD students of the P-Campus. A second start workshop for the PhD students hired later, originally planned for summer 2020, could not be realized due to Corona restrictions. In 2020, the fourth PhD thesis of

PGS 1 was successfully completed. The fifth PhD thesis was submitted in 2020 and successfully defended on February 4, 2021.

In 2020, 19 **third-party funded projects** (two of them started in 2020), that 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. Most of the projects were completed in 2019, some of the projects were still running in 2020. Due to Corona restrictions, some of the laboratory work was delayed, necessitating cost-neutral extensions for two projects (P-Cat and ProCycle). The ProCycle project was successfully completed in December 2020 and the P-Cat project is expected to end in summer 2021. Project reports can be made available upon request (except for P-Cat currently).

The following four publications received the **Publication Award 2020**, since authors of at least two partner institutes were involved in the peer-reviewed publications (P-Campus members in **bold**, (former) PhD students additionally in ***italics***):

Gros, P., Meissner, R., ***Wirth, M.A.***, **Kanwischer, M.**, Rupp, H., **Schulz-Bull, D.E.**, **Leinweber, P.** (2020) Leaching and degradation of $^{13}C_2$-^{15}N-glyphosate in field. Environ Monit Assess 192: 127, DOI: 10.1007/s10661-019-8045-4

Hu, Y., Peglow, S., ***Longwitz, L.***, Frank, M., Epping, J.D., **Brüser, V.**, **Werner, T.** (2020) Plasma-assisted immobilization of a phosphonium salt and its use as a catalyst in the valorization of CO_2. ChemSusChem 2020, 13, 1825 –1833, DOI: 10.1002/cssc.201903384

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. J Soils Sediments, DOI: 10.1007/s11368-019-02518-w

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 **public relations work** of the P-Campus included besides text writing, publishing and presentations also the maintenance of the website. Due to Corona restrictions, the "Long Night of the Sciences" at the University of Rostock, where normally the P-Campus would have presented current research topics to the public, was cancelled. In 2020, work continued on the information video on research in the P-Campus. In the process, many members of the P-Campus also provided input in the form of text blocks, photos and video recordings or other support for the subcontractor commissioned with the work. The video will be completed in the first quarter of 2021 and will later be freely available on the internet.

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. 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. 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 Farm Animal Biology (FBN), Dummerstorf
- Leibniz Institute for Baltic Sea Research Warnemünde (IOW)
- Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Satellite Collections North, Groß Lüsewitz
- Leibniz Institute for Plasma Science and Technology (INP), Greifswald
- 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.

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.

15 publications were published in “Cluster I: P in the Environment”. Especially the following publication can be highlighted, as it emphasizes the interdisciplinary collaboration in

the P-Campus. The institutions of the P-Campus members are inserted in brackets after the name in each case.

Berthold, M. (UR, Applied Ecology & Phycology), Nausch, G. (IOW), von Weber, M., Koch, S. (UR, AG Bodenphysik), Kahle, P. (UR, Soil Physics), Lennartz, B. (UR, Soil Physics), Tränckner, J. (UR, Water Management), Buczko, U. (UR, Landscape Ecology), Tonn, C., Ekardt, F. (UR, Faculty of Law; Research Unit Sustainability and Climate Policy), Bathmann, U. (IOW) (2020) Phosphorus and the Baltic Sea: Sustainable Management. Encyclopedia of Water: Science, Technology, and Society: 2479-2498, DOI: 10.1002/9781119300762.wsts0146, ISBN: 978-1-119-30075-5

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. 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.

The interdisciplinary nature of the cluster, which covers all sub-areas of the agricultural P cycle (soil, plant, animal, water, process engineering ...), enables a realistic assessment of the portion of the P application rates that in the future are replaceable with renewable P sources.

In 2020, seven publications were published in "Cluster II: Sufficiency and Efficiency of P Utilization, P Recycling". The following publication by PhD student Julia Prüter deserves special mention.

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 2020, 10(10), 466, DOI: 10.3390/agriculture10100466

In this publication, sophisticated spectroscopic analytical methods (Py-FiMS, XANES) are used across disciplines (soil science and aquaculture) in addition to classical wet chemical analyses, and the research results are linked.

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 (-3 to +5) and coordination numbers, phosphorus-containing compounds of most different 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. This is what makes it possible to access numerous products

and carry out many 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, and the synthesis of antitumor compounds are addressed.

14 publications were published in "Cluster III: P in Synthesis and Catalysis". PhD student Yuya Hu published two papers as lead author (also received the P-Campus publication award for one) and successfully defended her dissertation in October 2020.

Hu, Y., Peglow, S., Longwitz, L., Frank, M., Epping, J.D., Brüser, V., Werner, T. (2020) Plasma-assisted immobilization of a phosphonium salt and its use as a catalyst in the valorization of CO_2. ChemSusChem 2020, 13, 1825-1833, DOI: 10.1002/cssc.201903384

Hu, Y., Wei, Z., Frey, A., Kubis, C., Ren, C.-Y., Spannenberg, A., Jiao, H., Werner, T. (2020) Catalytic, kinetic and mechanistic insights into the fixation of CO_2 with epoxides catalyzed by phenol functionalized phosphonium salts. ChemSusChem 2020, DOI: 10.1002/cssc.202002267

In this cluster, the defended dissertation of Lars Longwitz (with grading summa cum laude) can also be highlighted. He was involved in four publications as co-author and published six publications as lead author during his doctoral studies as of 2017.

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).

11 publications could be assigned to "Cluster IV: Molecular Biology of P". Of these, two publications originated as a collaboration between the IOW and the working group Marine Biology of the UR on P in the metabolism of bivalves that can survive under hypoxic conditions (a). Furthermore, there are seven publications on P in animal metabolism (partly also assigned to cluster II) in responsibility of the FBN together with cooperation partners from the Faculty of Agricultural and Environmental Sciences and the University Medical

Center on the complex regulation of P absorption, utilization and excretion in the metabolism of quails, chickens and pigs (b; lead author from FBN) and two further publications with FBN participation (c) in collaboration with the University of Hohenheim.

(a) Publications on the metabolism of mussels under hypoxic conditions (IOW and University of Rostock)

Falfushynska, H.I., Sokolov, E., Piontkivska, H., Sokolova, I. (2020) The role of reversible protein phosphorylation in regulation of the mitochondrial electron transport system during hypoxia and reoxygenation stress in marine bivalves. Front. Mar. Sci. 7: 467, DOI: 10.3389/fmars.2020.00467

Sukhotin, A., Kovalev, A., Sokolov, E., Sokolova, I. (2020) Mitochondrial performance of a continually growing marine bivalve, *Mytilus edulis*, depends on body size. J. Experimental Biol. 223: jeb22633, DOI: 10.1242/jeb.226332

(b) Publications on complex P-regulatory activities (lead author from FBN)

Gerlinger, C., Oster, M., Reyer, H., Polley, C., Vollmar, B., Muráni, E., Wimmers, K., Wolf, P. (2020) Effects of excessive or restricted phosphorus and calcium intake during early life on markers of bone architecture and composition in pigs. J. Anim. Physiol. Anim. Nutr. 2020;00:1–11, DOI: 10.1111/jpn.13286

Oster, M., Reyer, H., Keiler, J., Ball, E., Mulvenna, C., Muráni, E., Ponsuksili, S., Wimmers, K. (2020) Comfrey (*Symphytum* spp.) as an alternative field crop contributing to closed agricultural cycles in chicken feeding. Sci. Total Environ. 742: 140490, DOI: 10.1016/j.scitotenv.2020.140490

Oster, M., Reyer, H., Ponsuksili, S., Trakooljul, N., Camarinha-Silva, A., Bennewitz, J., Rodehutscord, M., Wimmers, K. (2020) Towards improved phosphorus efficiency in poultry species. Europ. Poult Sci., 84, DOI: 10.1399/eps.2020.314

Oster, M., Reyer, H., Trakooljul, N., Weber, F. M., Xi, L., Muráni, E., Ponsuksili, S., Rodehutscord, M., Bennewitz, J., Wimmers, K. (2020) Ileal transcriptome profiles of japanese quail divergent in phosphorus utilization. Int. J. Mol. Sci. 2020, 21, 2762, DOI: 10.3390/ijms21082762

Ponsuksili, S., Reyer, H., Hadlich, F., Weber, F., Trakooljul, N., Oster, M., Siengdee, P., Muráni, E., Rodehutscord, M., Camarinha-Silva, A., Bennewitz, J., Wimmers, K. (2020) Identification of the key molecular drivers of phosphorus utilization based on host miRNA-mRNA and gut microbiome interactions. Int. J. Mol. Sci., 21, 2818, DOI: 10.3390/ijms21082818

Siengdee, P., Oster, M., Reyer, H., Viergutz, T., Wimmers, K., Ponsuksili, S. (2020) Morphological and molecular features of porcine mesenchymal stem cells derived from different types of synovial membrane, and genetic background of cell donors. Frontiers in Cell and Developmental Biology 8: 601212, DOI: 10.3389/fcell.2020.601212

Wubuli, A., Gerlinger, C., Reyer, H., Oster, M., Muráni, E., Trakooljul, N., Ponsuksili, S., Wolf, P., Wimmers, K. (2020) Reduced phosphorus intake throughout gestation and lactation of sows is mitigated by transcriptional adaptations in kidney and intestine. BMC Genomics 21: 626, DOI: 10.1186/s12864-020-07049-0

(c) Publications on complex P-regulatory activities (co-author(s) from FBN)

Sommerfeld, V., Omotoso, A.O., Oster, M., Reyer, H., Camarinha-Silva, A., Hasselmann, M., Huber, K., Ponsuksili, S., Seifert, J., Stefanski, V., Wimmers, K., Rodehutscord, M. (2020) Phytate degradation, transcellular mineral transporters, and mineral utilization by two strains of laying hens as affected by dietary phosphorus and calcium. Animals 10, 1736, DOI: 10.3390/ani10101736

Sommerfeld, V., Huber, K., Bennewitz, J., Camarinha-Silva, A., Hasselmann, M., Ponsuksili, S., Seifert, J., Stefanski, V., Wimmers, K., Rodehutscord, M. (2020) Phytate degradation, myo-inositol release, and utilization of phosphorus and calcium by two strains of laying hens in five production periods. Poultry Science 99, 6797-6808, DOI: 10.1016/j.psj.2020.08.064

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.

In Cluster V, eight publications were published in 2020, although this cluster is the smallest research cluster with only four members. In particular, the publication Heyl, Döring, Garske, Stubenrauch, Ekardt (2020) The Common Agricultural Policy beyond 2020: A critical review in light of global environmental goals. RECIEL, DOI: 10.1111/reel.12351 by the new PhD student Katharine Heyl, who started her PhD thesis in summer 2019 in the project "V. Governance options for closed P cycles - the GAP 2020 revision". This topic (Governance options for closed P cycles - the GAP 2020 revision) is elaborated as part of PGS 2.

3.2 Research Projects

Within the research clusters, 19 disciplinary and interdisciplinary, third-party funded projects (including PGS 2) were thematically assigned to the P-Campus in 2020 (Table 1). Two of these projects started newly in 2020.

Table 1. Third-party funded research projects thematically assigned to the P-Campus (status as of December 2020; *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	*01/2016-06/2020*	*DFG*	*University of Rostock (AUF, MNF), IOW*	*I*
CLIMARCTIC: Einfluss des Klimawandels auf arktische Boden- und See-Mikrobiome	*03/2017 - 02/2020*	*DFG*	*University of Rostock (MNF)*	*I*

Project Name	Term	Sponsor	Participating Partners of the P-Campus	Cluster
CRUSTFUNCTION II: Biodiversität und funktionelle Rolle von biologischen Bodenkrusten II	*07/2017-06/2020*	*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	07/2019-06/2023	WGL	FBN, IOW, INP, IPK, LIKAT, University of Rostock	I, II, III, IV, V
InFertRes: Innovative Fertilizers and Resource Efficiency in Agriculture	03/2018–02/2021	BMBF	University of Rostock (AUF)	II
InnoSoilPhos II: Innovative solutions to sustainable soil phosphorus management	03/2018 – 02/2021	BMBF	University of Rostock (AUF)	I, II, Q
INTEGRAL: Integrated carbon and trace gas monitoring for the Baltic Sea	*07/2017-06/2020*	*BONUS*	*IOW*	*I*
Kombination von Biokatalyse und Kristallisation für die Synthese chiraler Amine	*04/2019-03/2022*	*BMWi*	*University of Rostock (MNF)*	*III*
MitoBOX: The mitochondrial basis of hypoxia tolerance in marine mollusks	*02/2019-01/2022*	*DFG*	*University of Rostock (MNF)*	*IV*
NuReDrain: Innovative Nutrient Catching Reactive Barrier and Controlled Drainage Technologies for Sustainable Growth of the Agriculture Sector	*2017-2020*	*North Sea Region Programme (EU)*	*University of Rostock (AUF)*	*I, II*
OPTIMUS: Optimierung von Muschelfarmen zur Eutrophierungsvermeidung und zur Fischfutterproduktion in der Ostsee	*04/2017-03/2020*	*BONUS*	*IOW*	*I*
Characterizing endocrine and transcriptional determinants of P utilization mediated by the environment-host-microbiota interaction in laying hens and quails, Teilprojekt in FOR 2601	*06/2018 – 11/2021*	DFG	FBN	IV
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
PEGaSus: Phosphorus efficiency in Gallus gallus and Sus scrofa: Bridging the gaps in the phosphorus value chain	*09/2017-08/2020*	*ERA-NET SUSAN*	*FBN*	*I, II*
PNC-Processing: Stoffkreisoptimierung durch Fraktionierung von Gülle in Phosphor, Stickstoff und organischen Kohlenstoff	07/2019-12/2021	BMBF	University of Rostock (AUF)	II
Verbundvorhaben: Züchterische Verbesserung der Phosphor-Aneignungseffizienz von Stärkekartoffeln und eine ressourcenschonende Rohstoffproduktion; Teilvorhaben 1	03/2019-02/2022	BMEL	IPK	II
Verbundvorhaben: Züchterische Verbesserung der Phosphor-Aneignungseffizienz von Stärkekartoffeln und eine ressourcenschonende Rohstoffproduktion; Teilvorhaben 2	03/2019-02/2022	BMEL	University of Rostock (AUF)	II

Project Name	Term	Sponsor	Participating Partners of the P-Campus	Cluster
WETSCAPES: Stoffumsetzungsprozesse an Moor- und Küstenstandorten als Grundlage für Landnutzung, Klimawirkung und Gewässer-schutz	*01/2017-12/2020*	*European Social Fund*	*University of Rostock (AUF)*	*I, II, Q*

PGS 1, funded by the Leibniz Association (WGL), conducted research in eleven thematically affiliated individual projects, which are listed in table 2a. Two PhD students dropped out due to personal reasons, the respective supervisors finished the projects (red font). There were four dissertations successfully completed. In addition, a fifth dissertation was submitted in 2020 and successfully defended in February 2021 (green font). The sixth dissertation was submitted in early January 2021 (orange font). For the remaining three projects, the goal is to submit the dissertation during 2021.

Table 2a. Subprojects of the Graduate School 1 (PGS 1; 2015-2019, financed by the Leibniz Association) (green: dissertation fully completed, orange: dissertation submitted, defence 2021, 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

The PGS 2 consists of 15 projects (Table 2b), which all started by October 2020. Project I.1 will be re-advertised during the first quarter 2021 (orange font) as the original project officer passed away in the first half of 2020.

Table 2b. Subprojects of the Graduate School 2 (PGS 2, 2019-2023, financed by the Leibniz Association), project to be re-advertised in 2021 in orange font

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

Project	Participating Partners	Research Focus
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
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 potatoe production: Cloning ans squencing of candidate genes improving P aquisition 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 GAP 2020 revision	UR, IOW	V

Additionally, six new seed projects were granted in the second funding period (five started in 2019, one started in 2020 (Table 3)). In 2020, three seed projects of the six projects approved in July 2019 were still ongoing. Five projects were completed by the end of 2020 at the latest (including final report). One project was cost-neutrally extended to summer 2021 due to Corona restrictions. The respective short reports of the completed projects (green) can be provided upon request.

Table 3. Seed projects of the P-Campus 2019, funded by WGL grant of the P-Campus and approved in July 2019 (projects with final report available in green)

Project	Participating Partners
Funding Period 2	
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) (07/2019-12/2020)	UR, IOW
Dietary effects on DNA methylation in porcine parathyroid glands (EpiPTG) (07/2019-03/2020)	FBN, UR, UMR
Entwicklung enantioselektiver katalytischer Wittig Reaktionen basierend auf chiralen Phosphorverbindungen als Katalysatoren (P-CAT) (07/2020-06/2021)	UR, LIKAT

Abbreviations: FBN= Leibniz Institute for Farm Animal Biology, 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, doctoral students, and postdocs) whose thesis or project concerns phosphorus research. All relevant information are provided to young scientific members of the P-Campus. In addition to their inclusion in events involving the P-Campus and in scientific and thematic networks, for example, those of the DPP and ESPP, they can apply to the P-Campus for grants and for financial support for internationalization (travels, publications and visiting scientists, including longer stays).

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 doctoral projects of the first period and the 15 doctoral projects of the second period cover important areas of knowledge and research (table 2a + 2b). BSc and MSc thesis topics in phosphorus research have also been developed during the first period.

All doctoral students are supervised by a committee of scientists from at least two partner organizations of the P-Campus (e.g. the Leibniz Institute for Baltic Sea Research and the University of Rostock). The students present their work at the annual P-Campus Symposium, held in November. Lively exchanges of information between doctoral students are promoted through various events, such as workshops and the regularly held P-Breakfast (see Section 5). Positive support for these activities has come from opening up the events to other doctoral students with thesis topics in phosphorus-related research.

Until the end of 2020, four PhD students of the first Graduate School completed their doctoral thesis (including defence; green font in table 2a) and another PhD student submitted his doctoral thesis (orange font in table 2a). The defence date scheduled for Dec. 15, 2020, has been postponed to Feb. 4, 2021, due to Corona. The sixth dissertation was submitted at the beginning of January 2021. The remaining three dissertations are expected to be submitted in the course of 2021. Of the original eleven projects, two were abandoned for personal reasons and the projects were completed by the supervisors. In PGS 2, all 15 PhD projects started by November 2020. One project had to be reworked with regard to the project objectives and advertised again in early 2021 since the project officer died in May 2020. The position is to be filled in the first half of 2021.

3.4 Publications

Publications with reference to phosphorus research by the members of the P-Campus in 2020:

Baumann, K., Nastha, S., Shaheen, S.M., Rinklebe, J., Leinweber, P. (2020) Phosphorus cycling and spring barley crop response to varying redox potential. Vadose Zone Journal, DOI: 10.1002/vzj2.20088

Baumann, K., Shaheen, S.M., Hu, Y., Gros, P., Heilmann, E., Morshedizad, M., Wang, J., Wang, S.-L., Rinklebe, J., Leinweber, P. (2020) Speciation and sorption of phosphorus in agricultural soil profiles of redoximorphic character. Environ Geochem Health, DOI: 10.1007/s10653-020-00561-y

Beer, H., Bläsing, K., Bresien, J., Chojetzki, L., Schulz, A., Stoer, P., Villinger, A. (2020) Trapping of Bronsted acids with a phosphorus-centered biradicaloid - synthesis of hydrogen pseudohalide addition products. Dalton Transactions, 49, 13655-13662, DOI: 10.1039/d0dt03251d

Beer, H., Bresien, J., Michalik, D., Rölke, A.-K., Schulz, A., Villinger, A., Wustrack, R. (2020) Heterocyclopentanediyls vs heterocyclopentadienes: A question of silyl group migration. J. Organic Chem., 85, 14435-14445, DOI: 10.1021/acs.joc.0c00460

Beer, H., Bresien, J., Michalik, D., Schulz, A., Villinger, A. (2020) Reversible switching between housane and cyclopentanediyl isomers: an isonitrile-catalyzed thermal reverse reaction. Dalton Transactions, 49, 13986-13992, DOI: 10.1039/D0DT02688C

Berthold, M., Nausch, G., von Weber, M., Koch, S., Kahle, P., Lennartz, B., Tränckner, J., Buczko, U., Tonn, C., Ekardt, F., Bathmann, U. (2020) Phosphorus and the Baltic Sea: Sustainable Management. Encyclopedia of Water: Science, Technology, and Society: 2479-2498, DOI: 10.1002/9781119300762.wsts0146, ISBN: 978-1-119-30075-5

Berthold, M., Schumann, R. (2020) Phosphorus dynamics in a eutrophic lagoon: Uptake and utilization of nutrient pulses by phytoplankton. Front. Mar. Sci. 7: 281, DOI: 10.3389/fmars.2020.00281

Bresien, J., Pilopp, Y., Schulz, A., Szych, L.S., Villinger, A., Wustrack, R. (2020) Synthesis of sterically demanding secondary phosphides and diphosphanes and their utilization in small-molecule activation. Inorg. Chem., 59, 13561-13571, DOI: 10.1021/acs.inorgchem.0c01934

Chojetzki, L., Schulz, A., Villinger, A., Wustrack, R. (2020) Cycloaddition of alkenes and alkynes to the P-centered singlet biradical [P(μ-NTer)]2. Zeitschrift fuer Anorganische und Allgemeine Chemie, 646, 614-624, DOI: 10.1002/zaac.201900191

Ekardt, F., Jacobs, B., Stubenrauch, J., Garske, B. (2020) Peatland governance: The problem of depicting in sustainibility governance, regulatory law, and economic instruments. Land 2020, 9(3), 83, 1-24, DOI: 10.3390/land9030083

Eichler-Löbermann, B., Busch, S., Jablonowski, N.D., Kavka, M., Brandt, C. (2020) Mixed cropping as affected by phosphorus and water supply. Agronomy 2020, 10(10), 1506, DOI: 10.3390/agronomy10101506

Falfushynska, H.I., Sokolov, E., Piontkivska, H., Sokolova, I. (2020) The role of reversible protein phosphorylation in regulation of the mitochondrial electron transport system during hypoxia and reoxygenation stress in marine bivalves. Front. Mar. Sci. 7: 467, DOI: 10.3389/fmars.2020.00467

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

Garske, B., Stubenrauch, J., Ekardt, F. (2020) Sustainable phosphorus management in European agricultural and environmental law. Review of European, Comparative and International Environmental Law 2020;29: 107-117, DOI: 10.1111/reel.12318

Gerlinger, C., Oster, M., Reyer, H., Polley, C., Vollmar, B., Muráni, E., Wimmers, K., Wolf, P. (2020) Effects of excessive or restricted phosphorus and calcium intake during early life on markers of bone architecture and composition in pigs. J. Anim. Physiol. Anim. Nutr. 2020;00:1–11, DOI: 10.1111/jpn.13286

Grandane, A., Nocentini, A., Werner, T., Zalubovskis, R., Supuran, C.T. (2020) Benzoxepinones: A new isoform-selective class of tumor associated carbonic anhydrase inhibitors. Bioorg. Med. Chem. 2020, 28, 115496, DOI: 10.1016/j.bmc.2020.115496

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

Guardia-Puebla, Y., Llanes-Cedeño, E., Rodríguez-Pérez, S., Arias-Cedeño, Q., Sánchez-Girón, V., Morscheck, G., Eichler-Löbermann, B. (2020) Sustainable management of wastewaters generated from fruit and vegetables processing: Theoretical design of combined UASB and artificial wetlands systems. J. Water Land Develop. 47, 66-76, DOI: 10.24425/jwld.2020.135033

Gussone, N., Böttcher, M.E., Conrad, A.C., Fiebig, J., Pelz, M., Grathoff, G., Schmidt, B.C. (2020) Calcium isotope fractionation upon experimental apatite formation. Chem. Geol., 551, 119737, DOI: 10.1016/j.chemgeo.2020.119737

Habedank, F., Feldhusen, F., Schulz-Bull, D., Kanwischer, M. (2020) Analysis of organophosphate pesticides in surface water - Comparison of method optimization approaches. Journal of Chemometrics 34, 5: e3220, DOI: 10.1002/cem.3220

Harloff, J., Schulz, A., Stoer, P., Villinger, A. (2020) Pseudohalide HCN aggregate ions: $[N_3(HCN)_3]^-$, $[OCN(HCN)_3]^-$, $[SCN(HCN)_2]^-$ and $[P(CN{\cdot}HCN)_2]^-$. Dalton Transactions, 49, 13345-13351, DOI: 10.1039/d0dt02973d

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. Review of European, Comparative and international Environmental Law, 00, S. 1-12, DOI: 10.1111/reel.12351

Hu, Y., Peglow, S., Longwitz, L., Frank, M., Epping, J.D., Brüser, V., Werner, T. (2020) Plasma-assisted immobilization of a phosphonium salt and its use as a catalyst in the valorization of CO_2. ChemSusChem, 13, 1825 –1833, DOI: 10.1002/cssc.201903384

Hu, Y., Wei, Z., Frey, A., Kubis, C., Ren, C.-Y., Spannenberg, A., Jiao, H., Werner, T. (2020) Catalytic, kinetic and mechanistic insights into the fixation of CO_2 with epoxides catalyzed by phenol functionalized phosphonium salts. ChemSusChem, DOI: 10.1002/cssc.202002267

Hülsewede, D., Temmel, E., Kumm, P., von Langermann, J. (2020) Concept study for an integrated reactor-crystallizer process for the continuous biocatalytic synthesis of (S)-1-(3-Methoxyphenyl)ethylamine. Crystals, 10(5), 1-13, DOI: 10.3390/cryst10050345

Jung, P., Baumann, K., Emrich, D., Springer, A., Felde, V.J.M.N.L., Dultz, S., Baum, C., Frank, M., Büdel, B., Leinweber, P. (2020) Lichens bite the Dust - A bio-weathering scenario in the Atacama Desert. iScience 23, 11, DOI: 10.1016/j.isci.2020.101647

Legesse, S., Lemessa, F., Wolf, P., Eichler-Löbermann, B. (2020) Oat (*Avena sativa* L.) supplemented with fenugreek (*Trigonella foenum-graecum* L.) as a potential alternative for teff [*Eragrostis tef* (Zucc.) Trotter] for human nutrition in Ethiopia. Comm. Soil Sci. Plant Anal. 51, 22, 2846-2857, DOI: 10.1080/00103624.2020.1849268

Leinweber, P. Baum, C., Zacher, A. (2020) Und jetzt auch noch der Phosphor … . DLG-Mitteilungen 6/2020, 13-15.

Lennartz, B., Bauwe, A., Koch, S., Kahle, P. (2020) Wie gelangt Phosphor ins Meer?, DLG-Mitteilungen 6/2020, 20-21.

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

Lohrer, C., Cwierz, P., Wirth, M., 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

Longwitz, L., Werner, T. (2020) Reduction of activated alkenes by P(III)/P(V) redox cycling catalysis. Angew Chem Int Ed 132, 2782 –2785, DOI: 10.1002/anie.201912991

López, R., Eichler-Löbermann, B., Campos, R., Campos-Posada, G., Gomez, E. (2020) Respuesta de combinaciones rizobio – Sesbania rostrata en condiciones de estrés salino en el Valle del Cauto en Cuba. Livestock Research for Rural Development 32 (3), article #48 (http://www.lrrd.org/lrrd32/3/rlopez32048.html)

Meyer, L.-E., Brundiek, H., von Langermann, J. (2020) Integration of ion exchange resin materials for a downstream-processing approach of an imine reductase-catalyzed reaction. Biotechnology Progress 36, 5, DOI: 10.1002/btpr.3024

Negassa, W., Michalik, D., Klysubun, W., Leinweber, P. (2020) Phosphorus speciation in long-term drained and rewetted peatlands of northern Germany. Soil Syst. 4, 11; DOI: 10.3390/soilsystems4010011

Oster, M., Reyer, H., Keiler, J., Ball, E., Mulvenna, C., Muráni, E., Ponsuksili, S., Wimmers, K. (2020) Comfrey (Symphytum spp.) as an alternative field crop contributing to closed agricultural cycles in chicken feeding. Sci. Total Environ. 742: 140490, DOI: 10.1016/j.scitotenv.2020.140490

Oster, M., Reyer, H., Ponsuksili, S., Trakooljul, N., Camarinha-Silva, A., Bennewitz, J., Rodehutscord, M., Wimmers, K. (2020) Towards improved phosphorus efficiency in poultry species. Europ Poult Sci, 2020, 84, DOI: 10.1399/eps.2020.314

Oster, M., Reyer, H., Trakooljul, N., Weber, F. M., Xi, L., Muráni, E., Ponsuksili, S., Rodehutscord, M., Bennewitz, J., Wimmers, K. (2020) Ileal transcriptome profiles of Japanese quail divergent in phosphorus utilization. Int. J. Mol. Sci. 2020, 21, 2762, DOI: 10.3390/ijms21082762

Ponsuksili, S., Reyer, H., Hadlich, F., Weber, F., Trakooljul, N., Oster, M., Siengdee, P., Muráni, E., Rodehutscord, M., Camarinha-Silva, A., Bennewitz, J., Wimmers, K. (2020) Identification of the key molecular drivers of phosphorus utilization based on host miRNA-mRNA and gut microbiome interactions. Int. J. Mol. Sci., 21, 2818, DOI: 10.3390/ijms21082818

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, 10(10), 466, DOI: 10.3390/agriculture10100466

Rönspieß, L., Dellwig, O., Lange, X., Nausch, G., Schulz-Bull, D. (2020) Spatial and seasonal phosphorus dynamics in a eutrophic estuary of the southern Baltic Sea. Estuar. Coast. Shelf Sci. 233, DOI: 10.1016/j.ecss.2019.106532

Siengdee, P., Oster, M., Reyer, H., Viergutz, T., Wimmers, K., Ponsuksili, S. (2020) Morphological and molecular features of porcine mesenchymal stem cells derived from different types of synovial membrane, and genetic background of cell donors. Front. Cell Dev. Biol. 8:601212, DOI: 10.3389/fcell.2020.601212

Sommerfeld, V., Omotoso, A.O., Oster, M., Reyer, H., Camarinha-Silva, A., Hasselmann, M., Huber, K., Ponsuksili, S., Seifert, J., Stefanski, V., Wimmers, K., Rodehutscord, M. (2020) Phytate degradation, transcellular mineral transporters, and mineral utilization by two strains of laying hens as affected by dietary phosphorus and calcium. Animals 10, 1736, DOI: 10.3390/ani10101736

Sommerfeld, V., Huber, K., Bennewitz, J., Camarinha-Silva, A., Hasselmann, M., Ponsuksili, S., Seifert, J., Stefanski, V., Wimmers, K., Rodehutscord, M. (2020) Phytate degradation, myo-inositol release, and utilization of phosphorus and calcium by two strains of laying hens in five production periods. Poultry Science 99, 6797-6808, DOI: 10.1016/j.psj.2020.08.064

Stubenrauch, J., Ekardt, F. (2020) Plastic pollution in soils: Governance approaches to foster soil health and closed nutrient cycles. Environments, 7, 38, S. 1-18, DOI: 10.3390/environments7050038

Stubenrauch, J., Garske, B., Ekardt, F. (2020) Kunststoffe in Meeren und Böden: Regulierungsansätze im Wasser-, Naturschutz-, Bodenschutz- und Agrarrecht, Teil 2. Natur und Recht, 42, 457-464, DOI:10.1007/s10357-020-3706-1

Sukhotin, A., Kovalev, A., Sokolov, E., Sokolova, I. (2020) Mitochondrial performance of a continually growing marine bivalve, *Mytilus edulis*, depends on body size. J. Experimental Biol. 223: jeb22633, DOI: 10.1242/jeb.226332

Tränckner, J. (2020) Konzept zur Klärschlammentsorgung einschließlich Phosphor-Recycling in MV. DIALOG Abfallwirtschaft MV, Tagungsband, Schriftenreihe Umweltingenieurwissenschaften, Band 95, ISBN 978-3-86009-507-2, S. 475-488

Vassileva, M., Malusá, E., Eichler-Löbermann, B., Vassilev, N. (2020) *Aspegillus terreus*: From soil to industry and back. Microorganisms 8 (11), 1-10, DOI: 10.3390/microorganisms8111655

Waseem, M., Schilling, J., Kachholz, F., Tränckner, J. (2020) Improved representation of flow and water quality in a North-Eastern German lowland catchment by combining low-frequency monitored data with hydrological modelling. Sustainability, 12, 4812, DOI: 10.3390/su12124812

Weishaupt, A., Ekardt, F., Garske, B., Stubenrauch, J., Wieding, J. (2020) Land use, livestock, quantity governance and economic instruments: Sustainibility beyond big livestock herds and fossil fuels. Sustainability 12, 2053, 1-27, DOI: 10.3390/su12052053

Wieding, J., Stubenrauch, J., Ekardt, F. (2020) Human rights and precautionary principle: Limits to geoengineering, SRM, and IPPC scenarios. Sustainability 12(21), 8858, 1-23, DOI: 10.3390/su12218858

Wubuli, A., Gerlinger, C., Reyer, H., Oster, M., Muráni, E., Trakooljul, N., Ponsuksili, S., Wolf, P., Wimmers, K. (2020) Reduced phosphorus intake throughout gestation and lactation of sows is mitigated by transcriptional adaptations in kidney and intestine. BMC Genomics 21: 626, DOI: 10.1186/s12864-020-07049-0

Zicker, T., Kavka, M., Bachmann-Pfabe, S., Eichler-Löbermann, B. (2020) Long-term phosphorus supply with undigested and digested slurries and their agronomic effects under field conditions. Biomass & Bioenergy, DOI: 10.1016/j.biombioe.2020.105665

Zwicker, J., Smrzka, D., Steindl, F., Böttcher, M.E., Libowitzky, E., Kiel, S., Peckmann, J. (2020) Mineral authigenesis within chemosynthetic microbial mats: Coated grain formation and phosphogenesis at a Cretaceous hydrocarbon seep, New Zealand. The Depositional Record 6, DOI: 10.1002/dep2.123

3.5 Theses

In 2020, one P-Campus member completed his habilitation and four completed their dissertations (Table 4). A fifth dissertation was supervised by P-Campus members. P-Campus members also supervised 11 master's and 6 bachelor's theses.

Table 4. List of theses in the P-Campus

Thesis	Institution
Habilitationen	
Von Langermann, J. (2020) Integration von thermischen Trennverfahren in biokatalytische Synthesen zur Überwindung von Prozesslimitierungen	UR
Dissertations	
Gros, P. (2020) Untersuchungen der Eigenschaften und Wirkungsweisen von Glyphosat in Böden	UR
Hu, Y. (2020) Homogeneous and heterogeneous catalysis for nonreductive CO_2 fixation	LIKAT, UR
Jahanbakhsh, S. (2020) Experimental Investigation of Single Microdischarges in a Sinusoidally Driven Barrier Corona Discharge (PGS1)	INP, UG

Thesis	Institution
Longwitz, L. (2020) Entwicklung von neuen Methoden in der Phosphorredox-katalyse	LIKAT, UR
Meyer, L.-E. (2020) Anwendung von thermischen Trennverfahren zur integrierten Aufarbeitung bei biokatalytischen Reaktionen	UR
Master Theses	
Bäker, P. (2020) Kombinationseffekte von Düngung und Zwischenfruchtanbau auf die C:N:P-Stöchiometrie und ausgewählter Nährstoffpools im Boden	UR
Beerbaum, G. (2020) Einsatz von Mikrogranulaten in Kombination mit Mikroorganismen zur Substitution der Phosphat-Unterfußdüngung und Steigerung der Nährstoffeffizienz im Maisanbau	UR
Buhrand, L. (2020) Charakterisierung der Wurzelarchitektur von 200 Kartoffel-akzessionen in Abhängigkeit der Phosphorverfügbarkeit	UR
Freitag, F. (2020) Einfluss langjährig differenzierter P-Düngung auf P-Fraktionen im Boden unter Berücksichtigung von Zwischenfruchtanbau und saisonaler Variabilität	UR
Klintworth, S. (2020) Auswirkung der Düngung unterschiedlicher Biomasse-Aschen auf die Nährstoffaufnahme von Mais, Amarant und Lupine	UR
Kohnen, A. (2020) Ermittlung der Nitratbelastung des Grundwassers unter Waldstandorten in Nordrhein-Westfalen	UR
König, H. (2020) Düngewirkung von Biomasse-Aschen auf den Gehalt an leicht-löslichem Phosphor im Boden und den Biomasseertrag von Amaranth	UR
Korn, K. (2020) Phosphataseaktivität und Wachstum zweier Kartoffelgenotypen bei verschiedenen Phosphorkonzentrationen	UR
Linke, A. (2020) Aktivierung von Thiocarbonylverbindungen mit Biradikalen	UR
Rosenboom, J. (2020) Investigation of the reactivity of the biradical [P(μ-NTer)]$_2$ towards bromoalkanes and aldehydes	UR
Wiese, F. (2020) Fruchtfolgegestaltung im ökologischen Landbau	UR
Bachelor Theses	
Friedel, P. (2020) Aktivierungschemie von Heteroindandiylen	UR
Höppner, M. (2020) Einfluss von Biomasseaschen auf die Phosphorfraktionen im Boden in Kombination mit verschiedenen Fruchtarten	UR
Kruse, D.-G. (2020) Konzentration von Makro- und Mikronährstoffen in der Biomasse von *Taraxagum koksaghyz*	UR
Lüdtke, H. (2020) Untersuchung des saisonalen Einflusses auf die Konzentrationen des Herbizides Glyphosat und seines Metaboliten AMPA im Fluss Warnow	IOW, UR
Ohms, L. (2020) Phosphorchemie von Porphyrin-ähnlichen Molekülen	UR
Schmahl, H. (2020) Einfluss von Phosphorzufuhr und Zwischenfruchtanbau auf die Aktivität von Bodenenzymen	UR

Abbreviations: INP = Leibniz Institute for Plasma Research and Technology, IOW = Leibniz Institute for Baltic Sea Research Warnemünde, LIKAT = Leibniz Institute for Catalysis, UG = University of Greifswald, 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 Deutsche Phosphor-Plattform (DPP). In addition, the P-Campus is connected with other Leibniz ScienceCampi as well as through its scientists and their thematic networks.

Deutsche Phosphor Plattform (DPP) – Participation in general assembly (23.09.2020, Dr. D. Zimmer) and annual forum (24.09.2020, Dr. D. Zimmer), online

European Phosphorus Platform (ESPP) - Participation in webinar "Nutrients in the EUs Farm-to-Folk policy" and the general assembly (27.11.2020, Dr. D. Zimmer), lecture in the webinar: Dr. Jessica Stubenrauch (Cluster V), online

Associated partnership 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, Ass. Prof. Dr. Jakob Magid, Ass. Prof. Dr. Dorette Sophie Müller-Stöver)

The **interdisciplinary collaboration between partners in the P-Campus** can be demonstrated by the work on the herbicide glyphosate and its environmental fate. P. Gros (working group Soil Science, UR) worked on the translocation and degradation of glyphosate in soil as part of his PhD. In particular, the analysis of glyphosate and its degradation products was carried out in close cooperation with colleagues from the IOW. This resulted in the publication Gros (UR), Meissner, Wirth (IOW), Kanwischer (IOW), Rupp, Schulz-Bull (IOW), Leinweber (UR) (2020) Leaching and degradation of $^{13}C_2$-^{15}N-glyphosate in field. Environ Monit Assess 192, 127. This publication was awarded the P-Campus Publication Award in 2020. During the collaboration, it became apparent that no commercially available standard existed for the degradation product of isotopically labeled glyphosate, i.e., isotopically labeled AMPA. Due to this, no reliable qualitative and quantitative instrumental analysis of the degradation product AMPA by LC-MSMS was possible at this time. To make this possible nevertheless, the P-Campus funded the seed project "AMPA - Synthesis of isotope-labeled AMPA for qualitative and quantitative analysis of glyphosate degradation in soil" starting in spring 2019 (WGL funding period 1). In this project, LIKAT worked on the synthesis of the isotope-labeled AMPA together with colleagues from the IOW in the field of instrumental analysis in cooperation with the working group Soil Science (UR). A publication on this successful project is in progress. In parallel, M. Wirth (IOW) worked in her doctoral thesis on the processing of seawater samples to enable the analysis of very polar organic substances despite the interfering salt matrix. She exploited various techniques for this purpose, such as electrodialysis to reduce the salinity of seawater. The use of a special solid phase for the targeted enrichment of glyphosate and AMPA ultimately enabled the quantitative detection of both substances in Baltic Sea water samples for the first time. Two publications resulted from the work of M. Wirth: the publication Wirth (IOW), Sievers, Habedank, Kragl (UR), Schulz-Bull (IOW), Kanwischer (IOW) (2019) Electrodialysis as a sample processing tool for bulk organic matter and target pollutant analysis of seawater. Marine Chem 217 (also awarded the P-Campus Publication Award) and Wirth, Schulz-Bull, Kanwischer (2021) The challenge of detecting the herbicide glyphosate and its metabolite AMPA in seawater – Method development and application in the Baltic Sea. Chemosphere 262. During the second WGL funding phase of the P-Campus, the seed project "PIAG – Plasmainduzierte Abbaureaktionen in Glyphosat-haltigen Substraten" (start July 2019) was funded by the P-Campus as a collaboration between the working group Soil Science (UR) and INP. In this project, it was demonstrated that glyphosate degradation by plasma is possible through surface corona discharges. A detection of the intermediate and final products still has to be investigated in future work, for which, among other things, the analytics from the previous work of the IOW could be used.

The PhD projects I.2 and IV.1 in the second funding phase can also be highlighted as another example of cooperation and networking in the P-Campus.

PhD project "I.2 P-Pools and mobilization potential in lowlands and coastal regions"
The PhD student of the working group Soil Science cooperates with her supervisor of the LIKAT for ^{31}P-NMR analysis of soil and sediment samples. She also analysed sediment samples from the Baltic Sea in collaboration with colleagues from the IOW. In her last subproject, she collaborated with a former PhD student of the first funding phase of the working group Aquaculture and Sea-ranching and other colleagues of this working group (University of Rostock). This work resulted not only in a poster at the P-Campus Symposium, but also in the following papers:

Prüter (UoR, Soil Science), Strauch (UoR, Aquaculture and Sea-Ranching), Wenzel, Klysubun, Palm (UoR, Aquaculture and Sea-Ranching), Leinweber (UoR, Soil Science) (2020) Organic matter composition and phosphorus speciation of solid waste from an African catfish recirculating aquaculture system. Agriculture, 10(10), 466

Prüter (UoR), Leipe (IOW), Michalik (LIKAT), Klysubun, Leinweber (UoR) (2019) Phosphorus speciation in sediments from the Baltic Sea, evaluated by a multi-method approach. J. Soils Sediments, DOI: 10.1007/s11368-019-02518-w

PhD project "IV.1 Gene expression in biogeochemical cycling of phosphorus in biological soil crusts of sand dunes of the Baltic Sea"
This project is a cooperation between the working group Applied Ecology and Phycology at the UoR and the IOW. In addition to collaborating with IOW colleagues (second supervision), the PhD student also contacted colleagues at the Electron Microscopic Centre (UMR) of the University of Rostock and successfully collaborated with them on spatial analysis of elemental distribution in biological soil crusts. She also cooperated with colleagues from the working groups Soil Science and Soil Physics (at UoR) for additional soil analyses. She successfully contacted Dr. Christian Dolnik from Kiel University for the morphological determination of her moss samples and Dr. Tatiana Mikhailyuk for the algal communities in the soil crusts.

In the second quarter of 2020, a **network analysis of the P-Campus** was created from publications and conference posters to obtain an initial comprehensible overview of the collaboration and networking between P-Campus members and partner institutions. It was shown by means of the peer-reviewed publications of the last 45 years that P research in (the region of) Rostock has been bundled and intensified by the P-Campus. Calculating an impact factor (IF) for P-Campus publications, as for journals, yields a value of > 7. If the self-citations in the P-Campus are removed, the IF drops to > 6. This corrected IF is only slightly smaller than the IF and reflects the external impact of the P-Campus publications and thus their high importance in P research (Fig. 2).

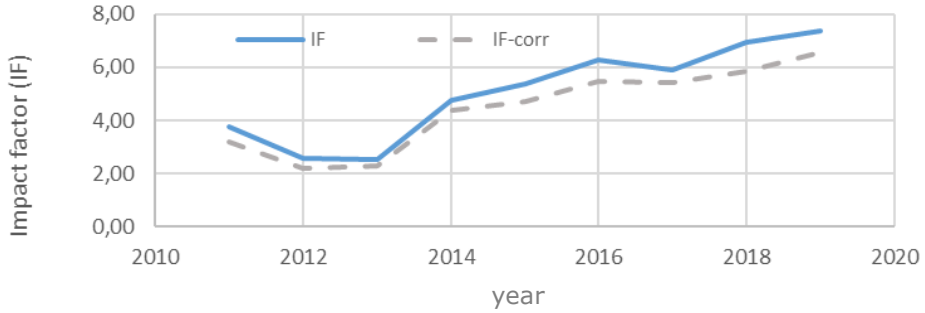

Figure 2. Impact Factor (IF) and corrected IF of P-Campus publications 2011 to 2019

Currently, the approximately 100 scientists of the P-Campus network more than 800 scientists with each other. Individual scientists from different institutions are highlighted as examples (Fig. 3). As intended by the WGL funding, the networking of the scientists of the Leibniz institutes takes place predominantly via the University of Rostock, which more or less forms the centre of the network with the faculties AUF (green dots) and MNF (orange dots). Scientists of the IOW (blue dots) themselves form an extensive network and are closely connected to the two faculties. The FBN (yellow) and the LIKAT (purple) each form individual networks, which are linked via individual specific scientists, primarily via the MNF. The INP (turquoise) and the IPK (red) are primarily linked to the P-Campus network via the AUF.

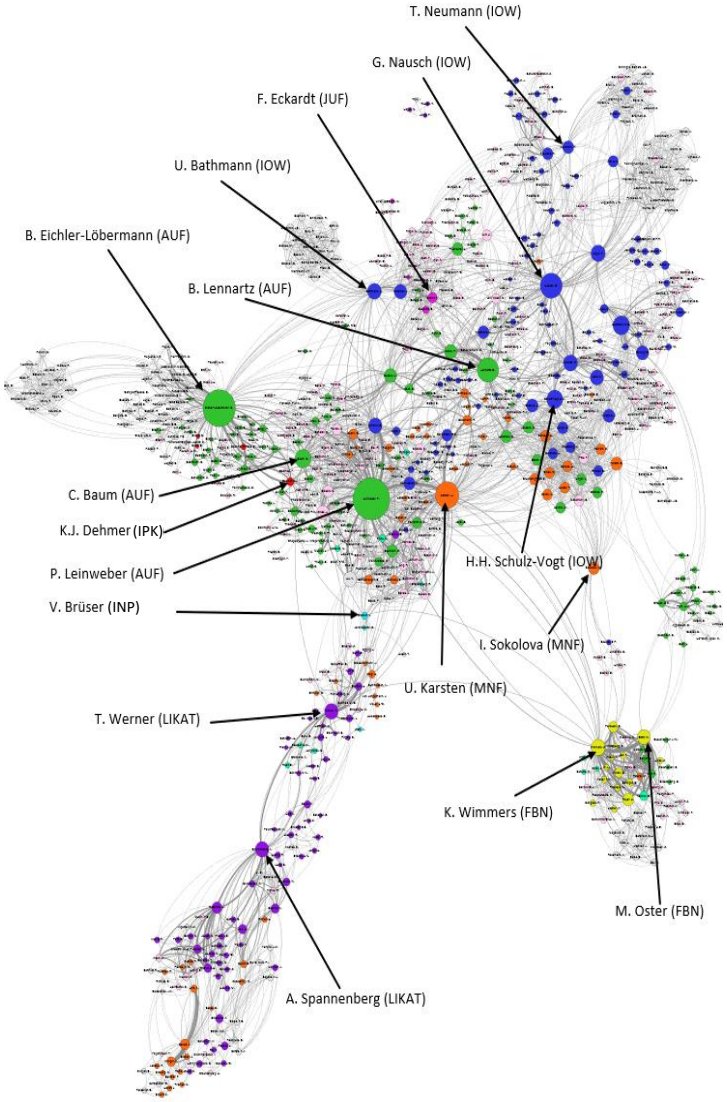

Figure 3. Networking of the scientists of the P-Campus via publications: each dot is a scientist; the dot color reflects the affiliation to the institute and the dot size corresponds to the number of collaborations, exemplary single persons are highlighted

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

Signing of the **extension of the P-Campus cooperation agreement**, 17.06.2020 at the Leibniz Institute for Baltic Sea Research, Warnemünde (IOW)

The **International P-Campus Symposium 2020** of the Leibniz ScienceCampus Phosphorus Research Rostock (16./17.11.2020) took place online via WebEx this year. There were 15 presentations and 5 posters presented from current research in the P-Campus. Despite all the Corona-related limitations, networking and collaboration in the P-Campus could be demonstrated via quite a few presentations. In the course of the

collaboration in the projects on glyphosate in the environment (see above), three lectures were presented: (1) M. Wirth "Project I.3 Environmental Relevance of the Herbicide Glyphosate"; (2) M. Kanwischer "Seed project: Synthesis of isotope marked AMPA for qualitative and quan-titative analysis of glyphosate degradation in soil" and (3) V. Brüser "Seed project PIAG: Plasma-induced degradation reactions in glyphosate-containing substrates". In addition, seven P-Campus PhD students from the second WGL funding period (starting between July 2019 and May 2020) gave a talk and three presented a poster. All P-Campus PhD projects have at least one dual supervision from the University of Rostock and a Leibniz institute.

The **lecture series of the P-Campus in WS 2020/21 "Phosphorus in the environment and in analytics"** took place online this time. This event resulted in a higher number of participants and the attendance of more external interested parties, since no travel was necessary as in the previous on-site events.

Table 5. Topics, lecturers and participants of the der letures series in the winter semester 2020/21

Date	Topic	Lecturer	NP[a]
15.10.2020	Electron microscopy in phosphorus research: Methods of elemental analysis and ultrastructural investigation	Dr. Marcus Frank (UR, EMZ)	25
29.10.2020	Ad- and desorption of phosphate – Phosphate trans-formation processes in soil	Prof. Dr. Dirk Freese (BTU Cottbus)	36
26.11.2020	Application examples of spectroscopic methods in P speciation: 31P-NMR and P-XANES	Prof. Dr. Peter Leinweber (UR)	20
10.12.2020	The role of fungi in the P cycle of soil and in the P sup-ply of plants	Prof. Dr. Christel Baum (UR)	14
14.01.2021	Land Use Governance and Phosphorus Governance: An Overall View	Prof. Dr. Dr. Felix Ekardt (FNK)	23
28.01 2021	Technological potential of low-temperature plasmas in the agricultural environment	Dr. Volker Brüser (INP)	23
11.02.2021	Insights into the role of bacteria for P cycling in soil - lessons learned from metagenomic studies	Dr. Stefanie Schulz (HMGU)	40
25.02.2021	Regulatory and economic instruments for sustainable phosphorus management	Dr. Beatrice Garske (FNK)	
11.03.2021	Endocrine and transcriptional regulatory circuits of phosphorus utilization in pigs and poultry	Dr. Michael Oster (FBN)	
25.03.2021	Potato diversity and phosphorus efficiency	Dr. Silvia Bach-mann-Pfabe (IPK)	

[a] Notice: The number of participants (NP) is the number of people registered for the webinar, not those who actually attended. It was observed that there were always a few people less present at the events.

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/doctoral 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 three months to discuss overarching issues as well as the strategic orientation and further development of the P-Campus.

Meetings of the steering group of the P-Campus: 04.02.2020, (12.06.2020), 11.09.2020

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)

European Society for Agronomy Congress, 01. – 04.09.2020, online

Eichler-Löbermann, B., Lange, C., Kavka, M., Hu, Y., Uptmoor, R., Zicker, T. (Little) short-term impacts of P fertilizer management in a long-term field experiment.

Hazarika, M., Kavka, M., Buhrand, L., Dehmer, K.J., Uptmoor, R., Bachmann-Pfabe, S. Screening for phosphorus efficiency in potato genetic resources.

Tropentag 2020, 09. – 11.09.2020, online

Guardia-Puebla, Y., Olivera,Y., Arias, Q., Morscheck, G., Eichler-Löbermann, B. Chemical pretreatments of rice straw for anaerobic digestion.

López, R., Saiz, L., Guardia-Puebla, Y., Arias, Q., Eichler-Löbermann, B. Nutrient recycling with sugar cane ash in urban agriculture.

Vazquez-Glaría, A., Kavka, M., Fernández, L., Ortega, E., Eichler-Löbermann, B. Root architecture of rice as affected by phosphorus starvation and salt stress.

21st Global Conference on Environmental Taxation, 24.09.2020, online

Ekardt, F. Livestock products and transnational economic instruments.

Garske, B. Economic instruments for phosphorus governance – How taxes and cap-and-trade systems achieve a sustainable phosphorus management.

Further Presentations

Buczko, U. Neubewertung der P-Düngeempfehlung auf Basis einer Meta-Analyse von Ergebnissen von Langzeit-Feldversuchen. Frühjahrstagung der VDLUFA Fachgruppen "Pflanzenernährung, Produktqualität und Ressourcenschutz" und "Bodenuntersuchung", Duisburg, 03.03.2020

Ekardt, F., Stubenrauch, J. Phosphor: Problem, Transformation, Governance. Phosphor-Workshop, Wissenschaftszentrum Umwelt, Universität Augsburg, 11.03.2020

Oster, M., Reyer, H., Ball, E., Fornara, D., Poulsen, H.D., Rosemarin, A., Arata, L., Chakrabarti, A., Sckokai, P., Magowan, E., Wimmers, K. Phosphorus efficiency in Gallus gallus and Sus scrofa – Bridging the gaps in the phosphorus value chain. Virtual seminar on sustainable animal production, ERA-Net SusAn, 17.11.2020

Oster, M., Reyer, H., Ball, E., Mulvenna, C., Fornara, D., Keiler, J., Arata, L., Chakrabarti, A., Sckokai, P., Poulsen, H.D., Wimmers, K. Beinwell als alternative Proteinquelle in der Hühnerernährung und Bestandteil landwirtschaftlicher Kreisläufe. Online-Abschlusstagung "Protein Paradoxes", 06.10.2020

Oster, M., Reyer, H., Gerlinger, C., Wubuli, A., Rosemarin, A., Sckokai, P., Ball, E., Damgaard Poulsen, H., Wolf, P., Wimmers, K. Molecular determinants of phosphorus utilization in pigs. Workshop FBN-CREA, Dummerstorf, 08.-09.01.2020

Oster, M., Reyer, H., Wimmers, S., Trakooljul, N., Camarinha-Silva, A., Bennewitz, J., Rodehutscord, M., Wimmers, K. P-FOWL: Effekte einer differentiellen Phosphorversorgung bei Geflügel. Frühjahrsveranstaltung der Deutschen Vereinigung für Geflügelwissenschaft e.V., Dummerstorf, 10.-11.03.2020

Sokolova, I. How to survive without oxygen: Mitochondrial bioenergetics, oxidative stress and cellular stress response in hypoxia-tolerant marine bivalves. Online-Seminarvortrag an der University of Maryland, Baltimore County, 28.10.2020

Werner, T. Be Green! Innovative catalytic and synthetic methods for material and life sciences. Vortrag an der Universität Paderborn, 25.06.2020

Werner, T. Innovative catalytic and synthetic methods for material and life sciences. Vortrag an der Universität Stuttgart, 04.05.2020

Werner, T. New Twists in Organocatalysis. GDCh-Kolloquium (Webinar), 11.06.2020

Wirth, M., Schulz-Bull, D., Kanwischer, M. Detection of the herbicide glyphosate and its metabolite aminomethylphosphonic acid in the Marine Environment. SETAC Europe SciCon, online, 04.05.2020

Other Events

16.12.2020 - Online meeting between P-Campus members and representatives of the Ministry of Education and the Ministry of Agriculture MV to present and discuss current results from the P-Campus; the following topics were presented in lectures:

Zimmer, D., Bathmann, U., Hoche, M. The Leibniz ScienceCampus Phosphorus Research Rostock 2020

Gros, P. Network analysis of the P-Campus

Kammann, S. PhD project "IV.1 Gene expression in biogeochemical cycling of phosphorus in biological soil crusts of sand dunes of the Baltic Sea"

Brüser, V. Seed project "PIAG - Plasmainduzierte Abbaureaktionen in Glyphosat-haltigen Substraten"

Wimmers, K. Seed project "EpiPTG - Dietary effects on DNA methylation in porcine parathyroid glands" and further current research at FBN

6.2 Posters (Selection)

BONARES Status Seminar, 17. - 19.02.2020, Leipzig

Buczko, U., Steinfurth, K., van Laak, M., Nawotke, C., Peiter, E., Reitz, T., Wacker-Fester, K., Zimmer, D. Comparability of the Calcium-Acetate-Lactate and Double-Lactate extraction methods to assess soil phosphorus fertility.

Garske, B., Stubenrauch, J., Ekardt, F. Regulatory and Economic Instruments of Phosphorus Governance. How to achieve a sustainable P management by combining policy instruments.

Steinfurth, K., Buczko, U. Validation of a CART and MLR analysis for the estimation of yield response to P-fertilization.

European Society for Agronomy Congress, 01. - 03.09.2020, online

Erlinghagen, R.L., Dehmer, K.J., Bachmann-Pfabe, S. Screening for nitrogen and phosphorus efficiency in potato.

Hazarika, M., Kavka, M., Buhrand, L., Dehmer, K.J., Bachmann-Pfabe, S. Screening for phosphorus efficiency in potato genetic resources.

6.3 Press

Ein paar Schippchen weniger - Article in Nachrichten aus der Chemie 68, pp. 38-40, January 2020

Phosphorforschung bis 2023 gesichert - Article on focus.de, 17.06.2020

Geld für Phosphor-Campus – short contribution for television (NDR Nordmagazin), 17.06.2020

Phosphorforschung am Ostsee-Institut gesichert - Article on svz.de, 17.06.2020

Phosphorforschung bis 2023 gesichert - Article on welt.de, 17.06.2020

Phosphorforschung gesichert - Article in newspaper NNN, p. 10, 18.06.2020

Mehr als eine Million Euro für Projekt in Rostock: Phosphorforschung bis 2023 in MV gesichert - Article in newspaper Ostsee-Zeitung, S. 15, 18.06.2020

Ostsee & Nordsee // Prof. Dr. Ulrich Bathmann (IOW), Karl-Michael Werner (Thünen-Institut) - Podcast "Interviews 4 Future", 30.07.2020, ab 10:59 min spricht Prof. Bathmann über den P-Campus

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: http://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

6.5 Others

Stubenrauch, J. Leader of the workshop "Landwirtschaft, Pestizide und Lebensmittelsicherheit", conference „Internationale Wirtschaftsbeziehungen gerechter gestalten. Das Handelsabkommen MERCOSUR unter der Lupe", 07.11.2020, online

For the third-party funded project PEGaSus, an English-language video is available since 2020 at:

https://www.youtube.com/watch?v=ODnN2UhDHAU&list=PLFnlwoEx7IG9shR4sPEwlRlxZZudiGQ2u&index=9

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**. Direct **coordination** is carried out by a staff scientist, supported by a secretary. 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 20 PhD students from 40 Working Groups are **Members** (see Partners and Members) of the P-Campus.

The 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. Ulrich Bathmann, IOW
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
PD Dr. Thomas Werner, LIKAT
Prof. Dr. Klaus Wimmers, FBN
Dr. Dana Zimmer, P-Campus

Substitutes:
Dr. Silvia Bachmann-Pfabe, IPK
Dr. Christian Hering-Junghans, LIKAT
Dr. Michael Oster, FBN
Prof. Dr. Axel Schulz, UR/LIKAT

7.2.5 Coordination Office

(Work and tasks 2020: see Appendix)
Dr. Dana Zimmer (Coordinator)
Maxi Hoche (Secretary)

7.2.6 Members

(Status: Updated during 2020)

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
Yuya Hu	Organocatalysis	Cluster III
Lars Longwitz	Organocatalysis	Cluster III
Dr. Dirk Michalik	Analytical Service	Cluster III
Prof. Dr. Uwe Rosenthal	Coordination Chemistry and Catalysis	Cluster III
Constanza Terazzi	Organocatalysis	Cluster III
Jan Tönjes	Organocatalysis	Cluster III
PD Dr. Thomas Werner	Organocatalysis	Cluster III

Leibniz 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 Almoosavi	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

Directorate

Prof. Dr. Ulrich Bathmann	Director	Cluster I
Dr. Evgeny Sokolov	Directorate	Cluster IV
Dr.Dana Zimmer	Coordination Office	Cluster II

Department Biological Oceanography

Philipp Braun	Microbial Processes and Phosphorus Cycle	Cluster I
Dr. Angela Vogts	NanoSIMS Lab	Q

Department Marine Geology

Prof. Dr. Michael Böttcher	Geochemistry and Stable Isotope Biogeochemistry	Cluster I, Q
Dr. Thomas Leipe	Microanalysis	Cluster I, Q

Department Marine Chemistry

Dr. Marion Kanwischer	Organic Contaminants	Cluster I, Q
Constantin Lohrer	Organic Contaminants	Cluster I, Q
Dr. Oliver Schmale	Biogeochemistry Trace Gases	Cluster I, Q
Prof. Dr. Detlef Schulz-Bull	Organic Contaminants	Cluster I, Q
Marisa Wirth	Organic Contaminants	Cluster I, Q

Department Physical Oceanography and Instrumentation

Dr. Thomas Neumann	Baltic Sea system dynamics	Cluster I
Dr. Hagen Radtke	Baltic Sea system dynamics	Cluster I

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

Dr. Silvia Bachmann-Pfabe	Genebank, Satellite Collections North	Cluster II
Dr. Christine Brandt	Genebank, Satellite Collections North	Cluster II
Dr. Klaus Dehmer	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

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

Dr. Volker Brüser	Catalytic Materials	Cluster II
Prof. Dr. Klaus-Dieter Weltmann	Director	

University of Rostock (UR)

Faculty of Agricultural and Environmental Sciences

PD Dr. Christel Baum	Soil Science	Cluster II
Dr. Karen Baumann	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
Michael Cramer	Water Resources Management	Cluster II
Dr. Carsten Croonenbroeck	Agricultural Economics	Cluster II
apl. Prof. Dr. Bettina Eichler-Löbermann	Agronomy	Cluster II
Beatrice Garske	Research Unit Sustainability and Climate Policy	Cluster II
Prof. Dr. Bärbel Gerowitt	Crop Health	Cluster II
Sebastian Heller	Grassland and Fodder Sciences	Cluster I
Katharina Heyl	Research Unit Sustainability and Climate Policy	Cluster V
Prof. Dr. Florian Jansen	Landscape Ecology and Site Evaluation	Cluster I
Dr. Petra Kahle	Soil Physics	Cluster I, II
Prof. Dr. Norbert Kanswohl	Agricultural Technology and Process Engineering	Cluster II
Dr. Mareike Kavka	Agronomy	Cluster II
Julian Kirchgesser	Agronomy	Cluster II
Dipl. Agr.-Ing. Ulrich Knaus	Aquaculture and Sea-Ranching	Cluster I, II
Philipp Koal	Agronomy	Cluster 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
Jonathan Schleyken	Water Resources Management	Cluster II
Kristin Steinfurth	Landscape Ecology and Site Evaluation	Cluster I
Jessica Stubenrauch	Research Unit Sustainability and Climate Policy	Cluster V
Prof. Dr. Jens Tränckner	Water Resources Management	Cluster II
Prof. Dr. Ralf Uptmoor	Agronomy	Cluster II
Paul Winklhofer	Crop Health	Cluster II
Prof. Dr. Petra Wolf	Nutrient Physiology and Animal Nutrition	Cluster II

Prof. Dr. Nicole Wrage-Mönnig	Grassland and Fodder Sciences	Cluster II
Annika Zacher	Soil Science	Cluster II
Theresa Zicker	Agronomy	Cluster II

Faculty of Law

Prof. 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
Martin Albrecht	Institute for Biological Sciences, Applied Ecology & Phycology	Cluster I
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 Physiol-ogy	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
Iris Schaub	Institute for Biological Sciences, Applied Ecology & Phycology	Cluster I
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 Esco-bar	Hematology, oncology and palliative care	Cluster III
PD Dr. Dagmar-Christiane Fischer	Pediatric Clinic, Experimental Pediatrics Group	Cluster II
Prof. 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
Ass. Prof. Dr. Jakob Magid
Ass. Prof. Dr. Dorette Sophie Müller-Stöver

8 Funding

In 2020, the P-Campus was funded by the Ministry of Education Mecklenburg-Vorpommern, by the Leibniz Association and by substantial 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).

Funds from the Ministry of Education Mecklenburg-Vorpommern (about € 132,000 in 2020) were used mainly to finance the Coordination Office of the P-Campus. 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

Leibniz ScienceCampus Phosphorus Research Rostock

Tasks of the Coordination Office 2020

In the following, the activities and thematic foci of the Coordination Office of the Leibniz ScienceCampus Phosphorus Research Rostock in 2019 are described. The Office is staffed by Dr. Dana Zimmer (scientific coordinator) since mid-October 2018. The position of the administrative assistant was vacant since July 2019 and is staffed by Maxi Hoche 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, but additionally the successful organization of the start of the new funding phase of the Leibniz Association from June 2019 on.

Other tasks included i.a. the external representation of the P-Campus (e.g. regular website update, organization video about P-Campus), the preparation of reports and emails providing information to interested parties, the organization of other events of different formats (e.g. lecture series during winter semester 20/21) 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 2020, 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. In addition, more so-called associate members were admitted to the P-Campus this year. Currently, members of the WG Soil Fertility of the University of Copenhagen and the WG Phosphorus Chemistry of the German Chemical Society are associate members in the P-Campus. Scientists of other research institutes, which deal with the topic phosphorus and are in close contact with regular members of the P-Campus, can become associated members. The admission of associated members conduces to an increasing external networking of P-Campus scientists and the internationalization of contacts. Contacts with external research institutes, ministries and authorities were regularly maintained (e.g. 16.12.2020 presentation of recent research results of the P-Campus to ministry members).

Due to the extension of the research clusters and since especially a gender-neutral orientation of the P-Campus should be experienced, as it is established in the guidelines of the Leibniz institutes and the University of Rostock, an extension of the steering committee with the focus on applications of women was organized and successfully realized. Since April 2019, three more women are members of the steering

committee of the P-Campus (Prof. Dr. I. Sokolova, PD Dr. D.-C. Fischer, Prof. Dr. B. Eichler-Löbermann).

Contacts to other networks were intensified, for example to the network Interdisciplinary Faculty (INF) and the DFG Graduate College Baltic Transcoast of the University of Rostock (e.g. stronger mutual exchange on events) and to the DPP (German Phosphorus Platform). The coordination of the P-Campus attended the DPP general meeting and forum on September 23-24, 2020 and the ESPP webinar and general meeting on November 27, 2020.

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. A first call for seed projects for the second funding period of the P-Campus was organized in May 2019. The funding of six new seed projects could be promised by the P-Campus with the official start of the second funding period in June 2019. Three of these projects can (partly) be allocated to cluster IV "Molecular Biology of P". This successful concept of the seed projects is also borrowed and extended for the second funding phase. The next call is planned for the second quarter of 2021.

To facilitate the application for seed projects, the assumption of travel and publishing costs but also the report of published publications and granted projects for the P-Campus members, old templates were improved respectively new templates were created. Since there are more foreign PhD students in the second funding phase, all forms and so on were translated into English.

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). Since several PhD students were employed just in October respectively November 2019, the start-workshop 'P analytics' was organized for November 2019 (CW 48) and the P Breakfast was organized and supervised by the Coordination Office on December 17, 2019. The P Breakfast and start-workshop 'P analytics' events planned for 2020 for PhD students employed from 2020 onwards could not be realized due to Corona restrictions. In fall 2020, the annual lecture series with a total of ten lectures from October 2020 to March 2021 was organized by the P-Campus office as a webinar. At the International P-Campus Symposium (Nov. 16-17, 2020, online) with the International Scientific Advisory Council, ten of the PhD students were already able to present their first results as posters or talks.

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 2020, this included, among other things, the organization of the P-Campus Steering Group meetings (including the presentation of current

developments, taking minutes, etc.), the organization of the signing of the extension of the cooperation agreement (being effective as good publicity), the organization of online meetings to initiate a Si-P project, the International P-Campus Symposium (online format) in November 2020 with the participation of the International Scientific Advisory Council, and the organization of the annual meeting (online format) between representatives of the P-Campus and the Ministries of Education and Agriculture, respectively.

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 has presented different research topics of the P-Campus to a broad public at the Long Night of Science at the University of Rostock every year. Due to Corona restrictions, the 2020 event could not take place. The Coordination Office organized the visit of partner institutes of the P-Campus (presentations and guided tours at FBN, AUF and IOW) for journalists of the German Science Journalists' Association on September 24 and 25, 2019 within the scope of their research trip "Phosphorus – and the future of agriculture". One of the journalists published an article about the visit at the P-Campus in January 2020 in the journal 'Nachrichten aus der Chemie' (Osterath, B. "Ressourcenmanagement – Ein paar Schippchen weniger").

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 writing pads and flyers. These measures were only possible to a very limited extent in 2020. The P-Campus Coordination also participated in the organization of the EWPC, which was to take place at LIKAT in March 2021. However, due to the corona pandemic, it was decided in November 2020 to cancel the EWPC for 2021 and postpone it to 2022. 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.

Another important task was the design of the website of the Leibniz ScienceCampus Phosphorus Research Rostock, 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). The coordination office also 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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atalysis
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INP
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