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JOURNAL FOR EUROPEAN ENVIRONMENTAL &
PLANNING LAW 12 (2015) 343-361

JOURNAL FOR EUROPEAN ENVIRONMENTAL & PLANNING LAW
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Legal Instruments for Phosphorus Supply Security

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Abstract

This article will show which legal measures could lead to more sound use of phosphorus, and which might not. From the perspective of natural science, there are varying accounts as to how long phosphorus will still be available. It is, however, undisputed that phosphorus is a finite resource with vital importance to humankind. It is also certain that overusing phosphorus causes environmental damage further increased by permanent application. In this context, the usage of phosphorus from stocks contaminated by heavy metals might increasingly become an issue. Regulatory policy incentives are required towards establishing more sound phosphorus use with increased focus on recycling. So far, phosphorus has involved tentative proclamations rather than legally binding measures. However, classical regulatory measures directed at single actions – the command-and-control approach – will not suffice in addressing resource and environmental problems, as phosphorus problems are more appropriately viewed as quantity problems. Additional economic instruments are needed in order to avoid enforcement deficits, rebound and shifting effects, and to promote recycling while decreasing phosphorus consumption. These economic instruments would also help in addressing several environmental problems regarding land use, resources, biodiversity loss and climate change all at once.

Keywords

Phosphorus – natural resources – sustainability – governance – EU policy

1 Phosphorus as a Scarce and Environmentally Relevant Resource: Call for Action?

The principle of sustainability forms the basis of modern environmental policy. By definition, sustainability is a way of life and economy which will – globally

 | DOI 10.1163/18760104-01204007

and for generations – allow for continued life on earth.[1] This requires a focus on using renewable resources within the limits of their regeneration and sparing use of non-renewable resources. One of those non-renewable resources is phosphorus (P), a key nutrient vital for plants, humans and animals. Moreover, P inputs into soil and waters potentially cause considerable environmental damage. This article will first give an overview of the difficult debate on these problems. Secondly, we will address the question of effective political options for action, which will be our main focus. We will demonstrate how the issue of P is interconnected to other environmental issues such as land use, resource scarcity, biodiversity loss and climate change. Likewise, questions of social distribution will be addressed.

P is a finite, non-substitutable resource whose long-term availability is absolutely necessary in securing the global food supply. The last several years have seen highly controversial accounts of its future availability. Estimates of the remaining accessible P reserves gained from phosphate rock vary strongly according to projections on economic and technical usability of deposits and therefore must be regarded as snapshots.[2] Between 1988 and 2012, statistical projections indicated an availability of P between 84 and 396 years.[3] In one study,[4] a Peak P in the year 2033 is estimated. The concept of Peak P in general is open to question from a historical and economic point of view.[5] So, instead of putting the main focus on geological P availability, Ulrich and Frossard (2014) suggest greater focus on socio-economic and environmental vulnerabilities that may occur from current and future P production and demand, such as by establishing fertilizer access to smallholding farmers and avoiding pollution in soil and water by using P.[6] The latter perspective obviously aims towards

1 *Ekardt F.*, Theorie der Nachhaltigkeit: Rechtliche, ethische und politische Zugänge, 2011.

2 BGR, Phosphat mineralischer Rohstoff und unverzichtbarer Nährstoff für die Ernährungssicherheit weltweit, 2013.http://www.bgr.bund.de/DE/Themen/Zusammenarbeit/TechnZusammenarbeit/Politikberatung_SV_MER/Downloads/phosphat.pdf?__blob=publicationFile&v=4 [01.12.2014].

3 Ibid.

4 *Cordell D. et al.*, Preferred future phosphorus scenarios: A framework for meeting long-term phosphorus needs for global food demand, International Conference on Nutrient Recovery from Waste Water Streams, 2009.

5 *Ulrich, A.E et al.*, Peak Phosphorus: Opportunity in the making. Exploring global phosphorus management and stewardship for a sustainable future, 2011; *Heckenmüller M. et al*: Global Availability of Phosphorus and Its Implications for Global Food Supply. An Economic Overview, Kiel Working Paper No. 1897, 2014.

6 *Ulrich A.E. et al.*, On the history of a reoccurring concept: Phosphorus scarcity. Science of the Total Environment 490, 2014, pp 694–707.

more careful use of P in general. Because of that, and because there is no doubt about the fact that P deposits are finite, there is no genuine difference in policy implications from either perspective.

The possible environmental damage and scarce P reserves in particular raise the question as to the quality of the remaining resources with respect to the availability of P not increasingly contaminated with heavy metals such as uranium (U) or cadmium (Cd). Rock phosphates from sedimentary deposits represent most of the P reserves still accessible worldwide.[7] These in particular are relatively heavily contaminated with heavy metals due to geogenic influences in contrast to igneous deposits. The following table shows the average geogenic burden of rock phosphates with Cd and U according to origin.

Almost 90% of P fertilizers produced worldwide are obtained from sedimentary rock phosphate.[8] According to a study by Dittrich & Klose (2008), the average Cd concentration in mineral nitrogen, phosphorus and potassium-based NPK fertilizers per unit of P lies between 18 mg Cd/kg P_2O_5 and over 60 mg Cd/kg P_2O_5 in triple superphosphate fertilizers. Results from 2003 showed that Cd concentrations of up to 20 mg Cd/kg P_2O_5 might not lead to long-term

TABLE 1 *Uranium and cadmium concentration of rock phosphates of different origins*[9]

	Rock phosphate				
	Sedimentary				**Igneous**
mg/kg	**USA**	**Morocco**	**China**	**Mittle East**	**Russia (Kola)**
Cadmium	6.1 – 92	15 – 38	<2 – 2.5	1.5 – 35	0.1 – 1.3
Uranium	65 – 180	75 – 155	23 – 31	40 – 170	10 – 28

7 BGR 2013.

8 *Mortvedt J. et al.*, Heavy Metal and Radionuclide Contaminants in Phosphate Fertilisers, 1995; *Van Kauwenbergh S.*, Cadmium and other minor elements in world resources of phosphate rock, The Fertiliser Society, Proceedings No. 400, 1997; *Raven, K. P.*, et al., Trace elements composition of fertilisers and soil amendents, 1997, p. 551–557; *Kharikov A.M./ Smetana V.V.*, Heavy metals and radioactivity in phosphate fertilisers: short term detrimental effects, 2000, http://www.fertiliser.org/en/ItemDetail?iProductCode= 6869Pdf&Category=TECH, [09.06.2015]; *Gupta C.K./ Sing H.*, Uranium Resource Processing, 2003; secondary Resources as resumed in *Schnug E./ Kratz S.*, Schwermetalle in P-Düngern, 2005.

9 *Van Kauwenbergh* 1997.

accumulation of Cd in the soil, whereas concentrations of 60 mg Cd/kg P_2O_5 and more would likely lead to a relatively high accumulation in the soil over a period of 100 years.[10] Apart from possible long-term accumulation, the main issue is that Cd ions in soils may become mobile and translocate easily into crops or groundwater through deeper soil layers. Cd already becomes mobile at pH values of 6.5.[11] A tendency for soils with low pH values and/or humus levels towards high transfer rates into crops has been reported.[12] Concentrations in the human body may reach critical levels caused by grain and vegetable consumption.[13] The European Food Savety Authority[14] established a tolerable weekly intake of 2.5 µg/kg body weight for Cd according to a recent risk assessment by the joint FAO/WHO Expert Commitee on Food Additives.[15] As a consequence, European Commission recently amended EC Regulation No. 1881/2006 for maximum Cd levels in foodstuffs in 2014.

Even though eliminating Cd and U from P is technically possible, economic factors have prohibited this from being practiced on a regular basis. Raising the price in the aftermath of the procedure and price-regulating speculation of remaining P reserves have encountered skepticism, as this raises concerns of possibly fostering unequal fertilizer distribution.[16] Ulrich et al. (2014) also anticipate considerable economic potential by using U from phosphate rock in the nuclear industry. New nuclear power plants under construction worldwide show that there most probably will be a demand for U in the future.[17] Issues facing permanent disposal, non-assessable uncertainties of disasters beyond all expectations and risks of terrorist attacks raise questions as to the suitability of nuclear energy as a future energy source.[18]

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10 European Commission, Draft proposal relating to Cadmium in fertilisers, 2003. http://ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=2966 (21.11.2012).

11 *Blum H. P.*, Handbuch des Bodenschutzes. Bodenökologie und -belastung. Vorbeugende und abwehrende Schutzmaßnahmen, 2004.

12 *Ruppe A. et al.*, Fortschreibung von Beurteilungsmaßstäben für den Wirkungspfad Boden-Pflanze: Methodik zur flächenrepräsentativen Erfassung pflanzenverfügbarer Stoffgehalte in unbelasteten Böden und Stoffgehalten in Nahrungs- und Futtermittelpflanzen, 2009.

13 BfR, Aufnahme von Umweltkontaminanten über Lebensmittel (Cadmium, Blei, Quecksilber, Dioxine und PCB), Ergebnisse des Forschungsprojektes LExUKon, 2010.

14 EFSA, Scientific opinion. Statement on tolerable weekly intake for cadmium, 2011.

15 WHO, WHO Food Additives Series 64, 73rd meeting of the JECFA, 2011.

16 *Lange J,*. Phosphor – so wichtig wie Luft, so knapp wie Erdöl?, 2009.

17 www.world-nuclear.org.

18 *Welch B.*, Nucelar Power risks: challenge to the credibility of sience, International Journal of Health Services, 02/1980, Vol 10(1), 1980, p 5–36; McDaniels T., Chernobyls Effects on the Perceived Risks of Nuclear Power: A small sample test, Risk Analyses 05/2006, Vol. 8(3),

The use of P and other mineral fertilizers such as nitrogen (N) is highly interlinked with the environmental problem of soil degradation as well as eutrophication in water bodies, biodiversity loss and global climate change. Continuous soil degradation worldwide ranges from soil sealing, desertification and salination to soil compaction, nutrient loss and soil acidification to soil contamination. According to the secretariat of the United Nations Convention to Combat Desertification, this accounts for losses of around 24 billion tons of fertile topsoil worldwide per year.[19] Soil degradation may not only occur due to heavy metals introduced into the soil through mineral fertilizers; the amount of humus in soils and therefore also natural soil fertility may decrease where rapid-action mineral fertilizers are mainly applied to the soil and crop rotation and cover crops to preserve natural soil fertility no longer play a role in intensive farming in specialized agricultural businesses.[20] Indeed, especially high amounts of N may lead to soil acidification.[21] Once degraded, soils with low pH levels may finally store less nutrients such as P for release into plants; nutrients may be washed out of the soil quickly by rain and flow into water bodies.[22] Agriculture is a major contributor for most of the diffuse input of P into water.[23] The anthropogenic increase in surface water nutrients leads to more restricted biodiversity, such as due to the possibility of excessive growth of algae in coastal regions and overturning waters. Over 400 "death zones" in water bodies have been identified worldwide.[24] Once in a river or sea, P is deposited in sediments in lakes or delivered to coastal waters where P recovery is virtually impossible.[25]

At the same time, conventional agriculture in particular is still highly dependent on mineral NPK fertilizers. Yield increases that began in the 1950s in

p. 457–461, 2006; *Kiroptin, S./ Nemceva G.*, Environmental, economic and social risks of nuclear power enginieering. The case of the southern part of the Ob-river basin, International Journal of Environmetal Studies 05/2015, Vol. 72(3), 2015, pp 1–12.

19 UNCCD, Desertification Land degradation and drought – some global facts and figures, 2012. http://www.unccd.int/Lists/SiteDocumentLibrary/WDCD/DLDD%20Facts.pdf [01.12.2014].

20 LfL, 20 Jahre Boden-Dauerbeobachtung in Bayern, Teil 3, Entwicklung der Humusgehalte zwischen 1986 und 2007, 2011, pp 43–44.

21 *Kotschi J./Jo Wetter K.*, Düngemittel. Zahlende Konsumenten, Intrigante Produzenten, in: Bodenatlas, Daten und Fakten über Acker, Land und Erde, 2015, p 20–21.

22 Ibid.

23 *Withers P.J.A. et al.*, Stewardship to tackle a global Phosphorus inefficiency: The case of Europe, In: AMBIO 2015, 44 (Suppl.2), 2015, pp 193–206; EEA, European waters—Assessment and pressures, 2012. *Frossard et al.* 2004.

24 UBA, Eutrophierung der Ostsee, 2014. http://www.umweltbundesamt.de/daten/gewaesserbelastung/ostsee/eutrophierung-der-ostsee [01.12.2014].

25 *Lange* 2009; *Beusen, A.H.W. et al*, Estimation of global river transport of sediments and associated particulare C, N and P, in: Global Biochemical Cycles, Vol 19, GB4S05, 2005.

Europe have been directly connected to mineral fertilizers.[26] The worldwide production of agricultural products has almost tripled since 1950, while agricultural area has increased only by 12%.[27] We are still confronted with global population growth and growing demand for meat products[28] as well as the never ending thirst for energy, which both depend on economic growth. This has led to an increasing demand for agricultural land and the respective fertilizers for food, animal feedstock and energy crop production.[29] The International Fertilizer Industry Assosiation (IFA)[30] expects a 2% global increase in demand for P fertilizers up to 2018. Most of the demand is expected to come from Latin America, followed by Africa and Asia. Cultivated land areas and therefore demand for P-fertilizers has been expending steadily, especially in Latin American countries.[31] One reason is the increasing large-scale production of animal feed mainly exported to Europe and used for intensive livestock farming.[32] P fertilizers are imported alongside crops for animal feedstock.

In contrast to the decreasing demand for P fertilizers in developing countries – and without taking into account P in imported food and animal feedstock – demand for P in countries such as Germany has stagnated at a relatively high level since 2012.[33] The year 2014 saw 284,000 tons of P_2O_5 sold in Germany.[34] The P input is regularly higher than P withdrawn by harvesting crops in the past, resulting in a surplus of nutrients such as P (and N) in a large total area in Germany and throughout Europe. Nutrient balances between 2005 and 2008 indicate P surpluses of 2 to 3 kg/ha in Germany, up to 25.5 kg/ha in Malta and

26 *Withers et al.* 2015.

27 *Beste A.*, Intensivfeldbau: Industrielle Landwirtschaft mit Zukunftsproblemen, 2015, in: Heinrich-Böll-Stiftung, IASS, BUND/Le Monde diplomatique (Ed.): Bodenatlas, Daten und Fakten über Acker, Land und Erde, p 18–19.

28 FAO, World Agriculture towards 2030/2050. The 2012 Revision, 2012. http://www.fao.org/docrep/016/ap106e/ap106e.pdf [10.06.2015]

29 WWF, Fleisch frisst Land. Ernährungsweisen. Fleischkonsum. Flächenverbrauch, 2014, pp 23 et seq. https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF_Fleischkonsum_web.pdf, [17.07.2015]; *Brot für die Welt*, Der Energiepflanzenanbau gefährdet das Recht auf Nahrung. Die aktuelle Biokrafstoffpolitk aus entwicklungspolitischer Perspektive, 2014.

30 IFA, Fertiliser Outlook 2014–2018, 2014.

31 Ibid.

32 *Lymbery P.*, Futtermittel: Viel Land für viel Vieh, in: Bodenatlas, Daten und Fakten über Acker, Land und Erde, 3. Auflage; WWF 2014, 2015, pp 34 et seq.

33 BMELV: Daten & Tabellen / Suche, 2015.http://www.bmelv-statistik.de/index.php?id=139&stw=D%C3%BCngemittel [08.08.2015].

34 IVA, Der Düngemittelmarkt 2014/15. Starkes Inlandsgeschäft treibt Umsätze, 2015.

20 kg/ha in the Netherlands.[35] Huge amounts of manure from industrial mass meat production adds considerably to the problem of over-fertilization.[36] Surplus P discharge through erosion, leaching or run-off from soil into water bodies has serious consequences as previously mentioned.

As P from phosphate rocks is a finite resource more sound recycling-oriented management seems to be warranted due to the environmental issues. The same follows considering the distribution issues already described and the connection between P fertilization and the environmental impact of conventional agriculture as mentioned above. Cordell et al. (2009) assumed that demand for P could be cut by 50%, initially only by changing dietary habits and efforts in food chain efficiency such as lowering food overproduction, reduced product chains and minimized food wastage. Several billion euros worth of food are wasted every year throughout Europe.[37] Secondly, recycling and recovery of P and the scarcer use of resources, but also organic farming merit more attention. Organic farming is preferable to conventional agriculture in several ways: cover crops that prevent erosion and improve P availability in soils are usually used more often,[38] and mixed farming and less specialized farms are also more common compared to conventional farming, which is mostly monocultural. [39] This may close P cycles more easily, while dispensing with mineral fertilizers, many of which are strongly polluted with Cd or U, and chemical pesticides. One-third less fossil energy per hectare of farmland is used and approximately twice the carbon dioxide can be stored in the soil without the use of mineral fertilizers and improved soil quality,[40] a decisive advantage in combating global climate change. Apart from that, around 2% of world energy is dedicated to processing N fertilizers in the Haber-Bosch process for energetic and material needs.[41] For that reason fossil fuel and mineral N fertilizer prices are highly coupled. Indirectly, there may be also a connection to the price of mineral P fertilizers where mineral N, P and also Potassium (K) fertilizers are often sold in combination. Furthermore, fossil fuel price increases would

35 Eurostat, Statistics Explained, 2014. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Fertiliser_consumption_and_nutrient_balance_statistics/de#Brutton.C3.A4hrstoffbilanzen [01.12.2014].

36 SRU, Umweltgutachten 2008, Umweltschutz im Zeichen des Klimawandels, 2008, p 468.

37 *Cordell et al.* 2009.

38 *Pimentel D. et al.*, Environmental, Energetic, and Economic Comparisons of Organic and Convetional Farming Systems, 2005.

39 BMELV, Agrarpolitischer Bericht der Bundesregierung 2015, 2015.

40 *Beste* 2015.

41 *Sutton M.A. et al.*, Our Nutrient World: The challenge to produce more food and energy with less pollution, 2013, p 8.

increase the cost of mineral N fertilizers, placing organic farming that operates mainly without mineral fertilizers at an advantage compared to conventional farming. Moreover, fertilizers are only applied to ensure soil fertility in organic farming rather than to meet a presumed requirement for the highest yield. Remaining inputs of harmful substances due to fertilization are therefore lower overall with a heavy general reduction in the risk of over-fertilization.[42]

The global trend, however, remains towards intensifying agriculture. The FAO (2012) predicts a production volume of 3 billion tons of grain (without rice) every year until 2050. Ninety percent of the necessary increase, starting at around 1.7 billion tons globally in 2010, is supposed to be attained through higher yields and intensified agriculture. Meanwhile, the amount of area used for agriculture has to be increased worldwide.[43] The projected increase in intensity will inevitably lead to increased use of P fertilizers involving the impacts described above. Dietary habits and food handling as well as acreage competition between food and energy crops need to be placed on the agenda.[44]

It is interesting to note that there is obviously a call for action regardless of who is right in the discussion on Peak P. Economic and technical fields of action all point in a similar direction: as a resource, P needs a different economic value to engender a more sound use of rock phosphate while intensifying the utilization of alternative P sources.

2 Approaches to Phosphorus in EU Law

Politics at EU level has been paying increasing attention to P as scarce resource vital to humans, plants and animals on one hand, and P and related heavy metals as harmful pollutants in soil and water on the other. Current approaches and policy programs relevant to the P issue will be presented briefly in this section. To remain within the scope of this contribution, we will be focusing on EU levels while only touching on individual countries.

The European Union has created a flagship initiative under the Europe 2020 Strategy for "a resource-efficient Europe" that includes the target of transforming the European economy into a resource-efficient low-carbon economy. Other measures such as the Raw Materials Initiative and the European

42 *Pimentel et al.* 2005.

43 BMELV, Die deutsche Landwirtschaft. Leistungen in Daten und Fakten, 2010.

44 *Ekardt, F./ von Bredow, H.*, Extended emissions trading versus sustainability criteria: Managing the ecological and social ambivalences of bioenergy, Renewable Energies Law and Policy, 2012, pp 49–68 for details.

Partnership on Raw Materials point in the same direction.[45] These efforts are based on the necessity of securing Europe's supply with crucial resources.[46] In May 2014, the European Commission presented an updated list of critical resources, which now contains twenty resources.[47] This list is an important instrument in the EU Raw Materials Strategy, and is intended to create incentives to produce, mine or recycle resources within Europe or conduct the respective research. Phosphate rock is among those six newly added resources classified as critical.[48] Including P as a resource on the list shows the increasing recognition of its economic relevance and importance for security of supply. However, there is no comprehensive legal regulation of P use so far.

The consultative communication of the European Commission[49] compiles all of the topics relevant to P as a resource so far. After a rather optimistic account of the current and future supply and demand situation, the communication highlights the environmental effects within the whole P cycle. Special focus lies on losses along the P chain, problems in mining, processing and conversion of P in fertilizers and animal feedstock, water pollution, and soil contamination caused by agricultural P use. The European Commission has pointed out that efforts need to be directed towards mining, processing, upgrading and transporting phosphate rock more efficiently. Increasing prices and the exhaustion of optimal deposits are the most probable driving factors for better use of P according to the Commission. Actual legal steps in this field have not so far been addressed.

Improvements in the inclusion of P in fertilizer security and transparency in fertilizer ingredients by labeling have been announced, however. Changes may start with the revision of the Fertilizer Regulation even though the time scheme of the revision is not yet clear. The use of phosphates and other P compounds in household detergents for textiles and dishwashers is limited by the Detergent Regulation. A revised version of the regulation was passed in 2013, and is intended to limit P input from detergents further.[50]

Another important starting point for the EU lies in more efficient P application and reduction of P losses in agriculture. Various action programs within the scope of the Nitrates Directive have been drawn up to lower current and prevent future water pollution. The directive also requires member states to implement and enforce rules according to good agricultural practice. Good

45 European Commission, COM 2014, 297 final from 26.5.2014, p 2.
46 European Commission, COM 2011 21 from 26.1.2011, pp 2–3.
47 COM 2014, 297.
48 European Commission, COM 2014: IP 14/599, Press Release from 26.5.2014, p 1–2.
49 European Commission, COM 2013 517 final from 8.7.2013.
50 COM 2013, 517, p 15.

agricultural practice includes time periods in which fertilizers should not be applied to agricultural areas or provisions on procedures for fertilizer input.[51] Besides mandatory regulation of nitrate fertilization, some member states such as Ireland and the Netherlands have already introduced P limits at national level.[52] This has improved some aspects of fertilizing practices throughout the last decades. The report by the European Commission on the implementation of the Nitrates Directive has however found major differences regarding N intensities. For instance, elevated nitrate concentrations in waters are measured in Germany,[53] so Germany has been requested to tighten its fertilization regulation, the main instrument for implementing the EU Nitrates Directive. A corresponding infringement proceeding aimed against Germany was initiated at the end of 2013.[54] There are also major differences among the European member states with regard to P intensities.[55]

Other legal acts on soils and water bodies in the EU indirectly address the P issue. The EU Nitrates Directive is an important instrument in implementing the EU Water Framework Directive, which aims at reaching a good ecological status in European waters. While a clear reference to phosphate fertilizers is also missing here, the directive points out that P compounds as harmful to waters and lists P as one of the agro-environmental indicators. The indicators describe the greatest burdens on water quality, but are not being applied yet due to limited available data and methodological difficulties.[56]

Even if there is an increased interest in soil protection as can be seen in the thematic Strategy for Soil Protection, an overarching European directive on soil is missing. Instead, the standards for good agricultural and environmental condition of land (GAEC), part of the Cross Compliance regulation within the common agricultural policy framework, encompass some soil-related requirements such as minimum soil cover or minimum land management reflecting site-specific conditions to limit erosion and thus contribute to the reduction of P losses in agriculture.[57] These regulations are not explicitly directed at P though, and there is still scope for improvement. For instance, obligations to

51 Annex II of the Nitrates Directive.

52 European Commission, COM(2013) 683 from 4.10.2013, p 10.

53 Ibid. pp 4–5.

54 European Commission, Nitratbelastung im Grundwasser: Kommission fordert Deutschland zum Handeln, 2014. http://ec.europa.eu/deutschland/press/pr_releases/ 12542_de .htm [20.11.14].

55 COM 2013, 683, p 4.

56 European Court of Auditor, Integration of EU water policy objectives with the CAP: a partial success, 2014, p 46.

57 Annex II of the Regulation (EU) No. 1306/2013.

limit P use by business owners are not covered by the Cross Compliance rules; the European Commission relies on national nitrate action programs to contain P-related regulations.[58]

"Greening" the common agricultural policy was introduced with the 2013 reform, and is intended to make the agricultural sector more environmentally friendly by linking direct payments to farmers to environmental performance. Disregarding the question of how ambitious these conditions actually are, the GAP remains focused on avoiding environmental harm through N surplus. Furthermore, the success of Greening depends on the member states, which have considerable leeway for implementation. The design of agro-environmental programs in rural development policy framework is also in the hands of the member states.[59] Those programs could in fact contribute to decreasing P losses in agriculture with the focus set accordingly. So far, this focus is missing.

The EU's approach to increasing P efficiency in animal farming is based on increasing accreditation of new phytase enzymes as additives for animal feed for mono-gastric livestock as well as P contents in diets adapted to requirement during the different life stages of animals known as "phase feeding." This aims at decreasing P intensities in animal feed. The European Commission hopes for further approaches to solutions from the current EU Program for Research and Innovation Framework[60] and the European Innovation Partnership on Agricultural Productivity and Sustainability.[61] Here again, that actual approach is somewhat vague. Moreover, improvement in P efficiency in animal farming does not preclude rebound effects, and any reductions of P in animal food may be nullified by rising consumption and production of animal-based food.

The EU also recognizes the potential of food waste avoidance and recycling as spelled out in the European Resource Efficiency Roadmap, which aims at reducing the disposal of food waste still fit for consumption by 2020. An actual legal regulation is missing – yet again. Besides avoiding food wastage, the EU focuses on improving the use of food waste. The Landfill Directive requires member states to reduce landfilling with biodegradable waste to 35% of the amounts of such waste produced in 1995 by 2016.[62]

Additionally, the European Commission includes an improved legal framework on the usage of animal by-products in animal feed to recover higher

58 COM 2013, 517, p 15.
59 *Garske / Hoffmann* 2015.
60 Horizon 2020.
61 COM 2013, 517, p 15–16.
62 COM 2013, 517, p 17.

amounts of P from agricultural wastage and agricultural by-products.[63] Similar efforts are envisaged for reusing P in organic fertilizers. The European Commission sees a lot of unused potential here. So far, there is no common strategy for promoting the recycling of P from manure, sewage or organically degradable waste while various techniques to eliminate hazardous materials from recycled P are not yet marketable. To make matters worse, the price of mineral P fertilizers usually lies below the price of fertilizers produced from recovered P. This also renders efforts at increasing P recycling ineffective.[64]

Sewage treatment is another field of action in improving P management. The Urban Waste Water Treatment Directive provides for a removal of P from sewage. Sequestration of P into a usable form is not pursued, even though procedures are available such as from processing sewage sludge. Using sewage sludge for fertilization is regulated in the Sewage Sludge Directive. Harmonization of high quality standards for the usage of sewage sludge on agricultural areas is missing.[65] Accordingly, there may be a problem with contamination in sewage sludge – and little incentive to replace mineral fertilizer with sewage sludge. Member states have individually taken specific efforts to protect the P resource. Sweden, for example, has set a national intermediate target to recover at least 60% of P compounds in sewage and use it in fertilizers by 2015. The Netherlands has formulated a target to increase the reuse P in different production processes in an agreement on the phosphate value-added chain. German legislation is also working on legal regulations to lower P wastage.[66] The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety is planning binding regulations for phosphate recycling while revising the sewage sludge regulation, which may also include encouraging recycling for other materials. The necessary regulations are to be written down in a new regulation on regaining phosphate (AbfPhosV). Passing the regulation through parliament has been delayed, and its implementation is not yet in sight in the near future.[67]

All this shows that the issue of P has increasingly gained a place on the European agenda while giving reason for political declarations of intent. However, little in the way of legal activity has emerged with actual requirements for improved handling of P. Far-reaching regulations such as limits for water and

63 Ibid., p 16–17.
64 Ibid., p 18–19.
65 Ibid., p 17–18.
66 Ibid., p 3.
67 Deutscher Bundestag, 17. Wahlperiode, Drucksache 17/12984 vom 05.04.2013, p 54.

soil pollution have been met at member state level.[68] There are still fundamental doubts as to whether traditional strategies of environmental law with individual command and control in matters such as fertilization and good agricultural practise is the best approach to P. This will be addressed in the next chapter.

3 Issues in Existing Legal Approaches

The situation described is usually answered with propositions aimed at changing details in regulatory law, such as imposing new obligations and restrictions for farmers what is referred to as the command and control approach. However, there are several reasons to assume that those or similar regulatory policy instruments will not ultimately be able to solve resource and environmental problems concerning P. The existing problem is of a more fundamental nature that goes far beyond the issue of P. Until today, environmental law most frequently consists of substantial legislation for specific products, crops or other topics such as vehicle emissions, building services and other clearly defined topics with specific sanctions in case of non-compliance. Issues of resources and environment are, however, a problem of quantity. In other words, the total quantity of resource usage needs to be taken into account – and oftentimes also the total quantity of environmental impact.

Concerning P fertilization, this implies that the accumulation of many fertilization procedures and the resulting over-fertilization and expenditure of a finite resource, not one individual fertilization procedure alone, causes environmental pollution and resource scarcity issues. This applies in a similar fashion to other environmental land use problems such as the contribution of agriculture to climate change through energy-intensive fertilization or methane-emitting livestock production.

Generally speaking, we are confronted with profound governance problems in environmental law. They arise where regulation is mainly aimed at single products, installations, industries or geographic spaces.[69]

68 See *Ekardt F./ Holzapfel N./ Ulrich A.E.*, Phosphorus, Land-Use and Absolute Quantity Reductions as a Legal Problem for more information on existing environmental regulatory law for P in Germany, 2010.

69 See *Ekardt* 2011; *Ekardt F./ Hennig, B.*, Ökonomische Instrumente und Bewertungen von Biodiversität. Lehren für den Naturschutz aus dem Klimaschutz?, 2015; *Ekardt F./ Hennig, B./ Hyla, A.*, Landnutzung, Klimawandel, Emissionshandel und Bioenergie, 2010; see also *Ekardt F./ Holzapfel N./ Ulrich A. E.*, Phosphorus, Land-Use and Absolute Quantity Reductions as a Legal Problem, 2010 for a more detailed account.

- An effective policy approach has to be coherent between substantial strength and the set target. With respect to P, increasingly recycling P as a resource and promoting organic farming would help cover the need for P in an alternative, more cycling-orientated fashion using organic fertilizers, cover crops and so on. This may avoid long-term scarcity and the increasing usage of contaminated stock as well as other environmental problems discussed at the beginning of this article. So far, there is no clear legal guideline leading in that direction. It is hard to imagine this formulated by means of a command and control approach as this would require regulating many details without addressing the special needs of a specific farmer.
- Regulatory law is generally subjected to exceptions and margins of appreciation for individual cases as exceptions will not apparently change the outcome. These exceptions will at times undermine the purpose of the norm if frequently applied.
- An effective governance approach needs to be effectively enforced. Not all environmental policies are complied with in practice. Environmental problems in agriculture cause particular difficulties due to the infinitely high number of minor procedures requiring administrative monitoring. It is hardly realistic to place a "police officer on every tractor," which would be necessary to enforce legal fertilization restrictions for example.
- Regulating individual procedures, products or crops, as is typical in regulatory law, causes incentives for sectoral, geographic and resource-based shifting (or relocating) effects. This occurs when environmental damage or resource consumption is relocated by the enterprises or citizens concerned as a result of policy measures. Resource consumption may be shifted into other sectors of life, places or to more intensive use of other resources. As an example, the transition from fossil to bio-fuels has placed greater burden on soil, water and nature in general without any cap on energy consumption (sufficiency). Capping P consumption in the EU only would contribute towards minimizing ecological problems in waters and soil in Europe but the resource problem would still prevail with P deposits used elsewhere.
- Another issue often confused with shifting effects is the rebound effect: regulations in environmental law for specific products, houses, industrial plants or cars have made it possible to improve these particular issues. At the same time, however, the number of greenhouse gas-emitting sites or products has still increased due to increasing prosperity in modern life, with overall consumption growth partially or completely eliminating any gains in efficiency of a specific good or service. Another form of rebound

effect occurs where increasing consumption is explicitly caused by the ecological improvement of a crop or service. Examples include raising room temperature due to a cleaner conscience from living in a low-energy house, or adopting a harder driving style in an energy-efficient car. More broadly, rebound effects include the phenomenon that a newer and more efficient appliances do not substitute the older ones, but are used in addition to them. This implies in terms of P that a cap on P application "per hectare" by regulatory law might seem like a good option at first glance, but if areas so far unused are cultivated for animal feedstock to meet globally growing meat consumption or for bio-fuel crops, there will be no overall reduction in P usage.

- Furthermore, regulatory environmental regulations cannot reflect issues that are hard to specify precisely. Aspects such as validity of food security or long-term availability of non-contaminated P are difficult to translate into regulatory criteria for single plants as there is no concrete relationship to specific fertilizer use.

The reasons for ignoring these governance problems and the subordination of ecological and resource-political questions go deeper than explanations such as economic and administrative self-interest might indicate. Ultimately, it is a multi-layered vicious circle involving farmers, consumers, politicians, law applicants, fertilizer producers and others that mutually strengthens certain basic attitudes contributing to this context as all participants are jointly dependent on each other.[70] This is why agriculture in its current orientation towards increasing short-term profit in addition to economic self-interest is aligned to traditional values such as increasing production, illustrating the underlying concept of the omnipresent growth paradigm. Furthermore, anthropogenic constants such as the narrow space-time focus of human emotionality on the "here and now" as well as habits, denial, and convenience will presumably make it rather difficult for most of those involved to face a long-term and currently invisible P problem with any level of commitment. Moreover, there is a problem with public goods: All those stakeholders involved know that possibly the ecological problem dimension and definitely the resource-problem dimension with respect to P cannot be resolved by single individuals, which often makes action less appealing. These are the same general problems that prevail within every societal transition towards increased sustainability.

70 *Ekardt* 2011.

4 Phosphorus Governance through Economic Instruments

The governance problems of traditional environmental policy as described above suggest that a command-and-control approach alone might not be the best legal option. However, this does not suggest a wait-and-see strategy either, as this would solve the issue of casual use of P even less. A governance approach which reflects the required holistic perspective would be more favorable – genuine quantity control and limitation would make mineral P scarcer and more expensive, giving incentives to increase recycling rates and resource protection while relieving ecological stress. Fertilization would mainly occur only when actually necessary, which might be assessed differently in different countries with different soil qualities. The same – or even stronger – effects may be reached in an indirect way, by limiting or pricing fossil fuels (see below). Further details on the approach outlined in the following will be subject to research at the Leibniz Science Campus Phosphorus Research at Rostock University during the next years.

Necessary quantity control (also called "pricing" in the following) may either explicitly limit the use of the P resource, and therefore also its ecological side effects, or put a price on the P resource. One possible way of pricing could be a reallocation of EU agricultural subsidies towards environmental services instead of supporting mass livestock production. This may also be advantageous from a fiscal point of view and in the interest of free global trade and fair market access for developing countries. Another sensible approach to pricing may be a tax on P. Alternatively a cap-and-trade system could be implemented along the same lines as EU emissions trading. This would require the initial distributors of P to input only those quantities of P into the market for which they have previously purchased the certificates by auction. The amount of certificates would be limited and eventually discounted.

To avoid shifting effects between different countries, this approach should theoretically be adopted worldwide. This will not happen in the short-term; the EU should lead the way until then. It should invite other countries to join in putting a price on P. Revenues from pricing could go towards developing countries to compensate for rising food prices. Imported products (and maybe also exported goods) from countries not willing to participate in pricing could be taxed through border adjustments comparable to value-added tax.[71] This governance approach – given that it is adopted on a geographically and substantially broad scale (including border adjustments) – has clear advantages over regulatory law.[72]

71 See *Ekardt* 2011 for legitimacy in international trade law.

72 *Ekardt* 2011; *Ekardt / Hennig* 2015; *Ekardt / Holzapfel / Ulrich* 2010.

- Quantity control is easier to implement and less likely to encounter enforcement problems than regulatory law.
- Quantity control prevents shifting effects as evasion is impossible – especially if the approach is applied comprehensively by a large number of countries.
- The approach eliminates rebound effects as it covers all forms of P usage.
- The approach could therefore also be unbureaucratic, supporting the principles of freedom and democracy as decision-making remains with the parliaments instead of administrative agencies.
- The approach gives incentives to increase recycling rates and resource protection while reducing ecological burden. Likewise, ecologically preferable rotation-oriented forms of land use such as organic farming would be supported by pricing P. Recycling P from residues of sewage treatment and waste business (sewage sludge and similar) into agriculture is another issue to address. This, however, would only be possible if the impending overload of soil with heavy metals and further organic constituents is countered by new treatment concepts.

Regarding P, as with other environmental issues like climate change, it is a matter of choice whether quantity control or taxes should be applied to the initial distribution or the end use. End use could mean for instance meat sold to a consumer. Taxing fertilizer producers would be easier to implement; higher fertilizer costs would be transferred to the consumer by the farmers purchasing the fertilizer.

The example of P also shows the importance of viewing different resources in their interdependencies. For instance, implementing quantity controls for P without corresponding greenhouse gas or fossil fuel quantity control including land use could lead to reduced fertilizing, and thus to lower crop yields in some circumstances; this may be compensated by higher land use for agriculture. Moreover, burning forests (fire clearing) and similar may increase as another means of fertilizing soil. A more detailed solution for the best economic governance approach to be analyzed in the Phosphorus Campus in the coming years will therefore need to address different resource and environmental issues in context. Besides the issue of P, problems such as climate change, loss of biodiversity, land use and N surplus problems require consideration. Pricing in one of these areas might lead to positive effects in many of the others. In any case, it will be essential to use governance units that are easy to measure to avoid implementation issues. The entrance point of a resource such as P fertilizer to the EU market can easily be monitored, but biodiversity and greenhouse gas emissions from a specific agricultural area are not as easy to estimate.

The governance unit most easily to measure would be fossil fuels. (Intensive) pricing on fossil fuels would not only strengthen climate protection in general, but also in terms of land use in particular, making N as a fertilizer component more expensive while reducing greenhouse gas emissions (carbon dioxide, methane, nitrous oxide), biodiversity loss and contamination and degradation of soils and groundwater. Pricing on fossil fuels would trigger resource efficiency in terms of fertilizers and food waste reduction, but also make organic farming much more attractive. Effects such as closed-loop cycles and organic farming would also indirectly lead to a reduction in mineral P overuse.

Quantity control of P or fossil fuels would also make the production of livestock in particular less attractive as the production of one calorie of livestock product currently requires a multiple of vegetable calories. Animal products would become more expensive and scarcer, food would be consumed more sparingly. Therefore, a price increase of P or fossil fuels would not endanger global food security, but trigger resource efficiency and a more ecologically sound lifestyle in Western countries. Moreover, this would lead to more lasting access to P. Explicitly pricing P or fossil fuels additionally provides the opportunity to reimburse developing countries for increasing food prices, if they participate directly or indirectly in the pricing system. The costs of this measure would therefore effectively lie with industrialized countries.

None of this necessarily implies that economic incentives will be sufficient in P policy. Even where economic incentives are created, additional regulatory measures may also be necessary for addressing issues such as appropriate sewage sludge treatment, which should be used more intensively while also being restricted to certain ecological and technical conditions as ecological damage in specific places (hot spots) is more effectively regulated by a command-and-control approach than by pricing.

P use and, in general, any administrative law or quantity control approach eventually has implications for social distributive justice. This not only refers to conflicts between economic freedom and the protection of physical preconditions of freedom – partly also guaranteed by fundamental rights and human rights – which are always present in environmental protection.[73] Rather, this refers to secondary effects that arise from the resulting compromises between these different rights in environmental law. In other words, harm and benefit arising from P application may not always align. This problem has a national and global dimension.[74] Eventually declining P rock reserves are likely to result in higher prices and potential quality degradation due to higher heavy metal

73 *Ekardt* 2011.

74 Ibid.

loads. While industrialized countries are still able to pay the price for high quality and fertilizer in general, developing countries may face severe availability, accessibility and quality issues. Moreover, soils in the southern hemisphere are currently exposed to substances such as heavy metals for production that is mostly consumed in industrialized countries. However, these particular questions on distribution speak for quantitative regulation rather than administrative regulation by legislation – it is not problematic to side with social adjustment payments in the former case, such as by paying higher prices for foodstuffs and other commodities. These compensation payments may for instance distribute the revenues arising from a charge or from a certificate system auctioning per capita to the citizens of every country. Another option would be partially or completely framing them as a north-south transfer.

5 Conclusion

Regardless of any individual estimation as to how scarce the resource P actually is, a call for action also emerges from the environmental impact of P. Specific, practical measures need to be taken to foster sound use of P; instead, the issue so far has remained in the sphere of non-binding proclamations. However, typical approaches in regulatory law – the command-and-control approach addressing individual activities – are not appropriate for addressing the characteristics of resource and environmental problems as quantity problems. In contrast, economic policy instruments are an effective supplement in avoiding compliance issues, rebound and shifting effects, and encourage more recycling of P as well as more sparing use. This also provides the chance of addressing different environmental issues concerning land use, resources, climate change and biodiversity at the same time.

Acknowledgements

The major point of origin of the ideas of this paper is our participation in the Leibniz ScienceCampus Phosphorus Research of Rostock University and other institutions funded by Leibniz Gemeinschaft, the German Federal Government and other donors.