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

(*http://ec.europa.eu/environment/consultations/phosphorus_en.htm*)

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The present response is based on feedback of Global TraPs' leaders, steering board, and members. The Global TraPs project includes representatives from all key stakeholder groups of the key nodes of the supply-demand chain, i.e. Exploration, Mining, Processing, Use, Dissipation and Recycling as well as Trade and Finance. Global TraPs' primary feedback – besides stressing the role that the EU may take in global phosphorus management – related to inaccurate data and resulting conclusions.

The following persons have provided input from a Global TraPs perspective:

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1. Discussion of goals formulated in the EC document

The EC document "Consultative Communication on the Sustainable Use of Phosphorus" (subsequently called CCSUP) is a comprehensive and balanced paper which sketches important parts of a roadmap to a resource-efficient use of phosphorus in Europe. From the perspective of Global TraPs, the priority and pressure of improving phosphorus management is described in a proper way. The last paragraph of the introduction adequately sketches the necessity of recycling and better use of organic phosphorus as well as the need of closing the phosphorus cycle as the physical limitations of access become more important.

> *The complete replacement of phosphate mined in the EU by recycled phosphorus is neither feasible nor necessary in the foreseeable future. However, greater recycling and use of organic phosphorus[1] where it is needed and available could stabilize the amounts of mined phosphate required and mitigate the soil contamination and water pollution issues. This will then put us on track to close the phosphorus cycle in the long term, when the physical limitations of the resource will become increasingly important* (page 3, CCSUP).

The CCSUP document is welcomed by Global TraPs, as the above goal is quite compatible with the guiding question of the Global TraPs project:

> *What new knowledge, technologies and policy options are needed to ensure that future phosphorus use is sustainable, improves food security and environmental quality and provides benefits for the poor?* (http://www.globaltraps.ch/)

Global TraPs therefore supports the overall objective of making phosphorus stewardship an integral part of the EU's sustainable development policies, both for agriculture and food security, and for high added-value strategic industries which depend on phosphorus chemistry. Phosphorus stewardship should be integrated holistically into the EU's particular policies including strategic materials and resources policies, farm and food, water and waste and bio-economy policies, in order to implement the synergies between better use of phosphorus to reducing eutrophication problems and developing local jobs in the circular economy. Europe may develop a practice which may be applied in many places of the world. We want to note here that sustainable management on all levels of the value chain is important. This is because only a minor part of the phosphate rock (PR) and phosphoric acid that is consumed and processed by European countries is produced in Europe, hence Global TraPs pursues the incorporation of the key players along the phosphorus (P) value chain in a transitioning towards sustainable phosphorus flows on a global scale.

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[1] Please acknowledge that many relevant waste materials are not composed of organic P. For instance

2. The specific role and responsibility of Europe in future sustainable phosphorus use and recycling should be outlined more comprehensively

2.1 Include consideration of principles of sustainable mining and processing of phosphates before import

More than 95% of the consumed phosphorus in Europe is imported as fertilizer, livestock feed, food and other organic products. Thus, in targeting sustainable phosphorus use, Europe has to take some responsibility with respect to the excavation and processing of the phosphorus which is imported from various countries outside of Europe. From a sustainability perspective it implies to consider the associated environmental impacts and social aspects of mining should be considered. CCSUP is currently not dealing with these aspects. Against this background, the work of the World Business Council for Sustainable Development would provide a good benchmark to identify phosphorus imports which do not meet basic levels of sustainable action (MMSD, 2002). Another guideline for sustainable mining is the Global Reporting Initiative Extractive Sector Supplement (The Global Reporting Initiative, 2010) that tracks the sustainability performance of the extractive industries.

2.2 P recovery from waste water is important, but represents only a small fraction of potential P recovery or efficiency

The technology and practice of recovery of phosphorus from waste water, manures and some other waste streams is most developed in some European countries as well as in Japan and Canada. Here, the pioneering role that these countries, and in particular Europe, could provide in P nutrient recovery should be considered.

However, given the current state of knowledge about the phosphorus cycle, other substantial losses of phosphorus (in addition to waste water and sewage) have to be acknowledged as potential sources for P recovery. In 2012, phosphate rock concentrate containing about 27 Mt of phosphorus were mined (Jasinski, 2013b) primarily for fertilizer production for the agricultural sector (90-95% fertilizer and animal feeds), but also for use in a variety of industries (i.e. food processing, ceramics/glass, steel, fire safety, speciality chemicals, medicine etc.). In addition, other land-based human activities (e.g., crop and livestock production, road construction) increased the loss of phosphorus (by soil erosion or waste discharge to rivers from where it is effectively lost from biological cycles in sediments or deep seawater) and weathering of phosphorus by several Mt of P per year. Further significant losses of phosphorus may result from inefficient mining and low-tech beneficiation (Scholz, Wellmer, & DeYoung Jr., 2013). Ultimately, around 40 to 50 Mt of P are annually mobilized for human intake of a little more than 3 Mt of P per year (Scholz, Roy, & Hellums, 2013). We argue that the whole supply-demand chain of phosphorus use should be looked at and the most efficient means and interventions for closing the supply demand chain should be assessed.

2.3 The development of meaningful methods to evaluate "prospective eco-efficiency" recycling technologies are missing and should be promoted

From the perspective of eco-efficiency (Scholz & Wiek, 2005) it is of interest to identify and to properly monitor which industrial residues (e.g., slag) and agricultural waste and product streams (e.g., crop residues, animal waste, yard waste, food waste, manure, waste water) provide opportunities for phosphorus recycling. Here, the determination of costs and learning curve characteristics are crucial as well. Based on almost three years work by Global TraPs, we argue that this only may be done in trandisciplinary processes, which include the knowledge (and data) of key stakeholders along the supply-demand chain and that of scientists who are experts for methods of prospective economic, environmental or even comprehensive sustainability evaluation. In order to make investments in the right place and the most efficient investment, we need proper methods and transdisciplinary discourses among the key stakeholders, which may help to identify those recycling areas that allow for the most efficient recycling. This process should employ a long-term view to avoid the exclusion of options because of short-term costs.

Waste water treatment plants are specific: Technologies for reusing phosphorus from waste water vary in efficiency depending on the *ingredients of the waste water* and the type, size, and location of waste water treatment plants. In particular, efficiency is affected by the type of phosphates (e.g., orthophosphate, tripolyphosphate, pyrophosphates), when removal occurs and at what stage of the clean-up process when removal occurs (e.g., from the incoming waste water, sewage or biological stage) it is conducted.

There is a large variety of methods for removing phosphorus from waste water: Technologies for extracting phosphorus from waste water or sewage rely on (1.) different types of biological (basic or enhanced) or chemical precipitation (e.g., based on lime, aluminium, iron), (2.) process-phase specific application of the technology to the waste stream (from waste water to sludge), (3.) direct application or extraction of phosphorus from the sludge a.) before or b.) after incineration or anaerobic digestion, (4.) different production chains in each technology mode (e.g., dehydration processes in application), and (5.) incineration technologies that extract the phosphorus from the ash or make it plant available by chemical or thermal procedures. Last but not least, each of the methods has beneficial and harmful products or by-products (including toxic elements) and might be associated with a negative or positive energy balance. Smart combination of the technologies along all stages of wastewater treatment may not only provide advantages, but also more efficient application of synergies.

Based on these variations, it is obvious that not a single technology that will be superior to all others under all conditions.

A meaningful scientific methodology for eco-efficiency is needed

From a science perspective, a methodology that allows for a comparative evaluation of different phosphorus extraction technologies is needed. The methodology should include:

- Acknowledgement of the specifics of a sewage plant (including a local environmental impact analysis of technology change)
- Incorporation of a cost-benefit analysis of phosphorus extraction
- Inclusion of a comprehensive environmental assessment considering the global environmental impacts (e.g., as was done by the damage-oriented Eco-Indicator 99 method (Goedkoop & Spriensma, 1999)); and
- Inclusion of an assessment of the prospective change of flows of materials by incorporating various scenarios (e.g., different demands of phosphorus or energy costs) in the assessment (Spielmann, Scholz, Tietje, & de Haan, 2005)

A comprehensive method should also allow for cross-sectional assessment and consider interactions as well as rebound effects. A specific challenge is to develop a method of evaluation that may assist in a comprehensive (comparative) prospective assessment of mined and recycled phosphates in a meaningful way.

The methodology of assessment should be easily applicable in practice

Special care should be taken that the method is not only a theoretical one, but may be applied to relevant sewage plants at reasonable costs. Furthermore, it should be applicable to relevant sewage plants at reasonable costs.

3. For assessing the supply risk of phosphate rock reserves, consideration must be given to vulnerability

With respect to supply security, much attention is dedicated to the large share of the world phosphate rock (PR) reserves in Morocco. The increase of phosphorus reserves in Morocco has caused some particular concerns internationally with respect to the validity of these data and – somewhat paradoxically as we are talking about an increase of a rather abundant resource – the future scarcity of phosphorus. To assess supply risk with respect to phosphorus, the following issues should be properly incorporated:

1. Not only have the estimates of Moroccan *reserves* increased (from 5.7 Gt to 50 Gt of PR), but estimates of other reserves almost doubled as well, increasing from 9.3 Gt in 1998 to 17.0 Gt in 2013. Given an annual consumption of about 0.2 Gt of PR/yr, these other sources provide a 'static lifetime' of 85 years without giving consideration to the Moroccan reserves (Jasinski, 2013b).

2. Phosphate rock may be considered a relatively low cost commodity and the different deposits of PR have not been intensely assessed in many parts of the world. Further, as far as we know, the estimate of PR reserves in Morocco is a conservative one, as the various sites have not been incompletely explored. It is likely that the currently economically mineable reserves of PR are above 100 Gt (van Kauwenbergh, 2010).

3. The concentration of PR *reserves* is not exceptionally different than that of some other minerals. For example, two countries (Canada and Russia) account for more than 80% of the present global potash reserves (Jasinski, 2013a). In the Russian case, however, it demonstrates that the availability and the price of the resource may significantly depend on political issues and business competition (as the Uralkali case demonstrates). Numerous examples exist for other minerals and metals that are important to food production and/or other societal needs (see Figure 1 below).

4. For assessing vulnerability with respect to phosphorus supply (among others) both bottlenecks with respect to annual production and of reserves have to be considered. Figure 1 presents the Herfindahl-Hirschmann Index (HHI) for many commodities. If we consider the production related HHI, the score for PR production between 2008 and 2010 (Figure 1) was between medium and high (i.e. moderately high). On the other hand, the HHI for PR reserves moved higher after the adjustment to the estimate for Moroccan reserves. However, we have to acknowledge that the HHI does not consider the "relative abundance" of phosphorus. As explained in 1. (above), against the background of the large reserves of phosphorus, the HHI thus does not provide a reliable supply risk or vulnerability assessment here as the high static lifetime of about 350 years mitigates the vulnerabilits. If the 'relative abundance' would be incorporated, the risk/vulnerability would become lower.

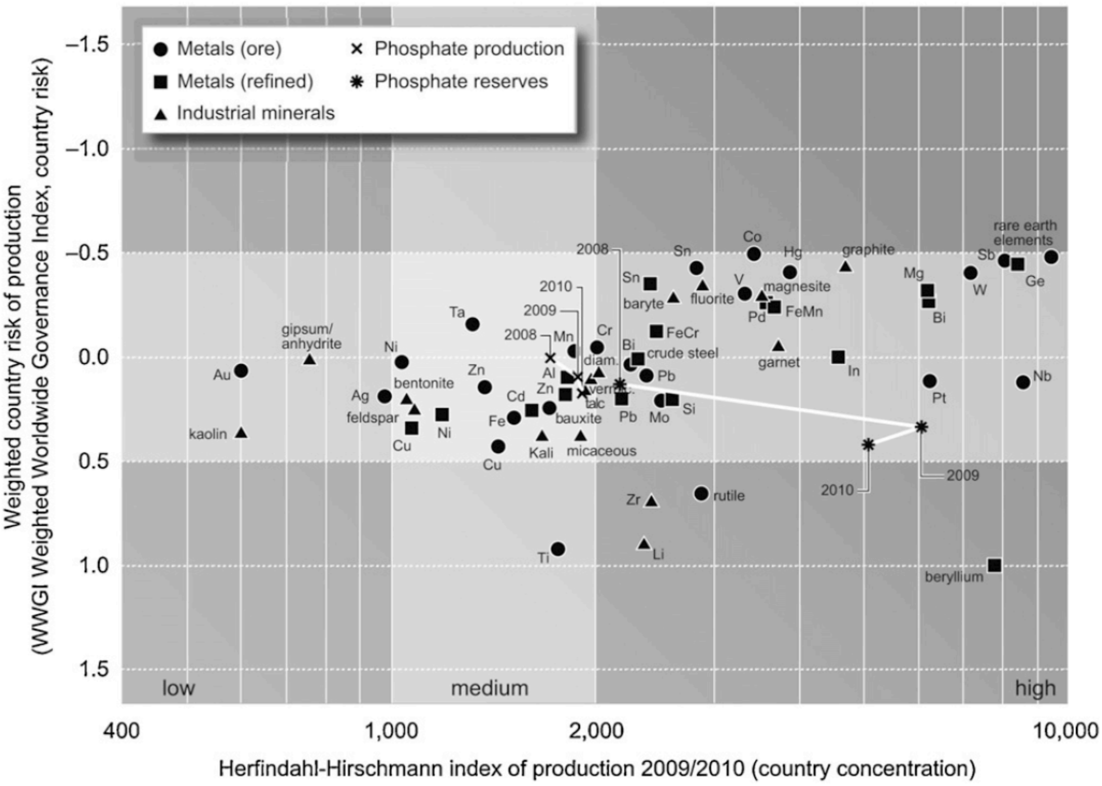

Fig. 1. Linkage of the Herfindahl–Hirschmann Index (HHI, figure according to Deutsche-Rohstoffagentur/BGR, 2011) with the Weighted World Governance Index ((WWGI data from Jasinski, 2009, 2010, 2011a, 2011b; Kaufmann, Kraay, & Mastruzzi, 2011); . Figure and legend taken from Scholz and Wellmer, 2013.

1. With respect to the supply risk of phosphates, risk assessment should consider not only the reserves, but also favorable cost factors supporting phosphate production capacities (See Figure 1, Scholz & Wellmer, 2013).

Further, the analysis should not focus on risk, but rather on vulnerability (Scholz, Blumer, & Brand, 2012). The exposure and the sensitivity to a disruption of phosphorus supply from specific countries is not only of interest, but also the ability to replace the needed resources from other sources is of equal importance, thereby reducing vulnerability, must be considered.

Global TraPs therefore supports the overall objective of making phosphorus stewardship an integral part of the EU's sustainable development policies, both for agriculture and food security, and for high added-value strategic industries which depend on phosphorus chemistry. Phosphorus stewardship should be integrated holistically into the EU's different policies including strategic materials and resources policies, farm and food, water and waste and bio-economy policies, in order to implement the synergies between better use of phosphorus, reducing eutrophication problems and developing local jobs in the circular economy. Also the idea of strategic partnership with phosphate producing countries may be considered as a policy option of sustainable phosphorus stewardship.

4. Specific shortcomings of the CCSUP

This section deals with some failures which may elicit wrong perception on phosphorus flows accessible in CCSUP. Also the second sentence of the call for consultation may provide a wrong accent or view for the challenging task of achieving sustainable phosphorus flows:

> *Phosphorus is widely used in agriculture and is an essential component in fertilizer and feed, but it is a non-renewable resource.*
> (http://ec.europa.eu/environment/consultations/phosphorus_en.htm)

Phosphorus atoms are not disappearing from earth. However, (high ore) PR is a nonrenewable resource given the human time scale. Here, it is of interest that phosphorus has a specific dissipative structure which may hamper recycling.

4.1 The amount of accrued manure is not correctly presented

In the EC report, Figure 1 on "Historical global sources on phosphorus fertilizers" (Cordell, Drangert, & White, 2009) is misleading. The amount of phosphorus in manure worldwide currently estimated at 10-15 Mt of P/year is bigger by almost a factor of 5 than the presented 2.5 to 3.0 Mt of P/year in Figure 2. Best estimates range from 9.6 Mt of P/year (MacDonald, Bennett, Potter, & Ramankutty, 2011a, 2011b) up to 15 to 24 Mt of P/year (Sattari, Bouwman, Giller, & van Ittersum, 2012a, 2012b). The following picture seems to be more adequate.

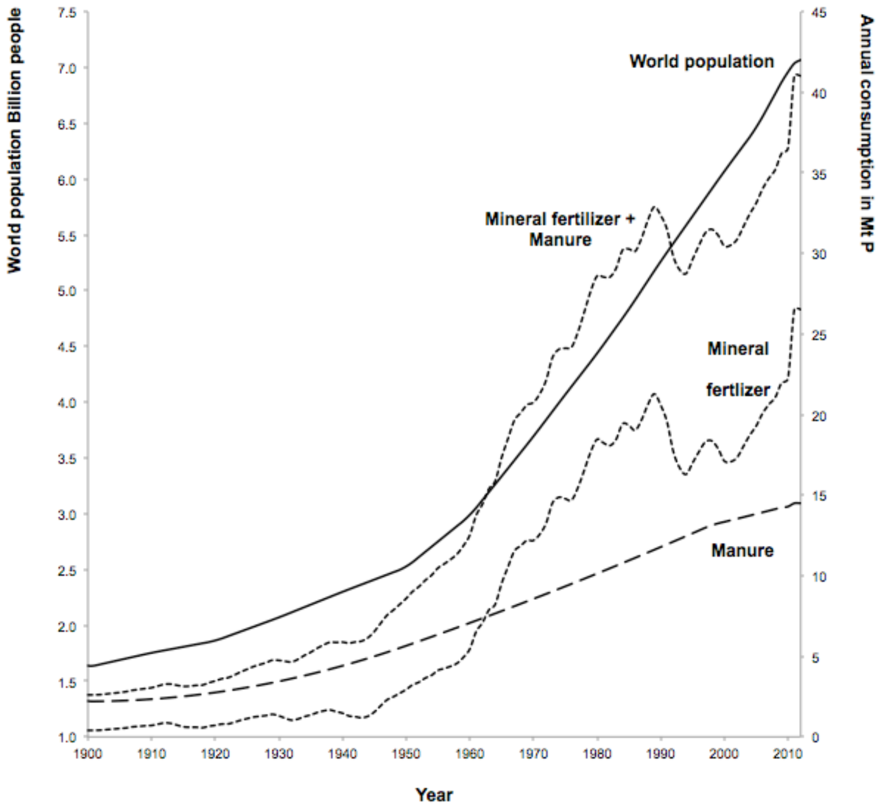

Figure 2: The evolution of phosphorus fertilizer use, where mineral phosphorus plays an increasingly important key role (phosphorus data – 80-85% for fertilizer use - from USGS, presented as moving mean with a three year sliding window; rough estimation of manure data based on literature; population data from (USCB, 2009); manure data extrapolated from different data on annual manure production) Source: Scholz, Roy and Hellums, 2013

4.2 The consumption and recycling, of P from current biofuel production streams and technology should be properly assessed

The rapid increase of biofuel production and its multiple trade-offs with crop production is critical from different perspectives (e.g., land use, crop price development, etc.). However, given current biofuel technology, there is evidence that the majority of phosphorus in biofuel production is recycled by feed. The current state (Scholz, Roy, et al., 2013) and the future potential (Sialve, Bernet, & Bernard, 2009) of phosphorus recycling from biodiesel, bioethanol etc. should be assessed. Indeed, phosphorus reuse and recycling are an essential condition for significant development of biofuels and bioresource production (The National Academies of the U.S., 2012). The EU should integrate this into its bioeconomy strategy.

A specific issue that may be reflected from the European Union also from the aspect of phosphorus flows is that biofuel production is widely externalized and does not take place in Europe on a large scale.

4.3 The need for fertilizer innovation is underestimated

A large share of the phosphorus fertilizer is of the mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP) type. Like most commercially available mineral fertilizers, these phosphate fertilizers were developed more than 50 years ago. Though there is evidence that these fertilizer work well in many agroclimatic conditions and cropping sytems; hoewever their production results in generation of which is. phosphogypsum.

The amount of phosphogypsum annually produced as a by-product of wet-process (sulphuric acid based) phosphoric acid production (precursor to most phosphate fertilizers) is significant, particularly if one considers environmental regulations that prevent its use in some countries. Assuming a production of 22 Mt of sulphuric acid based phosphoric acid production, an additional 110 Mt of phosphogypsum by-product is produced and proper strategies for best using the phophpogypsum of the past and the future are a global issue.

Compared to other nutrients, phosphorus is relatively immobile. In other words, applied phosphorus (from mineral fertilizers or manure), which is not taken up by the crop, will remain in the soil becoming slowly available to subsequent crops, unless soil erosion or surface water runoff (in the case of manure) is an issue. This retention and recycling characteristic has resulted in tremendous stock building of phosphorus in European soils in some regions, which can potentially supply future plant needs for many years suggesting moderate vulnerability to supply risks, given a proper diversification of the supply portfolio.

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