



Four Years of Mutual Learning on Sustainable Phosphorus Management

Amit Roy, IFDC, Muscle Shoals, U.S.A. Practice Leader Global TraPs

Phosphorus (P) is a key element that is essential to plant, animal and human lives. It is a naturally occurring finite element found in minerals and rocks in the form of phosphate. Among several, two broad issues surrounding phosphorus are (1) its finite nature vis-à-vis its importance in food security; and (2) the negative environmental impacts of excess phosphorus, particularly in freshwater and coastal marine ecosystems. Therefore, sustainable management of phosphorus, both from resource and environmental standpoints, is extremely important. Several initiatives have been launched to develop a pathway to sustainably manage this vital resource, but none involved both a multi-stakeholder forum of key actors from the phosphorus supply-demand chain with different viewpoints, and a mutual learning among science and practice. The goal of the project was to utilize the knowledge and experience for an assessment of current information and knowledge gaps, and the development of sustainable options for the way forward. The Global TraPs Project was designed to provide such a forum. This project was

formally launched on February 6, 2011, as a five-year transdisciplinary project to identify technologies and policy options needed to ensure that future P use is sustainable, improve food security and environmental quality and provide benefits for the poor. Since its inception, more than 300 from academia, NGOs, advocacy groups and the private sector have been engaged in the multi-stakeholder dialogue within the framework of the Global TraPs Project and have participated in five major events (Table 1).

This final newsletter briefly summarizes the major activities and completed outputs of the Project. There are a few ongoing activities including case studies in Kenya and Vietnam focused on smallholder access to P. The results of these case studies will be communicated through the Global TraPs website (www.globaltraps.ch).

| | Date | Location | Goals/Mission |
|------------------|----------------------|---------------------|--|
| 1st Workshop | 2011, Feb. 5-6 | Phoenix, AZ, USA | Building partnership and co-leadership |
| 2nd Workshop | 2011, April 31-May 1 | Zurich, Switzerland | Consenting the Guiding Question |
| 3rd Workshop | 2011, August 29-30 | Zurich, Switzerland | Identifying critical questions |
| 4th Workshop | 2012, May 15-16 | El Jadida, Morocco | Defining cases - setting priorities |
| World Conference | 2013, May 20-22 | Beijing, China | Learning from cases - exploring policy options |

Table 1: Global TraPs' Events

From Myths to Data – Achievements of Global TraPs and Some Future Challenges

Roland W. Scholz, Fraunhofer IGB, Stuttgart, Germany; Science Leader Global TraPs

Global TraPs was the first international attempt to assess and approach sustainable phosphorus management using a transdisciplinary process (Figure 1). Scientists and a wide range of practitioners focused on sustainable phosphorus use across *all stages of the supply-demand chain* over a four-year period. Participants ranged from phosphorus traders via mining companies, and phosphorus producers to farmers' organizations, recycling companies, and representatives of international organizations such as the IFA, IPNI, FAO, UNEP and Greenpeace. The ultimate project goal was to develop *system analysis-based policy options* for sustainable phosphorus use for consideration by policymakers; options that reflected science knowledge and stakeholders input along the supply-demand chain.

Global TraPs provided a *comprehensive system analysis* that may serve to define options for reducing environmental pollution, for increasing efficiency and avoiding losses, for identifying secondary mining opportunities, for recycling and resource conservation options, etc. This system analysis was documented in the book *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (2014), which was jointly written by 18 practitioners and 23 scientists based on a high number of reviews and feedback from the fields of science

and practice. A central consensus appreciated by all stakeholders was that sustainable phosphorus management calls for a transition *from myths to data*. This phrasing was used in the closing remarks of Prof. Rattan Lal (President of the International Union of Soil Sciences) in a review on the above-mentioned book. In the course of working on sustainable phosphorus management, a number of myths were encountered, such as: "We will have a physical scarcity-driven peak phosphorus"; "We can (soon) globally increase the yield [by] 30% when increasing efficiency by 30%"; "There are no losses in the mines"; or "Phosphorus recycling from wastewater may be the major focus of recycling phosphorus." All of these statements sound politically appealing, but they lack either a proper system of understanding or they cannot be substantiated by the data. The complexity of phosphorus management will challenge the scientific system to provide both data and proper system knowledge to address these concerns. Thus, the request for transdisciplinary phosphorus management and its acceptance will not only challenge industry but also science.

Sustainability learning and adapting to the needs of the future ask for time and efforts from all key stakeholder groups. In this context, it may be of interest that the Global TraPs project terminated one year early because announced

funding from industry was withdrawn. The withdrawal was reasoned mainly with the lack of time of high-level experts from industry. Sustainability learning for sustainable resources management asks for time and commitment for all stakeholder groups.

While Global TraPs did not reach its ultimate goal of producing policy options for key stakeholders and policymakers on a broad scope, it did have significant achievements (see pages 2 and 3 of this final newsletter). In order to properly utilize the achievements of Global TraPs, a proposal was made to transfer Global TraPs into a more permanent structure under the UNEP Global Partnership for Nutrient Management (GPNM). A proposal launched for “transitioning ... Global TraPs phosphorus initiative to ... “(GPNM)” was positively dealt with at the third Steering Board Meeting of the GPNM, held on December 10 and 11, 2014.

From a personal perspective, the knowledge necessary to establish sustainable phosphorus management is still critically underdeveloped compared to the knowledge base for nitrogen or other important minerals or to other environmental challenges. Hopefully, the GPNM platform will acquire sufficient funding for developing strategies that promote the commitment of key stakeholders for sustainable action. Development and implementation of appropriate strategies will take time and commitment and will call for proper institutionalization, such as national and international platforms. Thus, I am gratified that, in addition to the UNEP–GPNM Phosphorus Task Team, the strategy of founding a German Phosphorus Platform was first promoted at the Global TraPs Reprocessing Industry Cluster Europe (RICE) meeting on February 2, 2013, at Fraunhofer IWKS. My personal thanks to all who

contributed to the multiple achievements of Global TraPs that are documented in this newsletter. For me, Global TraPs developed much knowledge and many orientations which allow for better and sustainable management in phosphorus management.

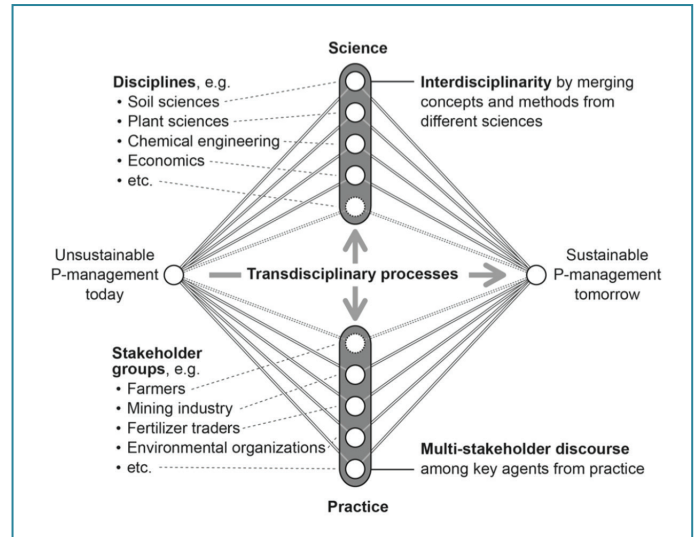


Figure 1: A transdisciplinary process on sustainable phosphorus use relates (a) an interdisciplinary process of system analysis and of identifying options for improving the practice of phosphorus use (upper lens) and (b) a multi-stakeholder discourse among key agents of the supply-demand how to change practice (lower lens). The transdisciplinary process can be seen as a mutual learning process among science and practice for providing socially robust orientations for sustainable phosphorus management.

Documentation of Main Products of Global TraPs

1. Workshops and a World Conference

Key stakeholders from the phosphate industry (i.e. practice) and scientists from various disciplines participated in four Workshops and one World Conference. Workshops 1 and 2 focused on the building of partnership, negotiating rules of communication, and most importantly, formulating the Global TraPs Guiding Question which was used to steer and focus the project. Workshops 3 and 4 dealt with the identification of critical questions of sustainable phosphorus management and the identification of selected

cases that could address knowledge gaps and contribute to sustainability learning. The 2013 World Conference (jointly organized by Global TraPs, UNEP-GPNM and the Chinese Agricultural University Beijing) discussed the global system analysis and provided initial policy orientations for coping with critical questions (see Global TraPs homepage). The system analysis of the global anthropogenic supply-demand chain is presented in the book *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (page 3).

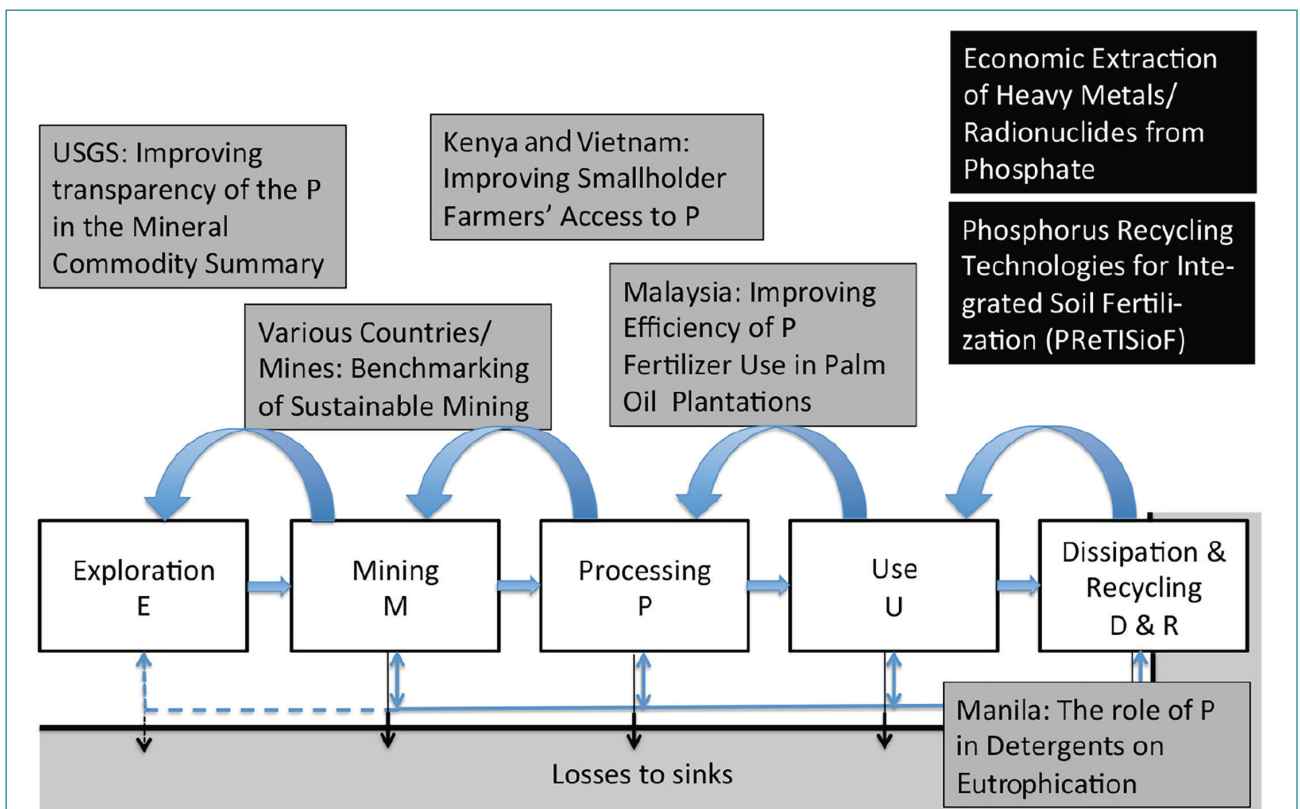


Figure 2: Case Studies conducted to improve efficiencies at various stages of the P supply-demand Chain.

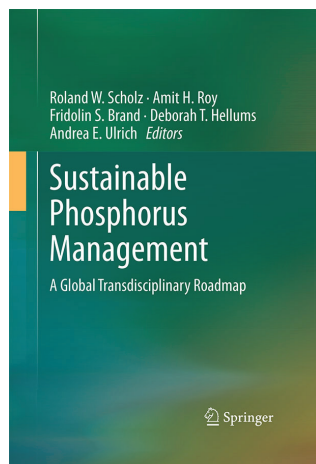
2. Global TraPs Case Studies

Based on the critical questions formulated in Workshops

3 and 4, a set of case studies were identified to provide insight into answers while acknowledging the complexity and multiple constraints that sustainable transitions incur. As can be taken from Figure 2, the case studies range from improving the chain. transparency of the data on phosphorus reserves, resources and future available ores (see Christesen, 2014), transitioning to sustainable mining (Baumann, 2011), improving smallholder farmers use of phosphorus fertilizers in Kenya and in Vietnam (Birech et al. 2015; Tran et al., forthcoming), studying the potential for efficient phosphorus use in palm-oil production and evaluating the share of phosphorus in detergents in developing countries' megacities. Some of the identified studies could not be initiated due to funding constraints.

3. A Comprehensive System Analysis for Addressing Pertinent Global Issues

A major output of the Project was the publication, "Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap" edited by Roland Scholz, Amit H. Roy, Fridolin S. Brand, Deborah T. Hellums and Andrea E. Ulrich, 2014, Springer. This multi-authored volume addresses several pertinent global issues including: global P reserves, food security, transdisciplinarity, pollution abatement and sustainable P management in agro-ecosystems.



4. Papers in Scientific Journals

Several papers were published in highly reputable journals such as *Global Environmental Change and Earth Systems Dynamics*. The Papers of Scholz and Wellmer (2013 and 2015) were related to the discussion in the Exploration Node (see Figure 1). These papers elaborated – among others – that the short-term Peak Phosphorus hypothesis was based on a misapplication of the Hubbert analysis; the main arguments here are that the phosphorus market is not a supply market and that there are significantly large resources which may become reserves in the future. As phosphorus is essential, long-term supply security has become a public concern. A recent article by Wellmer and

Scholz (in press) in the *Journal of Industrial Ecology* suggests the formation of an independent international institution which acquires knowledge about the geopotential and resources in order to better understand what proportion of the phosphate rock may become economically mineable in the future. Additional papers were prepared on the sustainable phosphorus management and the mutual learning process in the Global TraPs project (see <http://www.scientificpapers.globaltraps.ch/>).

5. Book Chapters and Conference Proceedings

In addition to the seven papers/chapters and 10 Spotlights that were published in the Springer book, the MSc Thesis of Christesen was published at BGR in Hannover (Christesen, 2014) and Ulrich and Cors (2011) reported on the early initiatives at the Baltic 21 Conference Global TraPs project (references noted under <http://www.scientificpapers.globaltraps.ch/>).

6. Strategic Papers

There were four papers produced, which may be considered strategic. The most recent paper focused on seven areas addressed by Global TraPs (Roy & Scholz, 2014) and identifies 1) supply security, 2) improving efficiency and avoiding losses, 3) sustainable mining, 4) innovation in fertilizer processing and products, 5) promoting recycling along the demand-supply chain, 6) redefining planetary boundaries and 7) launching transdisciplinary processes for identifying policy options. A second paper presented Global TraPs, Response to an EC Consultative

Communication on the Sustainable Use of Phosphorus (Scholz & Roy, 2013).

Based on inputs of Global TraPs scientists and practitioners, it stressed 1) "The specific role and responsibility of Europe for future sustainable phosphorus use and recycling should be conceived in a more comprehensive way"; 2) the necessity to analyse vulnerability with respect to supply security and 3) some misperceptions that under laid the European Union (EU) proposal. A brief input paper to the 4th Sustainable P Summit in Montpellier stressed the need for system analysis and of transdisciplinary processes (Roy et al., 2014). – Finally, the early paper of Eilittä (2011) informed about the principles of communication applied in Global TraPs (Eilittä, 2011, see URL www.globaltraps.ch).

7. Master Studies Related to Global TraPs

Six master theses and one extended internship report were written by students of the Technical University Freiberg, Leuphana University Lüneburg, University of Oldenburg (Germany) and of ETH Zurich (Switzerland). Three theses dealt with critical aspects of the phosphorus cycle, i.e., sustainable mining of phosphate rock (Baumann, 2013), the role of detergents or the socio-political settings and practice of phosphorus recycling from wastewater in Japan and Switzerland (Wemyss, 2012) and the role of phosphorus detergents in Manila Bay (Lotze, 2014). The discussion related to phosphate rock scarcity launched a thesis on the reliability of publicly available data of reserves and resources (Christesen, 2014). All theses were run with strong support from private companies and public institutions. Three studies dealt with the transdisciplinary process (Luthardt, 2014; Mass-Deipenbroch, 2014; Wunderlich, 2014) or the case-based mutual learning session, a format of relating science and practice knowledge applied at the Global TraPs World Conference in Beijing (2013). (<http://www.mastertheses/globaltraps.ch/>)

8. Mutual Learning Sessions and Dialogue Sessions on Critical Questions

Mutual learning sessions (MLS) and Dialogue sessions (DS) are a special format for collaboration between science and practice through a transdisciplinary process. During the 2013 Beijing conference 144 people participated in ten MLS and two DS. The sessions dealt with cases or topics which were chosen in order to gain insight into how to answer key critical questions which have been identified in Global TraPs Workshops 3 and 4.

One idea of case-based MLS (cbMLS) is that one obtains better insight into how to answer critical questions (i.e. "How do we cope with manure management in concentrated animal factory meat production?"). If one looks at well-selected cases (e.g., a typical hogger in China which present an unsatisfying practice from a sustainable development perspective), case-based learning has the advantage that the constraints which hamper sustainability and the complexity of the socio-technological layer of a problem remain intact. Preparatory work for the MLS and the topic-oriented DS included development of comprehensive subject booklets jointly produced by the participants. The booklets included basic information about the problem (i.e., the critical question and how it has been traditionally dealt with before in science and practice), the case and the specific (political, financial, cultural, etc.) constraints. Thus, in cbMLS, scientists and other stakeholders participate in a process of mutual understanding and of developing policy options. The direct, experiential case encounter and the interaction with key stakeholders are providing a special type of problem framing which allows for development of mutual learning. For more information please visit the Global TraPs homepage¹. This method is described in a paper of Villsmaier et al. (2015)².

¹ See <http://www.globaltraps.ch>

² See <http://www.globaltraps.ch/MLS-DS.html>

Global TraPs follow up

There are various follow up activities of Global TraPs (see page 1). One is the editing of a special issue on Losses and Efficiencies in Phosphorus Management of the Journal *Resources, Conservation and Recycling*. Prof. Roland W. Scholz and Prof. Thomas Hirth, Fraunhofer IGB, Stuttgart, Germany are the editors of this special issue. Most contributions are from scientists and practitioners who have been involved in Global TraPs. The Special issue will appear in October 2015.

Contacts

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Documentation of Global TraPs Subprojects and Documents (Supplement to Global TraPs Newsletter 13)

1. Global TraPs Case Studies (2011-2014)

1.1 Comparison of sewage recycling practice in Japan and Switzerland. D. Wemyss, R. W. Scholz (ETH Zurich, Switzerland); H. Ohtake (University of Osaka, Tokyo); L. Morf (AWEL Canton Zurich, Switzerland)

1.2 Documenting Reserves Transparency of the Mineral Commodity Estimations –the Example of Phosphate Reserves and Resources. Case study team and supervisors: C. Christesen, J. Gutzmer (TU of Resources Freiberg, Germany); B. Röhling (BGR Hannover), F.-W. Wellmer (formerly BGA, Hannover, Germany), S. Jasinski, J. DeYoung, Jr. (USGS, Washington, U.S.A.)

1.3 Environmental Assessment of Igneous P Mining in Phalaborwa South Africa. Case study team and supervisors: L. Botha, FOSKOR (Phalaborwa, South Africa); Ingrid Watson, University of Witwatersrand (SA), R. W. Scholz (Fraunhofer IWKS, Alzenau, Germany)

1.4 Malaysian Palm Oil: Sustainable Fertilizer Use in Plantations. Case study team and supervisors: L. Hermann (Outotec, Oberursel, Germany), R. Ishak (Felda, Malaysia); A. R. Zahara, (University of Malaysia); D. J. Lang (Leuphana University, Germany)

1.5 Manila Bay Detergents. Case study team and supervisors: L. Borjas-Santos (Resource Management and Development, Laguna Lake Development Authority, Manila, Philippines); N. Lotze, B. Siebenhüner (University of Oldenburg, Germany); G. Jacinto (Universities of the Philippines, Manila), R. W. Scholz (University of Zurich & Fraunhofer IWKS, Alzenau, Germany)

1.6 SMAP Kenya; Smallholder Farmer Access to Phosphorus: R. Birech (Egerton University, Kenya); R. Njoroge (Eldoret University, Kenya); R. W. Scholz (Fraunhofer IWKS, Germany); Olaf Weber (University of Waterloo, Canada); D. Nyameino, A. Kioko, C. Mutisya (Kenya Cereal Grower Association, CGA); A. H Roy, D. T. Hellums, (IFDC Muscle Shoals, U.S.A.)

1.7 SMAP Vietnam; Smallholder Farmer Access to Phosphorus: T. M. Tran, H. H. Bui (Vietnamese Academy of Soil and Fertilizer), A. H. Roy, D. T. Hellums, (IFDC Muscle Shoals, U.S.A.); R. W. Scholz (Fraunhofer IWKS, Alzenau, Germany)

2. The Global TraPs Springer Book

2.1 Scholz, R. W., Roy, A. H., Brand, F. S., Hellums, D. T., & Ulrich, A. E. (Eds.). (2014). *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap*. Berlin: Springer.

The Chapters of the Springer Book

2.2 Hermann, Schipper, W., Langeveld, K., & Reller, A. (2014). *Processing Node: What Improvements for What Product?* In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.),

Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap (pp. 183-207). Berlin: Springer.

2.3 Mikkelsen, R., Binder, C. R., Frossard, E., Brand, F. S., Scholz, R. W., & Viltsmaier, U. (2013). *Use: What Technologies, Information and Transdisciplinary Approaches are Required to Sustainably Transform P-Use?* In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 257-181). Berlin: Springer.

2.4 Scholz, R. W., Roy, A. H., & Hellums, D. T. (2014). *Sustainable Phosphorus Management. A Transdisciplinary Challenge*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap*. (pp. 1-128). Berlin: Springer.

2.5 Vaccari, D. A., Mew, M., Scholz, R. W., & Wellmer, F.-W. (2014). *Exploration: What Reserves and Resources?* In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 129-153). Berlin: Springer.

2.6 Watson, I., van Straaten, P., Katz, T., & Botha, L. (2014). *Mining and Concentration: What Mining to What Costs and Benefits?* In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 153-183). Berlin: Springer.

2.7 Weber, O., Delince, J., Duan, Y., Maene, L., McDaniels, T., Mew, M., et al. (2014). *Trade and Finance as Cross-Cutting Issues in the Global Phosphate and Fertilizer Market*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 275-294). Berlin: Springer.

2.8 Yarime, M., Carliell-Marquet, C., Hellums, D. T., Kalmykova, Y., Lang, D. J., Le, Q. B., et al. (2014). *Dissipation and Recycling: What Losses, What Dissipation Impacts and What Recycling Options?* In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 231-256). Berlin: Springer

Spotlights of the Springer Book

2.9 Elser, J. (2014). *Health Dimensions of Phosphorus*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 229-231). Berlin: Springer.

2.10 Freyer, B. (2014). *Phosphorus in Organic Agriculture*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. H. Hellums & A. E. Ulrich (Eds.),

Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap (pp. 243-245). Berlin: Springer.

2.11 Gantner, O., Schipper, W., & Weigand, J. J. (2014). *Technological Use of Phosphorus: the Non-Fertilizer, Non-Feed and Non-Detergent Domain*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. H. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 237-242). Berlin: Springer.

2.12 Le, Q. L., & Scholz, R. W. (2014). *The Yen Chau - Hiep Hoa case study: Avoiding P Fertilizer Overuse and Under-Use In Vietnamese Smallholder Systems*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 119-123). Berlin: Springer.

2.13 Malley, D. F. (2014). *Options in Processing Manure From a Phosphorus Use Perspective*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 204-205). Berlin: Springer.

2.14 Roy, A. H., Hellums, D. T., Scholz, R. W., & Beaver, C. (2014). *Fertilizers Change(D) the World*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. H. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap*. Berlin: Springer.

2.15 Schnee, R., Stevens, H. C., & Vermeulen, M. (2014). *Phosphorus in the Diet and Human Health*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 232-236). Berlin: Springer.

2.16 Scholz, R. W., & Le, Q. L. (2014). *A Novice's Guide To Transdisciplinarity*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 116-118). Berlin: Springer.

2.17 Scholz, R. W., Wellmer, F.-W., & DeYoung Jr., J. H. (2014). *Phosphorus Losses in Production Processes Before the "Crude Ore" and "Marketable Production": entries in reported statistics*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 174-182). Berlin: Springer.

2.18 Tirado, R., & Krishnan, V. (2013). *Phosphorus and Food Security from a Greenpeace and Indian Smallholder Farmer View*. In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), *Sustainable Phosphorus Management: A Global Transdisciplinary Roadmap* (pp. 295-299). Berlin: Springer

3. Scientific Papers

3.1 Scholz, R. W., Hellums, D. T., & Roy, A. H. (in press). "Global Sustainable Phosphorus Management: A Transdisciplinary Venture". *Current Science*.

3.2 Scholz, R. W., Ulrich, A. E., Eilittä, M., & Roy, A. H. (2013). "Sustainable Use of Phosphorus: a Finite Resource". *Science of the Total Environment*, 799-803.

3.3 Scholz, R. W., & Wellmer, F.-W. (2014). *Interactive comment on "Recent revisions of phosphate rock reserves and resources: reassuring or misleading? An in-depth literature review of global estimates of phosphate rock reserves and resources" by J. D. Edixhoven et al.* *Earth System Dynamics Discussions*, 4, C575–C598.

3.4 Scholz, R. W., & Wellmer, F.-W. (2015). *Phosphate reserves and resources: What conceptions and data do stakeholders need for sustainable action? Comments and thoughts emerging from the paper: J.D. Edixhoven, J. Gupta and H.H.G. Savenije: Recent revisions of phosphate rock reserves and resources: A critique.* *Earth System Dynamics Discussions*, 6, 31–80.

3.5 Vilsmaier, U., Engbers, M., Luthardt, P., Maas-Deipenbrock, R.-M., Wunderlich, S., & Scholz, R. W. (forthcoming). *Case based Mutual Learning Sessions: Knowledge Integration and Transfer in Transdisciplinary Processes.* *Sustainability Science*.

3.6 Wellmer, F.-W., & Scholz, R. W. (in press). "The Right to Know the Geopotential of Minerals for Ensuring Food Supply Security: the Case of Phosphorus." *Industrial Ecology*.

4. Book Chapters and Conference Proceedings

4.1 Christesen, C. (2014). *Critical Assessment of Data on Reserves and Resources of Phosphate Rock (Berichte zur Lagerstätten- und Rohstoffforschung).* Hannover: BGR.

4.2 Ulrich, A. E., & Cors, R. (2011). *Global TraPs: An International Effort to Promote Sustainable Use of Phosphorus: (pp. 26-28) Baltic 21.*

5. Strategic Papers

5.1 Eilittä, M. (2011). *The Global TraPs Project. Transdisciplinary Processes for Sustainable Phosphorus Management (2010-2015). Multi-stakeholder forum to guide and optimize P use. Zurich and Muscle Shoals: ETH-NSSI and IFDC.*

5.2 Roy, A. H., & Scholz, R. W. (2014). *Seven Focus Areas of Global TraPs - 2012-2015.* *Global TraPs Newsletter*, 12, 7-11.

5.3 Scholz, R. W., & Roy, A. H. (2013). *Response of the Global TraPs Project ("Transdisciplinary Processes for Sustainable Phosphorus Management" - <http://www.globaltraps.ch/>) to the EC Consultative Communication on the Sustainable Use of Phosphorus Communication from The Commission*

to the European Parliament, The Council, the European Economic and Social Committee and The Committee of the Regions. In G. TraPS (Ed.). *Alzenau/Muscle Shoals.*

6. List of Master Thesis and Internship Reports

6.1 Baumann, L. (2013). *Human-Environment Systems of a Phosphate Rock Mine. Encountered challenges for the environmental management at Foskor, a Phosphate Rock Mine in Phalaborwa South Africa.* Zurich, Muscle Shoals AL, Phalaborwa: *Global TraPs & Foskor, Internship Report Environmental Systems Science Department, ETH Zurich, Zurich, Switzerland.*

6.2 Christesen, C. S. (2014). *Critical Assessment of Data on Reserves and Resources of Phosphate Rock.* Technical University of Freiberg, Freiberg.

6.3 Geissler, B. (2014). *Sustainable Phosphorus Mining Actors, Sustainability Standards and Performance Evaluation of a Business Case.* University of Graz, Graz.

6.4 Lotze, N. (2013). *A Transdisciplinary Case Study in Manila, Philippines: Phosphorus Detergent Impact on Eutrophication in Laguna de Ba.* Carl von Ossietzky University of Oldenburg, Oldenburg.

6.5 Luthardt, P. (2014). *Mutual Learning in Transdisciplinary Research Projects.* Leuphana Universität Lüneburg, Lüneburg.

6.6 Maas-Deipenbrock, R. M. (2014). *Beyond Qualitative Group-Based Research Methods: Mutual Learning Sessions as a Transdisciplinary Approach.* Leuphana Universität Lüneburg, Lüneburg.

6.7 Wemyss, D. (2012). *Lessons Learned and Transferable Technology for Phosphorus Recycling from Domestic Wastewater in Japan and Switzerland.* ETH Zurich, Zurich.

6.8 Wunderlich, S. (2014). *International Transdisciplinary Processes for the Preparation of Decisions in the Context of Sustainability Challenges.* Carl von Ossietzky University of Oldenburg, Oldenburg.

7. Booklets of Mutual Learning Sessions and Dialog Sessions of the Beijing Conference

7.1 Cooper, J., Zhang, T. & Kabbe, C. (2013). *MLS 1.3: Sewage: Practice and Options for Better Phosphorus Recycling at the Weijia Sewage Treatment Plant.* 1st Global TraPs World Conference, June 18-20, 2013, Beijing.

7.2 Hermann, L., Steiner, G. & Droste, N. (2013). *MLS 2.3: Malaysia Palm Oil.* 1st Global TraPs World Conference, Beijing.

7.3 Hu, Z., Gantner, O., Langeveld, C. P., ten Wolde, K. W., Nolte, C. & Kabbe, C. (2013). *DS 3.5: Technology Innovation in Fertilizers.* 1st Global TraPs World Conference, June 18-20, 2013, Beijing.

7.4 Lotze, S. N. (2013). *MLS 2.4: Manila Detergent Study.* 1st Global TraPs World Conference, June 18-20, 2013, Beijing.

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