P-REX

Sustainable sewage sludge management fostering phosphorus recovery and energy efficiency

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Pre-Normative matrix. Review of fertilization schemes. Review of current legal framework for phosphorus recovery.

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Glossary

Struvite	Magnesiumammoniumphosphate (MAP)
Arable land	Arable land is the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow ("FAOSTAT - Concepts & definitions - Glossary (list)". FAO. Retrieved 2 November 2013)
Agricultural area	The sum of areas under arable land, permanent crops and permanent meadows and pastures ("FAOSTAT - Concepts & definitions - Glossary (list)". FAO. Retrieved 2 November 2013)
Land	Land can be divided into agricultural land, forest and other land. ("FAOSTAT - Concepts & definitions - Glossary (list)". FAO. Retrieved 2 November 2013)
ESU	1 European size unit or ESU is defined as a holding generating an income of less than 1200 €/a.
WWTP	Wastewater treatment plant
Organic fertilizer	Fertilizer consisting of organic materials

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1 Introduction

1.1 Scope

This report contains a pre-normative matrix linking required quality with market price for recycled phosphorus, a review of fertilizing schemes, showing where those materials can be best used in agriculture and a survey of the European legal framework relevant to phosphorus recycling.

The work focuses on mineral fertilizer. Worlwide, some 90% of the phosphorus ore is used for mineral fertilizer production (Kongshau, et al., 2012). Mineral fertiliser is a complement to organic fertilizers such as manure and compost (see Chapter 3 in P-REX deliverable D11.1 for detailed P flows). Therefore mineral fertilizer will be the first to be replaced by mineral phosphorus recycled from wastewater. This is possible since the secondary phosphorus has processing, storage and application properties similar to mineral fertilizer.

1.2 Objectives and Method

The first part of this report is a pre-normative matrix for recovered phosphorus-containing materials and compares market requirements and available product properties to develop categories, in which the various phosphorus containing materials can be divided. These have a certain quality range and a certain price range and should act as a tool for recyclers and producers interested in secondary feed-stocks.

To develop the matrix, properties of existing and upcoming recycling materials were summarized based on results of Work Area 3 of P-REX. These were compared with the requirements of the fertilizer, feed and technical markets. Market actors and other experts estimated current price ranges.

The pre-normative matrix is a first step to create more transparency and facilitate production and use of secondary phosphorus. It can be further developed in dialogue with market participants and new findings on quality, legislation and price can be integrated.

The second part of the report, a review of fertilization schemes, is based on literature and synthesizes present knowledge with the explicit goal to enable discussions on fertilizer quality testing and requirements. These are presently adapted to fertilizers based on phosphorus rock and thus often not adapted to the somewhat different properties of secondary fertilizer materials.

The third part of this report is a study of legal and societal factors whose objective is to provide an overview of legal responsibilities of an EU-based recycler, manufacturer, importer or distributor of recycled phosphates for fertilizing purposes completed with attitudes and habits of stakeholders (mainly authorities and general public). The success of phosphorus recycling projects is governed by profitability, legal framework and also those attitudes (see Czech study). The study of legal factors covers European regulations being automatically enforced and European directives being enforced by corresponding national legislation in EU-Member States and to some extent in Switzerland, despite of the latter not being part of the European Union. National regulations of the Czech Republic, Germany, Spain and Switzerland are separately considered in this document at least as far as special regulations apply to fertilizer products and recycling of phosphorus from the wastewater stream. The summary of relevant legislation covers mainly three categories:

- Legislation governing the product covers obligations on quality, packaging and handling of products in general and fertilizer in particular.
- Legislation governing the production plant covers the requirements for building a production plant for recovery of mineral phosphorus. This legislation deals for example with permits for operation, assessment of environmental impact of the plant and the various limits on emissions.
- Legislation governing waste and management regulates for example wastewater treatment, use and treatment of sewage sludge and protection of water and (agricultural) soil. This legislation can be a driver for phosphorus recovery technologies: restriction in the direct use of sewage sludge usually makes implementation of those technologies more attractive.

Together with the results of the market studies (see D11.1 of P-REX) this report will provide a baseline for the coming report D11.3 (Figure 1) where past business cases will be analyzed and future possible business models will be developed and described. These models together with the present study of legal and societal factors will be the basis for suggestions for the most promising and urgent modifications of policy.

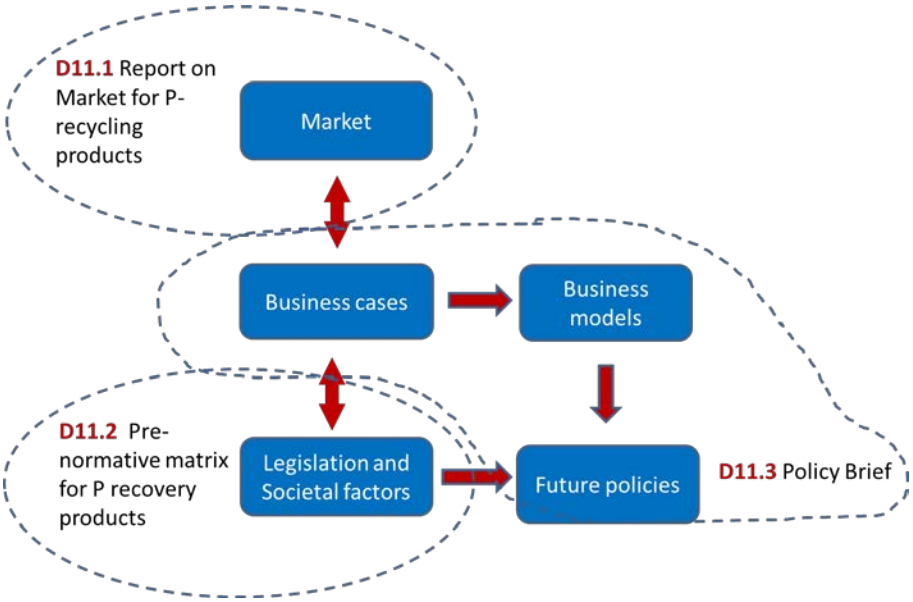

Figure 1: Diagram of results and reports foreseen in the DoW of P-REX

2 Pre-Normative Matrix

2.1 Introduction

This chapter presents a pre-normative matrix for recovered phosphorus- containing materials which compares market requirements and properties of available product to develop categories in which the various phosphorus containing materials can be divided. These have a certain quality range and a certain price range and should be a tool for recyclers and producers interested in secondary feedstock.

Quality criteria for the market such as nutrient concentrations, bioavailability and fulfilment of the legally binding limitations for any pollutants were linked to market price of mineral phosphorus materials as estimated by market actors. Specifically, the quality and price of three market segments (fertilizer, feed, and technical uses) was compared to quality and price (or disposal cost) of sludge, sludge ash and major recycling materials.

The pre-normative matrix is a first step to create more transparency and facilitate production and use of secondary phosphorus. It will be further developed in dialogue with market participants and new findings on quality, legislation and price can be integrated.

2.2 Materials and Methods

2.2.1 Materials

Three digested sewage sludge types, one mono-incinerated sewage sludge ash, three struvite types and three ash-based materials were analysed. The sewage sludge samples were gained from sewage treatment plants using either Bio-P or iron salts for phosphorus removal. All of the samples were anaerobically digested.

Sewage sludge was included in the matrix due to its widespread usage in the agriculture in Europe. Sewage sludge ash from mono incineration was included as well since it is available in large amounts and the starting material of several recovery processes. Both of these materials are waste according to the current European legislation. Usage of sewage sludge as a fertilizer is nevertheless allowed, if certain threshold values for heavy metals are not exceeded. Currently the EU legislation (EU Sewage Sludge Directive - Application of Sewage Sludge in Agriculture (86/278/EEC), Table 54 Limit values for heavy metal concentrations in sludge for use in agriculture in mg/kg dry matter) is rather lax compared to that of many member states and limits might become stricter in the future. In general though, waste materials need to be deposited. Incineration of the sludge reduces its volume and mass and thus reduces the landfill costs. However, the ashes are in some cases considered hazardous waste due to high heavy metal concentrations, and need to be landfilled accordingly in a safer and more expensive way. If sewage sludge ash is further processed into a product it ceases to be waste under certain conditions, according to the End-of-waste criteria of the Waste Framework Directive (Directive 2008/98/EC, see details in Chapter 5).

Struvite from three different recovery processes grouped into one category since they have similar quality. Three different ash-derived materials, produced by a wet-chemical, a thermo-chemical and a metallurgical process were considered. The ash derived materials show considerable heterogeneity and must be considered separately.

2.2.2 Methods

Heavy metal, organic pollutant and nutrient concentrations were measured within P- REX and complemented with literature values for sewage sludge and sewage sludge ashes. They were compared with the legal requirements for fertilizer, feed and technical markets.

An overview of plant availability was made based on P-REX analyses and pot tests. The plant availability of the materials was evaluated according to their water and citrate solubilities (VDLUFA vol 2, Method 4.1.7. and EU fertilizer ordinance, Method 3.1.4). In the pot tests under laboratory conditions the relative fertilization effect (RFE) in comparison to a conventional fertilizer triple super phosphate (TSP) was determined for all materials in two different soils with pH of 5 and 7 using maize as a test plant. Recycled materials, sewage sludge or sewage sludge ash were used as the phosphorus source and other nutrients were added to avoid deficiencies. See P-REX deliverable D8.1 for detailed results and methods.

Data on nutrient content and contaminant concentrations of sewage sludge, sewage sludge ashes and recycled materials were obtained from P-REX analyses. Additional data on nutrient content and contaminant concentrations of sewage sludge and sewage sludge ashes from literature were used to generalize P-REX results. The sewage sludge nutrient values originate from LUFA Nord-West measurements (median of 3882 German sludge samples) and the contaminant concentrations from Kratz and Schnug (2005). The sewage sludge ash concentrations were taken from Adam and Krüger (2012) and represent ashes from all 11 mono-incineration plants in Germany. Some values for contaminant concentrations of recycled materials were received from external measurements as indicated in the pre-normative matrix.

The materials fulfilling all the requirements and those close to fulfilling them were identified.

The materials considered in the matrix were pooled in general categories. Ranges of values for nutrient and contaminant concentrations were used to reflect the heterogeneity within the categories.

2.2.3 Choice of solvent for plant availability estimation

The immediate plant availability of fertilizers is classically determined by water solubility of the nutrients. For phosphorus, several other extraction methods exist as well. The extraction methods currently used in EU and in Germany are summarized by Kratz and Schnug (2009). A typical phosphorus fertilizer sold on the market for conventional agriculture today is almost 100% water soluble. For recycling fertilizers, this may be difficult to reach. However, despite of low water solubility, pot tests showed good plant availability of recycled fertilizers in many cases.

Better correspondence to plant availability in pot tests have been reported for solubility in citrate or citric acid, especially in case of struvites (Willelms et al 1976, Kratz et al 2010, Pinnekamp et al 2011). The heterogeneity of the ash-based fertilizers makes it difficult to use citrate solubility as an indicator for all the recycled materials (Kratz et al 2010). According to the German and the EU recommendations, citrate solubility methods can be used for evaluation of the plant availability of Ca-Al-phosphates, dicalcium phosphates, superphosphate, TSP and multi-nutrient fertilizers, whereas the citric acid solubilities are recommended among others for evaluation of the P-availability from Thomas phosphate and other slags (Kratz and Schnug 2009). Both citrate and citric acid are known root exudates of plants. They alter the local chemical conditions in the rhizosphere for example by decreas-

ing the pH (citric acid) or complexing cations which interfere with phosphorus dynamics (citrate) - thus often enabling a higher uptake of phosphorus from the soil than otherwise expected (Frossard et al 2004, Jones 1998. For detailed explanation on phosphorus dynamics in the soil, see chapter 3.1.2. of this report).

Thus, solubility of a fertilizer in citrate or citric acid can give valuable information on its plant availability. The pre-normative matrix reports both water and neutral ammonium citrate solubility of the materials.

2.2.4 Evaluation

In order to give a general overview, three categories with specific parameter requirements were defined. Legal and technical requirements were evaluated according to the EU (feed) and German legislation (fertilizer) and typical specifications of actors (feed and other non-food use). The German legislation was used as a reference due to lack of threshold values on EU-level. Also, plant availability of recycled materials was evaluated against the performance of TSP. In both of the categories, poor performance or non-compliance was labelled with "-" or "- -", limited performance with "0" and good performance with "+" or "++". Details on the evaluation can be found in Table 1.

2.3 Comparison

The pre-normative matrix is presented in Table 1

2.3.1 Legal and technical requirements

It is clearly visible from the matrix, that the recycling materials are not appropriate to be used as such in feed or other non-food uses. To penetrate these markets, the production processes would need to be adjusted in such way, that the concentrations of aluminium, calcium, magnesium and especially iron are reduced in order to fulfil the requirements. In two of the three recycling materials also the arsenic concentration exceeded the limits.

The reference sewage sludge did not fulfill the legal requirements for fertilizers due to one exceeding heavy metal value (Tl). The requirements for the organic contaminants were met. In the internal measurements also the Hg threshold was exceeded by one of the three sludges.

Even though the sewage sludge may fulfil the prevailing sludge legislation and can be applied as a fertilizer, its heavy metal content in relation to nutrient is often higher than allowed for mineral fertilisers in Germany. Further processing of the sewage sludge ash to mineral recycling reduces the heavy metals content. The EU fertilizer regulation is currently being revised to enable harmonized evaluation of different nutrient sources as fertilizers. This can possibly lead to same quality requirements for (recycled) fertilizers as for other nutrient sources. The question, whether the new regulation also should apply to the sewage sludge is still open. The contaminant-nutrient ratios in the materials will be more prominent in the upcoming fertilizer regulation.

Further processing of the sewage sludge ash to mineral recycling materials lowers the contaminant content. None of the threshold values according to the German fertilizer regulation were exceeded by the recycled materials, in contrast to sludge ash. Organic contaminants limits in the ash-based materials could not be verified, since they were not measured.

2.3.2 Nutrient concentrations

In general fertilizers with a high grade are preferred, saving transport and handling costs. Fossil phosphorus rock has a phosphorus concentration (13-17% phosphorus; Kongshaug 2012) about twice as high as sewage sludge ash (4-10% phosphorus). The Leachphos process and struvite precipitation produce the recycled materials with the highest phosphorus concentrations, comparable to phosphorus rock. The ASH-DEC process removes heavy metals and leaves the phosphorus concentration unchanged and thus the same as sewage sludge ash. The Mephrec process produces slag with a rather low phosphorus concentration, similar to the less concentrated ashes. The recycled fertilizers have a phosphorus content of at most 60% of that of the highly concentrated Triple super phosphate (TSP). The difference in phosphorus grade in comparison to TSP is to some extent compensated by the ammonium in the struvite. Sewage sludge has around 50% organic content, which obviously leads to a lower mineral content than in sewage sludge ash. However, the organic content can be beneficial for the soil.

2.3.3 Plant availability

The classification of the plant availability of the phosphorus varies depending on the method used. Using water solubility only would lead to the conclusion, that neither the recycled materials nor sewage sludge or sludge ash are plant available. The neutral ammonium citrate solubility indicates higher solubility: three out of the four recycling material types (struvite, Leachphos material and ASH-DEC material) and sewage sludge have good solubility results whereas the solubility of the Mephrec slag and sewage sludge ash are poor.

The plant availability as assessed in pot tests of recycled materials ranged from good over limited (some struvite qualities) to poor (Mephrec material). The plant availability of sewage sludge ash in pot tests was poor. For sewage sludge, the pot tests indicated good plant availability in one of the three cases. This sludge was obtained with biological phosphorus removal, which is used in a small fraction of the WWTP in Europe and known to lead to enhanced plant availability of the end material in comparison to the more common iron precipitation.

The pot test results thus largely confirm the citrate solubility results. Therefore, solubility in neutral ammonium citrate could be a candidate method for evaluation of plant availability of recycled phosphorus materials. In contrast, water solubility as a sole method can be ruled out. Further, the processing of the sludge ash to recycled fertilizer materials can be identified as a favourable from plant nutrition point of view, if suitable processes are used.

Table 1: Pre-normative matrix for evaluation of the different recycling fertilizers. The underlying data is based on product characterization and plant availability tests within P-REX project. The nutrient and contaminant concentrations have been completed with external data according to the foot-notes. Market price ranges were given by experts as per footnotes. Evaluation of the fulfillment of the legal limits: + + all requirements met, - all but one requirement met, - - several requirements not met. Evaluation of the plant availability: + (good) ≥ 80 %, 0 (limited) 50-80 %, - (poor) 0-50% P-solubility or RFE. RFE = relative fertilization effect in comparison to TSP.

	Market segments			Sludge Dry matter [1]		Sludge ash [2]		Struvite [3]		Treated Sewage Sludge Ash		
	Mineral fertilizer	Feed	Other non-food uses	min	max	min	max	min	max	Leachphos, Calcium Phosphate [4]	ASH DEC, sodium treatment [5]	Mephrec, slag [6]
Limits (mg/kg)												
Feed. Legal limits (2003/100/EC) Technical specific. (W. Schipper 2013)	As < 10; F < 2000 and other limits Fe, Mg, Ca, Al: 10 to 300			- -		- -	- -	- -	- -	- -	- -	- -
Other uses. techn. spec. (Schipper 2013)	Fe, Mg, Ca, Al: 10 to 300			- -		- -	- -	- -	- -	- -	- -	- -
Fertilizer heavy metals (German fertilizer regulation)	As < 40; Pb < 150; Cd < 50 (mg/kg P_2O_5); Cr(VI) < 2; Ni < 80; Hg < 1; Tl < 1			-[7]		- -[7]	++[7]	++	++	++	++[7]	++[7]
Fertilizer organic contaminants (German fertilizer regulation)	Perfluorinated tensides < 1; I-TE dioxins and dl-PCB < 20 ng-WHO TEQ			++		-[8]	-[8]	++	++	[9]	[9]	[9]
Nutrients (%)	**TSP**											
P (phosphorus)	23			3		4	10	10	14	12	6	4
K (potassium)	1			0		0	1	0	2	0	1	1
N (nitrogen)	0			6		0	0	5	5	0	0	0
Mg (magnesium)	1			0		1	2	8	11	1	1	2
Ca (calcium)	19			3		5	24	0	1	22	10	24
S (sulphur)	1			2		0	2	0	1	7	1	0
P Plant availability												
P plant availability in pot tests	+			**0**	+	-		**0**	+	+	+	-
Solubility in Water	+			-	-	-		-	-	-	-	-
Solubility in neutral Ammoniumcitrate	+			+	+	-		+	+	+	+	-
Price range (Euro/to P; delivered)												
Market price range	Rock (14% P) 400 -1500 (500) TSP (20% P) 800 - 2100 (1400)[10]	DCP (25% P) 2000[11]	H_3PO_4 (8% P) 2000 - 3000[12]	-2000 to -9000[13]		-1000[14]		300 - 1000 (Niches up to 6000)[15]		"Rock" (14% P) 850 - 1100 DSP (16% P) 1200 - 1600[16]	n.d.	700 - 1700[17]
Other components												
				50 % organics				Sand				

[1] Nutrients: LUFA Nord-West (2014); Organic Pollutants: P-REX; Pollutants Kratz and Schnug (2005)

[2] Adam and Krüger 2012

[3] P-REX, apart from Cr(IV), Tl Wessling (2013), N was calculated from the molecular formula $NH_4MgPO_4 \cdot 6H_2O$

[4] P-REX, apart from Cr(IV), Tl Bachema (2014)

[5] P-REX, apart from Tl BAM (2014)

[6] P-REX

[7] No Cr(VI) measured

[8] No dioxins and PCBs measured

[9] no organic contaminants measured

[10] World Bank. Range 2009-2013 (End 2013), Harbour price.

[11] Rob de Ruiter, Ecophos, oral communication 2013

[12] Willem Schipper, oral communication 2013

[13] Christian Kabbe, KWB and Jiri Palcik, ASIO, oral communication. Landfill, incineration and composting in Germany, Netherlands and Czech republic 20-80 Euro/to sludge. Assumption for price caculation: 30% dry matter.

[14] Anders Nättorp, FHNW, Oral communication. Swiss landfill around 80 CHF/to ash

[15] Christian Kabbe, KWB, 2014. Jim Hotchkies, Ostara, oral communication 2013

[16] Jürg Bühler, BSH Umweltservice oral communication, 2013

[17] Ingitec, 2009 Mephrec- Metallurgiisches Phosphor-Recycling, final report. Ingitec, oral communication 2014

2.3.4 Market price

The market prices start at the lower end with phosphorus rock in the fertilizer market which has low plant availability and costs about 500 Euro/to (Figure 2). A plant available and also more concentrated product, triple super phosphate, currently costs around 1400 Euro/to phosphorus. The offered or estimated prices for recycled mineral phosphorus materials are in the same range, from 300 to 1700 Euro/ to phosphorus. More pure products could be used in feed or technical applications with prices ranging up to 3000 Euro/to phosphorus. A company offering sewage sludge or sewage sludge ash in general needs to pay the receiving company disposal costs (negative market price of the material).

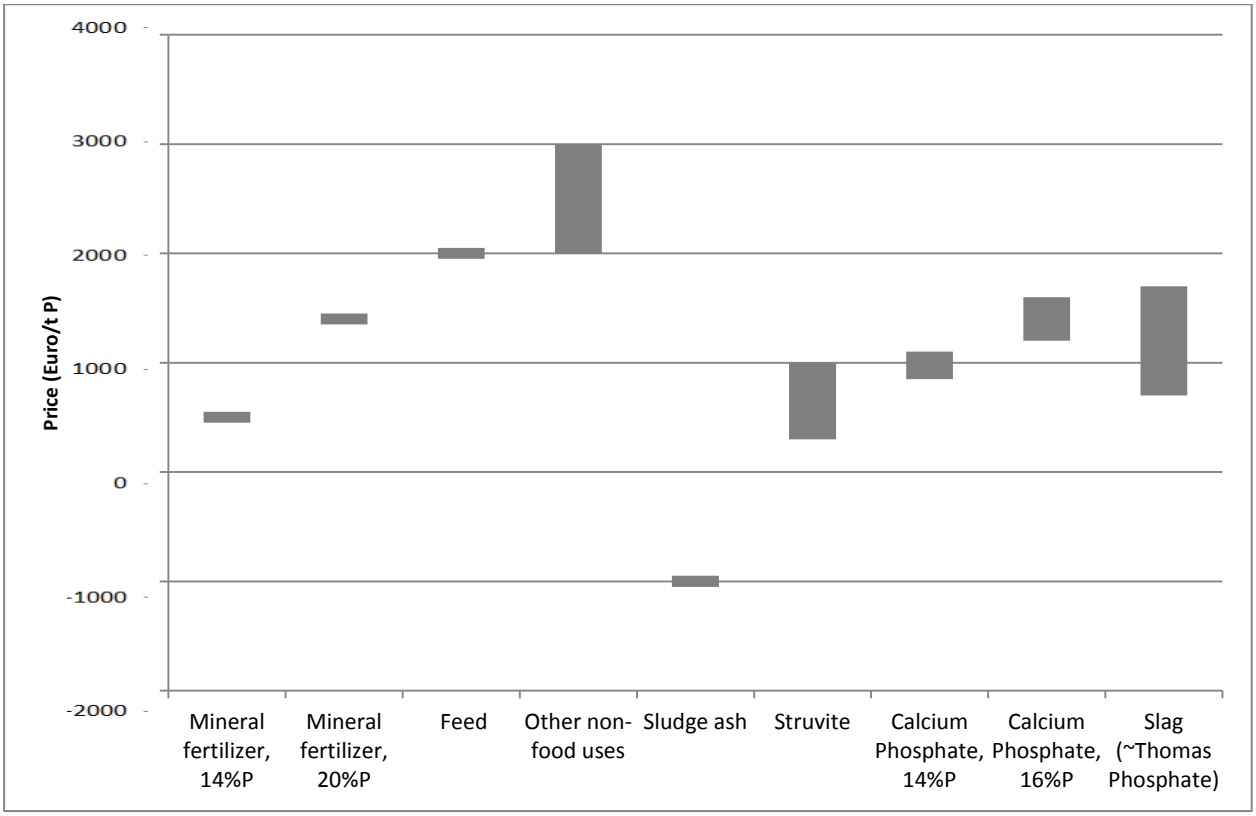

Figure 2: Market price estimations of three markets (fertilizer, feed other non-food), two wastes (sewage sludge and sewage sludge ash) and three types of recycled phosphorus-containing materials (struvite, calcium phosphate and slag). Ranges are indicated as such and averages or sole quotations are indicated as a bar.

2.4 Conclusion and outlook

The matrix illustrates that all recycled materials comply with the current legal requirements for fertilizers in Germany, all but one can be evaluated as plant available and the phosphorus concentrations are in the range of phosphorus rock or sewage sludge ash, somewhat lower than conventional fertilizers. Three of the four material types (struvite, Leachphos, ASH DEC with sodium additives) outperform both sewage sludge ash and some types of sewage sludge both in terms of plant availability (relative fertilization effect) and legal requirements regarding the heavy metals. On the other hand, the sewage sludge is also able to improve the soil fertility through its content of organic matter and nitrogen. Nitrogen is also present in struvite, giving added value to this recovered material.

Assessment methods of fertilizer performance may need to be expanded beyond a comparison to readily plant available TSP and water solubility as sole method when evaluating recycling materials. It is likely that some of the recycling fertilizers will perform better as slow release fertilizers, enabling them to re-

lease the phosphorus to the soils over years (see also chapter 3) as desired in organic farming. Thus, re-evaluation of the needs of the end users and "sustainable" fertilization schemes may lead to new market niches for the recycled materials as fertilizers.

The offered and projected price ranges for recycled mineral phosphorus-containing materials are in line with those in the fertilizer market and dependent on grade and plant availability. Higher prices could be obtained for phosphorus for feed and other non-food uses, but the recycled materials do not fulfill the more stringent technical and legal requirements for these markets.

The pre-normative matrix is a first step to create more transparency and facilitate production and use of secondary phosphorus. It will be further developed in dialogue with market participants and new findings on quality, legislation and price can be integrated.

3 Niches and alternative fertilisation schemes

3.1 Review of current P supply, fertilization schemes and the current soil phosphorus kinetics, flows, and pools

3.1.1 P supply

Currently, within the European Union (EU-27), a yearly total amount of 1 to 1.5 Mt of P is applied on agricultural or horticultural land. Inorganic fertilizers and manure accounted for more than 95% of the P input in the EU-27 between 2005 and 2008 (EUROSTAT). P input from other sources (e.g. sewage sludge, industrial waste, compost etc.) is at the moment insignificant. However, as a result of a general lack of data in many countries, the importance of these agricultural P sources could be underestimated.

About half of the P applied as fertilizer in Europe has organic origin (Slurry, Farm Yard Manure, digestates from anaerobic digestion). Regional shares vary widely with land use, stock densities, cropping structure, and agricultural intensity.

P nutrient inputs per hectare are not evenly distributed within Europe. On average, within the EU-27 member states, 19 kg of phosphorus per hectare was applied in 2008. National averages ranged from 50 kg P ha^{-1} in Malta and 40 kg P ha^{-1} in the Netherlands to 7 kg ha^{-1} in Latvia and 6 kg ha^{-1} in Bulgaria. The Gross Nutrient Balance per hectare for P within the EU-27 in 2008 was slightly positive with a surplus of 1kg Phosphorus per hectare. More detailed examination shows, that there are huge differences between the countries: Cyprus, for example, has a surplus of 21 kg P ha^{-1} on the other hand, Hungary shows a negative Gross Nutrient Balance of -15 kg nutrient per ha (Eurostat, “Gross Nutrient Balance (N, P)”) (Table 2). (Currently, generally low rates are applied in eastern European countries due to limited availability of funds in agriculture and relatively low livestock densities. Significant exports of agricultural products also contribute to a negative balance. In Germany in 2010/11, 124,850 t of Phosphorus were sold as mineral fertilizer. This would account for an average of 6.45 kg per hectare of mineral phosphorus applied during the year. The corresponding balance ranged between 26 kg P ha^{-1} and -26 kg P ha^{-1}, mainly influenced by the amount of manure used for fertilization (Deutscher Bundestag Drucksache 17/11486). In recent years European P fertilizer sales (beyond a clear midterm decrease) have varied from year to year significantly. It has to be taken into account, that sales do not necessary equal amounts applied and farmers may postpone P fertilization for years as a reaction to changing marked prices.

Table 2 :P nutrient inputs per hectare within the European Union and Gross Nutrient Balance in 2008 (Source: EUROSTAT)

	Nutrient input per hectare	Gross Nutrient Balance per hectare
	(kg Phosphorus per hectare)	
European Union (27 countries, 2008)	**19**	**1**
Belgium	33	5
Bulgaria	6	-4
Czech Republic	16	1
Denmark	26	7
Germany	25	1
Estonia	9	-8
Ireland	22	3
Greece	13	-3
Spain	17	3
France	23	2
Italy	20	-4
Cyprus	27	21
Latvia	7	-1
Lithuania	8	-10
Luxembourg	20	1
Hungary	8	-15
Malta	50	20
Netherlands	40	10
Austria	19	2
Poland	21	7
Portugal	14	3
Romania	9	-2
Slovenia	25	7
Slovakia	10	-4
Finland	15	5
Sweden	13	1
United Kingdom	26	7

Soil phosphorus kinetics, flows, and pools

Soil P exists in various chemical forms but can generally be classified as inorganic P (Pi) and organic P (Po). These differ in fate and behavior in soils (Turner et al., 2007). Pi usually accounts for 35 % to 70 % of total P in soil (Harrison, 1987). P contents in arable soils vary between 0.02 and 0.1 %. In organic soils (moor, fen, peat etc.) concentrations may be higher. Within the topsoil (0 - 30 cm depth) the total amount may be 600 to 3000 kg of P ha^{-1}. According to Mengel & Kirby (2001), phosphorus in soils can be classified into three 'pools' depending on their accessibility to plants:

- Solution P
- Labile P
- Non Labile P

The major fraction is nearly inaccessible for plants, it consists of insoluble and fixed P forms referred to as 'Non Labile P' including primary phosphate minerals, humus P, insoluble phosphates of Ca, Fe, Al and P fixed by hydrous oxides and silicate minerals. Only phosphates in the soil solution are completely accessible for plants. This is the smallest of all three pools. The labile P-Pool equilibrates the two other pools. If P is removed from the soil solution by plant roots, the change in the P concentration leads to a release of P from the labile P-Pool into the soil solution. On the other hand, if phosphorus is added to the soil solution (e.g. through fertilization), enormous amounts of P can be fixed in the labile pool (Mengel & Kirby, 2001) (Figure 3).

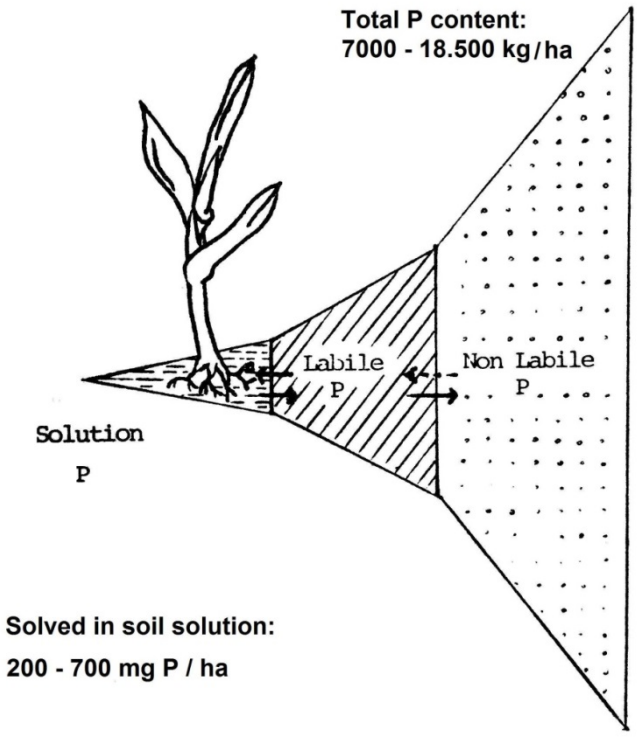

Figure 3: Only the phosphorus solved in the root zone can be taken up by plants directly. This pool is replenished by more phosphorus coming into solution from the labile pool which may origin from the non-labile pool. (Source: modified after Agricultural Committee of ISMA, 1980)

In order to satisfy crop requirements, (e.g. 18 kg P / ha per year for cereals) the soil solution must be replenished 20 times (silty soil) to 90 times (sandy soil) per year (Römer 2011).

Organic P (phytates, nucleic acids) can mostly not be taken up by plants. Large amounts of inorganic P in soils are in the non-plant accessible form of apatite and weathered forms of it. Primary P minerals (e.g. apatites, strengite, variscite) are very stable, and the release of available P from these minerals by weathering is generally too slow to meet the crop demand. In contrast, secondary P minerals including calcium (Ca), iron (Fe), and aluminum (Al) phosphates vary in their dissolution rates, depending on size of mineral particles and soil pH (Pierzynski et al., 2005; Oelkers and Valsami-Jones, 2008). With increasing soil pH, solubility of Fe and Al phosphates increases but solubility of Ca phosphate decreases, except for pH values above 8 (Hinsinger, 2001). The P adsorbed on various clays and Al/Fe oxides can be released by desorption reactions. All these P forms exist in complex equilibria with each other, representing from very stable, sparingly available, to plant-available P pools such as labile P and solution P (Shen et. al. 2011).

Because plants can generally take up P that is solved in water only, a continuous supply to the soil solution is necessary in order to meet the demand of growing plants. Freely available P cannot be buffered in the soils in significant quantities, which requires the activity of microorganisms (mineralization). Mineralization depends on a number of environmental factors like temperature, moisture, texture, pH-value and others. The less favorable these conditions are, the more P is fixed in a stable form and the less of the nutrient is accessible by plants. Mobilization and immobilization of P in the soil solution are bidirectional and happen simultaneously. Plants take up P in soluble form as orthophosphate (mainly $H_2PO_4^-$ and HPO_4^-) either directly via the roots or indirectly with the help of root fungus (mycorrhiza). Acidification of the rhizosphere in response to P deficiency has been demonstrated for some species and can alter the solubility of sparingly-soluble inorganic P compounds, particularly Ca-phosphates in alkaline soils (Richardson et al 2009). Plant roots and associated microorganisms can also influence the rhizosphere pH via redox-coupled reactions. Additionally, exudation and respiration can contribute some proportion of rhizosphere pH decrease as a result of a build-up of the CO_2 concentration (Hinsinger et al. 2003). However, the ability to acquire P via these mechanisms is low for some commercially relevant crops like maize (Figure 4).

Even if the total P-content in a soil is high, plant availability might be low because phosphates tend to stay in stable bonds. In Figure 2 (Shen et. al. 2011) an overview is given about the extremely complex P pools and dynamics in soil as well as their influencing factors.

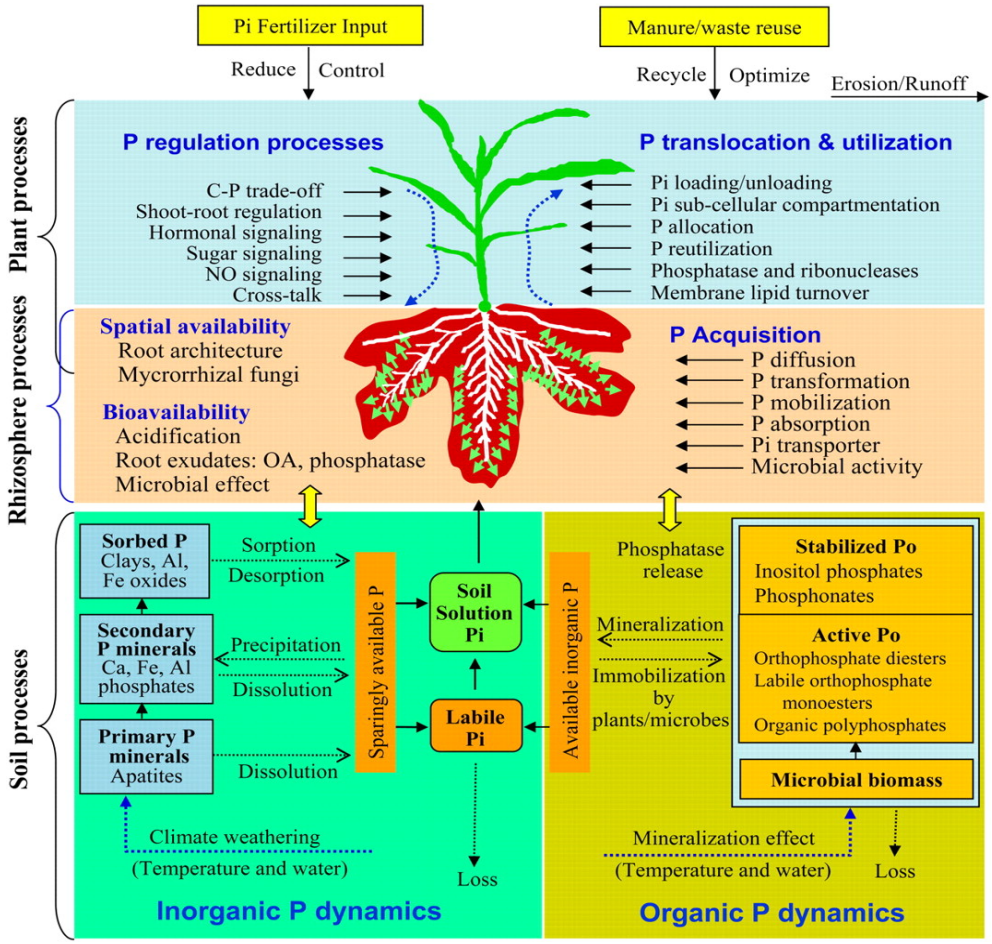

Figure 4: Dynamics and pools of P in soil, Source: Shen J et al. Plant Physiol. 2011; 156:997-1005

Because of the charactesristics of phosphorus such as low solubility, low mobility, and high fixation by the soil matrix, its availability to plants is dominantly controlled by two key processes:

(a) spatial availability and acquisition of P in terms of plant root architecture as well as mycorrhizal association, and

(b) bioavailability and acquisition of P based on the rhizosphere chemical and biological processes.

The phosphoros solved in the soil solution is increased by fertilizer application or replenished by the labile P pool (Figure 4). Rates of release of the non labile soil P-pool to the labile pool are, however, too slow to contribute significantly to the crop over one growing period. Thus, the phosphorus available to the crop is that which can be dissolved during the growing season of a crop. Normally, this will only be a small fraction of the total phosphorus in the soil (Figure 3).

3.1.2 Plant availability of P from fertilizers

Fertilizing with mineral phosphorus has only been practiced for around 150 years. The P-fertilizing effect of bone meal is used since the beginning of the 19th century, later phosphate acid was added to further increase plant growth but, however, without knowledge of the existence of elements essential for plant growth and their bio-availability. Justus von Liebig (1803-1878) demonstrated as early as in 1840, that P can also be used from mineral sources (phosphate rocks). His work on mineral plant nutrition led to a change of fertilizing practices – and to yields raised by the factor 5 to 10 since then.

Adequate P-fertilization on soils poor in phosporus requires a large amount of P because more than 80% of the P fertilzer may be strongly absorbed or precipitated by the soil and not be immediately available to

the crop (Sample et. al. 1980; Sanyal & De Datta 1991). Because of the poor utilization of the available soil P reserves during an annual growing period are only around 5 to 15 % in general (Agricultural Comitee of ISMA, 1980). Therefore P amounts provided in the form of fertilizer must be much greater than the annual requirements of the crops. Figure 5 gives an estimate on the contribution of P fertilizer on plant nutrition in one vegetation period. If fertilizer is broadspread on soil, up to 13 % of its P can be taken up by plants. Banding (e.g. unter foot placing when sowing row crops) can increase this share to 25 %.

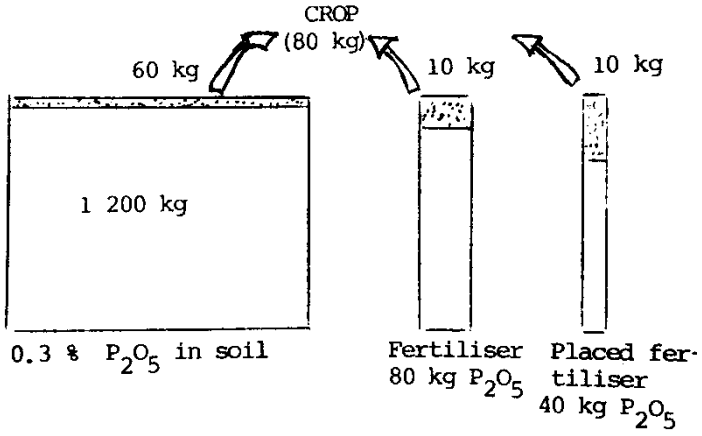

Figure 5: The role of mineral P-fertilizers in crop nutrition. Broad spread P fertilizer has a theoretical efficiency of 13 % for an annual crop. Placed fertilizer can have 25 % efficiency in one vegetation period. (Source: Handbook on Phosphate Fertilization, Agricultural Committee of ISMA, 1980)

A surplus of phosphate reserves can mean safety against various climatic hazards or soil physical defects wich are likely to slow down or hinder the uptake of phosphorus by the crop. As a consequence, in order to ensure high yields, fertilized soils in most cases contain much higher concentrations of available phosphorus than natural ecosystems. In intensive agricultural systems, particularly those of Western Europe, a long history of phosphate fertilization has built soil P such that crops show only very limited yield responses to current fertilizer applications (Hedley et. al. 1993; Hedley et. al. 1995). P-Fertilizer applications are used to maintain or raise the concentration of the available phosphorus in the soil in order to maintain its nutritional potential. The maintainance requires at least the amounts equal to what was removed in form of harvested products.

Because of the complexity of the phosphorus dynamics in soils, fertilizer recommendation are, unlike such referring to nitrogen, not directly related to yields but to soil concentrations. In Germany and also in other parts of Europe, soil is classified into one of five categories according to its P-content (Table 3). Category C represents the optimum - P input via inorganic fertilizers and manure should be equal to P output (harvested crops, etc.). If the P-content is lower, P input should be higher than P output to enrich the soil P content. Soils in category D only need a reduced Phosphorus fertilization, whereas no fertilizer should be used on soils with a P-content in category E.

Table 3: Classification of soil P-contents and fertilization recommendations in Germany (Source: VDLUFA-Standpunkt Phosphor)

Category	P-Content (mg P/ 100mg soil)	Fertilization
A	≤ 2,0	highly increased fertilization
B	2,1 - 4,4	increased fertilization
C	4,5 - 9,0	maintenance fertilization
D	9,1 - 15,0	reduced fertilization
E	≥ 15,1	no fertilization

As it is commonly difficult to show a direct relation between P fertilization and crop yields in field experiments, in Germany the actual concentration values of the categories have been subject to discussions and where consequently lowered periodically since the 1970ths. Not more than 3 to 6% of all arable land in Germany (375,000 - 750,000ha) are currently classified as categorie “A” (Römer 2013a). Similar numbers have been found for Switzerland (BUWAL, 2004). P fertilizer application can improve yields on fields in categorie “A”, however, no increase of crop yields could be shown in numerious field experiments when soil classified as “B” received additional P fertilizer (Römer, 2013a, Claassen et. al. 2010).

In addition to ensuring crop yields, fertilizing with P has to meet sustainability criteria like balanced nutrient flows which means that the amount of P removed from a field by harvested products needs to be replaced in oder to maintain sufficient P levels in soils.

The conditions described above are found in wide areas of Europe but may not be transferable to other regions e.g. the tropics. In many areas of the world, especially such with low capital input in agriculture, crop yields are significantly limited by the availability of P in soils.

Evaluating the efficiency of P-fertilizers proved complex and generally difficult. Their solubility in water and stepwise in weak to strong acids is taken as a first indication regarding their expected P plant availability. However, this assessment does not take into account physical, chemical and biological P – soil – plant interactions which may influence the actual nutrient uptake much more than the sole chemical solubility. Traditionally, with the historical background of using raw phosphate rocks and partially acidulated raw phosphates, mineral fertilizer was required to be fully water soluble with the exception of application on very acidic soils (Mengel 1986, Steffens 1987, Scharafat & Fink 1973). Myint (2005) has shown that fine ground raw phosphate rocks do not contribute to plant nutrition in 20 years of time when the pH-value of the soil is between 6 and 7 which applies for most soils in Europe. A positive effect of a fertilizer has to be experienced within a financially recognizable time (Classen et al. 2010). This is relevant for P fertilizers as soil chemical and biological processes may enable any P source to become available to plant over time. If the chemical characteristics of a fertilizer cause that these processes last too long, its use may not be justified.

Complete water-solubility is often referred to as crucial quality criteria for any mineral P-fertilizer (Schnug et al., 2003). This quality measure has in the past also been transferred to recycling P-fertilizers. However, field trials have shown that solubility in a weak acid may promise equal nutrient uptake results as such from 100% water soluble P fertilizer (Römer, 2006). This implies that requirements with respect to chemical solubility have to be revised. When results from pot experiments are compared with chemical solubility analyses of the fertilizers, it becomes obvious, that the chemical characteristics cannot serve as

a satisfying tool to define the plant availability of a fertilizer (see e.g. results from pot experiments in this project). It can nevertheless give a first hint on which P-availability can be expected.

A more realistic way of evaluating plant availability from P fertilizers is measuring the P uptake of plants grown in controlled environments like pots or small containers. The limited amounts of soil used in this experiments ensure that situations are created in which P becomes actually limiting for plant growth. It further provides the option of testing the influence of different soils on uptake rates.

3.2 Recycling fertilizers

3.2.1 P-plant availability of struvites

Struvite (Magnesium Ammonium Phosphate Hexahydrate, also called “MAP” but not equal to the marketed fertilitzer Mono Ammonium Phosphate) is a product derived from the waste water stream by means of precipitation as a result of pH-value change and addition of Mg. In its crystalline form it usually carries little contaminants. Compared to other P recycling products, the fertilizing value of struvite has been studied well. Often it is described as “slow release” fertilizer with the same nutritional value as TSP or DAP in a given period of time. In some cases, this could be shown independently from the type of soil or its pH-value. P-uptake rates of struvites are generally good but vary according to type of soil (pH-value) and precipitation method. Mg-P tends to be taken up to a greater extent than Ca-P or Fe-P compounds. However, the presence of Fe seems to reduce P plant availability of struvite (Römer 2006). Despite struvite is not water soluble its plant availability can be equivalent to TSP. For this reason, the application of struvite can be recommended on any soils classified as B, C or D. In very low P concentration soils (category A) rapid availability of P from TSP or DAP may have advantages compared to struvite. This, however, has not been shown in field experiments yet.

3.2.2 The requirement of treating phosphate rich ashes

Kuligowski et al. (2010) concluded that untreated ash and solid manures used in his study were not suitable as starter P fertilizer, but could be used to maintain the level of available P in soil. The authors also found indications that ash/manure P contributed significantly to the plant P uptake during the growing season of barley. Just like fine ground raw phosphate rocks, untreated ashes may be an efficient fertilizer on very acidic soils. For ashes in most other cases a treatment is required in order to make P more plant available.

Due to the variety of different methods of P recycling and the fact that characteristics of products are still subject to changes as a result of process adaptations, general conclusions regarding P availability are difficult to draw. Pot or laboratory experiments have the (fundamental) weakness, that no long term effects can be assessed and that biological and chemical conversion processes in the soil can only be taken into account to a very limited extent. This may lead to under-estimation of mid to long term P availability especially from raw phosphate rocks or incineration ashes as these fertilizers may need intensive chemical or biological conversion processes in order to become plant available (Römer, 2013b).

3.2.3 P-plant availability of ash-based fertilizers

Ash-based products vary widely concerning their contents of plant available P. It is commonly accepted, that untreated sewage sludge ash does not significantly contribute to plant nutrition in Europe which makes a treatment necessary.

The ASH DEC technology is a thermal decontamination process comparable to calcinations (www.outotec.com). It enables the reduction of heavy metals and P availability improvement by addition of $MgCl_2$ (older process) or Na_2CO_3 (new process) at temperatures around 900°C. In laboratory and pot experiments the (old) ASH DEC product showed improved plant availability compared to untreated ash but mostly did not reach the fertilizing effect of TSP (Kratz et al. 2010, Cabeza Perez 2011, Waida & Weinfurtner 2011). According to Severin et al. (2014) the new ASH DEC product performed equally to TSP on slightly alkaline silt. In own pot experiments (within the P-REX project) a significant effect of the pH of the soil on plant performance of the ASH DEC products was detected. Both products (old and new) performed equally on acidic soil. On (almost) neutral soil, however, only the new product showed a yield equal to TSP whereas the fertilizer efficiency of the old product was low.

LEACHPHOS refers to a P recycling process where the nutrient is extracted from ash by means of wet chemistry. While some plant experiments showed generally good plant availability of the product, on slightly acidic soil less P was taken up from the LEACHPHOS CaP-product compared to fully water soluble TSP (AWEL, 2013). The pot experiments within the P-Rex project showed very high plant availability of the P contained in the LEACHPHOS product if applied on acidic soil and good performance on rather neutral soil. These results are supported by the analyzed data: Nearly 100% of the phosphorus is citric-acid soluble. With current knowledge, the LEACHPHOS product can be recommended as a fertilizer in most situations. Compared to other ash based products its plant availability seems very high. However, as not many experiments have been carried out with the product more detailed information in the issue might be generated in future.

The fertilizer produced in the Mephrec® process was often described as “similar to the formally known Thomasmehl” – Thomas phosphate - a slag based byproduct of the steel industry. This could, however, not been confirmed in own pot experiments and in such carried out in Saxony (LfULG, 2013). Neither the high share of citric acid soluble phosphorus, nor plant availability as high as quoted (Ingitec Abschlussbericht 2009) was found. There is generally few data on plant availability of the Mephrec® product available which makes fertilizer use recommendations uncertain. Current knowledge suggests a rather slow P-supply in the first year after spreading. However, long term effects are unknown.

3.2.4 Fertilizing schemes

In Europe, local P fertilizing schemes depend on economic factors, livestock density, official fertilizing recommendations, advertising of producers and retailers, specific restrictions e.g. for organic farming, and others. Taking into account a given soil status, climate, and crop to be grown P fertilizer can be applied on a yearly basis or every 3 to 5 years. Yearly applications have the advantage that in row crops like maize the nutrient can be directly placed in the root zone (banding) ensuring a high spatial availability and a better efficiency. For technical reasons, however, the placement can only show its efficiency in one year. In the following years the concentration of P in the band may lead to lower efficiency because the seeds cannot be placed on top of the band again.

Contrary suggestions have been made whether P should be applied as a starter fertilizer directly at sowing time (rapid availability) or some time before sowing to allow the P to enter the soil solution. Single placements only every 3 to 5 years may help reducing application costs and are justified by the low uptake efficiency of mineral fertilizers in one year.

Fertilizing schemes can be adopted according to the chemical availability of P in a fertilizer product. For individual P-recycling products this would mean developing scenarios in which their application would meet crop nutritional requirements as well as helping to maintain soil P concentrations.

In order to develop fertilizer recommendations for P-recycling products, a scheme needs to be developed which describes the main influencing factors. According to current knowledge, the factors are:

- Type of fertilizer and chemical characteristics
- Soil nutritional status
- Soil pH-Value

The actual fertilizing value of new P-recycling products often still has to be tested under a variety of conditions. Substantiated fertilizing recommandations can therefore only be made for products that have been tested in pot or field experiments. Table 4 gives examples of such fertilisers. Based on experimental data, the criteria displayed memtioned above can help developing fertilizer recommendations.

Table 4: Samples of possible fertilizer recommendations of P-recycling products

Fertilizer product	Suitable fertilizing scheme
Sewage sludge	Application according to official guidelines, plant availability of P reduced with high Fe contents
Struvite	Generally suitable for application in category B, C and D, preferably every 3 years and not placed at the time of seeding
Untreated ash	Suitable for very acid soils
Thermo-chemically treated ash (ASH DEC, Na_2CO_3)	According to current knowledge suitable for loamy, alkaline soils but less for acidic sandy sites
Chemically treated Ash (LEACHPHOS)	Good plant availability, better efficiency on acidic soils.
Thermo-metallurgic treatment (Mephrec®)	Lower plant availability in the first year than other ash-based products. Unknown long-term effect. Possibly suitable as slow-release fertilizer to maintain P contents in soil

3.2.5 Using P-recycling fertilizers in organic farming

Organic farming follows principles of sustainability as well as social and philosophic criteria. Different directions of organic farming exist and show a variety of farming guidelines. Almost all of them do not allow using fossil or synthetically made mineral fertilizers or sewage sludge. Beside national laws, the legal basis for organic farming is presented in the EU legislation on organic farming (834/2007). Most German organic farming associations follow guidelines stricter than EU law (Bioland 2013, Demeter 2014, Naturland 2014).

The current legal situation in the EU does not allow the use of P-recycling fertilizers in organic farming. However, a demand exists especially after Thomas-phosphates have become unavailable due to change in technology of iron production and the efficiency of raw phosphates is low except on very acidic soils. Beside the legal requirements, recycling P products in organic farming would need to fulfill selected sus-

tainability criteria and philosophic requirements. In this way, the BIOLAND-association defines, that chemical solubility of mineral fertilizers must not be improved by chemical treatment (Bioland 2013). According to their guidelines, the use of easily soluble P-fertilizers is generally forbidden. Despite not in all guidelines explicitly stated, most organic farming associations reject mineral fertilizers containing quickly available phosphorus.

Possible P fertilizers in organic farming are:

- Fine ground raw phosphate rocks
- Thomas phosphate (very limited availability due to change in iron production technology)
- Calcium carbonate made from sources like sea algae or sea shells

Due to lower P inputs from imported feed and the limited availability of effective mineral fertilizers, the potential need for P fertilizers in organic farming is generally larger than in conventional farming. Organic farms without livestock are likely to have a negative P-balance of 20 kg per hectare and year. Farms with animals production may reduce the balance to minus 5 kg P per ha per year (Debruck J., 2007). Zimmer and Dittmann (2004) found a deficit of 11 kg P per ha per year for animal keeping farms in Brandenburg (Germany) and 8 kg for arable farms. Other authors found more balanced P-supply for organic farms in Austria (Starz et al 2013)

As the total amount of phosphorus per hectare accounts to 7.000 to 18.500 kg (in 1 m depth) sufficient crop supply may be given for more than 100 years before a yield reduction is expected to be experienced. Due to the limiting yields in organic farming caused by the deficiency of nutrients other than P, lower soil concentrations are suggested compared to conventional farming. Soil contents in category “B” may be generally suitable for sufficient yields in organic farming (Kolbe H., 2001).

Despite all efforts of closing nutrient cycles, phosphorus which leaves a farm in form of marketed products is rarely returned to fields because of unsuitable sewage systems respective the fact, that sewage sludge is generally not allowed to be used in organic farming. However, organic farming should generally follow the idea of P recycling in order to maximize the sustainability of crop production. According to an official statement from the press office of the BIOLAND-association guidelines regarding the use of mineral recycling fertilizers can be changed as soon as the sustainability can be shown in terms of energy efficiency and spread of pathogens and heavy metals. However, before the associations start discussing the issue, a change in the EU legislation on organic farming would be necessary (Johanna Schüßler 05.04.2013, BIOLAND public relations via email).

4 Legal Summary

Summary of Legal and Societal Factors Governing the Production, Trading and Use of Recycled Phosphates

This document summarizes the legislation in relation to phosphorus for fertilizing purposes relevant to an EU-based recycler, manufacturer, importer or distributor. The main focus is on European legislation (Chapter 5).

Table 5 gives an overview on European Regulations and Directives relevant for activities aiming at placing recycled phosphates on the market. Chapters 4-0 cover the country specific legal frameworks relevant for phosphorus recycling in depth and significant differences are exemplarily taken up in this summary. The summary of relevant legislation is divided in three categories:

- Legislation governing the product covers obligations on physical/chemical characteristics, packaging and trading of products in general and fertilizer in particular.
- Legislation governing the production plant covers the requirements for building a production plant for recovery of mineral phosphorus and fertiliser production, including the permits for construction, operation and the environmental impact of the facility.
- Legislation governing waste management regulates wastewater treatment, use and treatment of sewage sludge and protection of water and (agricultural) soil.

Table 5: European legislation relevant for recycling of phosphorus in mineral form for fertilizing purposes

Title	**Number/Abbreviation**	**Enact-ment/Implementation**	**Focus**
Regulations	Automatically enforced in all Member States		
Registration, Evaluation, Authorisation and Restriction of Chemicals	Reg. (EC) 1907/2006 REACH	01.06.2007	Safe use of chemicals
Classification, labelling and packaging of substances and mixtures	Reg. (EC) 1272/2008 CLP/GHS	20.01.2009	Safe use of chemicals
Fertiliser Regulation Under recast aiming at enabling recovered phosphate products Type definition in annex I	Reg. (EC) 2003/2003	11.12.2003	Free trade. Scope, types, declaration, identification, properties and testing of EC-fertilisers
Organic Products Regulation	Reg. (EC) 834/2007	28.06.2007	General rules on organic farming
Production, labelling and control of organic products Type definition in annex II	Reg. (EC) 889/2008	05.09.2008	Production, labelling and control of organic products
Shipment of Waste Regulation	Reg. (EC) 1013/2006	14.06.2006	Safe transport of waste
Animal By-products Regulation	Reg. (EC) 1069/2009	21.10.2009	Use of animal by-products, human health protection
Directives	Implementation in Member States' legislation needed		
Directive on Industrial Emissions (Integrated Pollution Prevention and Control)	Dir. 2010/75/EU IED (IPPC)	06.01.2011	Permission for polluting activities, emission limits, BAT
Directive on the Assessment of the Effects of certain Public and Private Projects on the Environment	Dir. 2011/92/EU EIA	13.12.2011	Environment and health protection, assessment of impacts of projects and installations
Waste Framework Directive	Dir. 2008/98/EC WFD	12.12.2008	Environment and health protection by waste management; definition of end of waste status
Landfill Directive	Dir. 1999/31/EC	16.07.1999	Safety of waste disposal
Water Framework Directive	Dir. 2000/60/EC	23.10.2000	Inland, coastal and ground water protection

Title	Number/Abbreviation	Enact-ment/Implementation	Focus
Nitrate Directive	Dir. 91/676/EEC	31.12.1991	Nitrates from agricultural sources including farmyard manure; code of good agricultural practices
Groundwater Directive	Dir. 2006/118/EC	12.10.2006	Prevention and control of groundwater pollution
Urban Wastewater Treatment Directive	Dir. 91/271/EEC	21.05.1991	Environment protection from wastewater discharge
Sewage Sludge Directive	Dir. 86/278/EEC	12.06.1986	Use of sewage sludge on cropland

4.1 Legislation governing the product

The first critical question for the recycler is, if the outcome of the intended recycling process is a product or if it remains a waste. Applicable regulations largely depend on the answer to this question, because chemical substances, preparations or articles (with the exception of compost) are subject to registration under REACH (Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (EC) 1907/2006). Waste is per definition not a substance and therefore exempt from registration under REACH but subject to the waste regulations. The main practical difference is that REACH requires registration with a documentation explaining the chemical and physical properties of the product including potential hazards which may arise from the handling and use of it. In turn, the recycler can easily trade the registered product. A product remaining in the waste regime does not need to be registered but is restricted in transport and use, particularly if shipped across borders or sold to a fertiliser manufacturer for processing (see 4.3and 5.3).

The EU Regulation on Classification, Labelling and Packaging of chemicals (CLP Regulation (EC) 1272/2008) aligns the existing EU classification system to the UNGHS (Global Harmonised System of Classification and Labelling of Chemicals). All companies manufacturing or importing hazardous substances are required to appropriately classify, label and package them in accordance with CLP since December 1, 2010 and to duly notify the European Chemicals Agency (ECHA).

A product being placed on the market as a fertiliser must comply with the following fundamental principles:

I. Fertilisers must have a value for plant cultivation and/or serve the safeguarding of fertility of soils
II. Determined quality standards have to be met and important product characteristics, for instance types of nutrients, nutrient concentrations and solubility of nutrients must be declared
III. Application of fertilisers must not be detrimental for human health and the environment.

In every member state of the European Union, placing fertilisers on the market is governed by Regulation (EC) 2003/2003 (European Fertiliser Regulation) which is currently under revision. In addition, member states usually have a national Fertiliser Act regulating the principles of fertiliser production, admission and use as well as a Fertiliser Regulation determining the scope, types, characteristics, tolerances and test conditions for fertilisers and soil improvement products.

The fertiliser acts usually distinguish between:

“EC Fertilisers”: these must comply with Regulation (EC) 2003/2003 and may be placed on the market within the whole EU without restrictions.

“Other than EC Fertilisers”: these are fertilisers that may be placed on the market if being in compliance with the national fertiliser regulation. Products that are lawfully sold in compliance with the national fertiliser regulation in one EU member state may also be sold in other EU member states if not declared “detrimental to human health or the environment”, with understandable arguments (in accordance with Reg. (EC) 764/2008 about “mutual recognition” following the “Cassis de Dijon” judgment of the European Court of Justice, 20.02.1979).

In real life, recyclers may first check compliance of their product with the European regulation. Producers of complex fertilisers (NP, PK and NPK types with and without secondary and trace nutrients) are likely to find their product in compliance with Regulation (EC) 2003/2003. Single nutrient fertilisers will rather not be compliant because these fertilisers are more comprehensively determined and usually name a raw material (e.g. rock phosphate) being processed by certain methods. If a product is not in compliance with European regulations, recyclers may check if national regulations provide a special chapter for recycled phosphates. Regulations in Germany and Switzerland have been adapted to accommodate recycled fertilisers within their legal framework. However, where special – national - regulations for recycled products exist, they are usually much stricter in terms of heavy metal and other pollutant concentration. Compliance with the Swiss regulation will be particularly difficult for most secondary phosphates. In contrast, fertiliser regulations in Czech Republic and Spain do not accommodate recycled products and it may be impossible to lawfully place a recycled product on the market, as long as it is not lawfully sold in another EU member state or in compliance with the European Regulation (EC) 2003/2003.

No recycled phosphate qualifies for being sold as a fertiliser for organic farming, governed by Regulation (EC) 834/2007 and Regulation (EC) 889/2008. Reg. (EC) 889/2008 at least has been conceived to accommodate new products. Applications must be filed by Member States’ Governments and there is a long backlog of applications currently under review. Organic farming may, however, be an interesting niche market for so-called “slow release” mineral phosphate fertilisers such as struvite or calcined phosphates.

The European Fertilizer Regulation (EC) 2003/2003 is currently under review and is expected to be replaced in the forthcoming years. It is expected that the accommodation of recycled fertilizers in the new regulation will be facilitated, provided these products are safe and in compliance with the above mentioned basic characteristics which a product needs to comply with to be called a fertilizer.

Provided that the recycled material remains a waste, two additional European regulations govern its handling: Shipment of Waste Regulation (EC) 1013/2006 and – in case of being a slaughterhouse waste - Animal By-products Regulation (EC) 1069/2009. Particularly the Shipment of Waste Regulation (EC) 1013/2006 can be an additional burden for a recycler who wants to ship material across European borders because notification is needed to both countries and the approval of the shipment may take several months. Category 1 slaughterhouse residues (animal by-products) must be combusted to securely destroy pathogens causing mad cow disease.

4.2 Legislation governing the production plant

Whereas regulations are self-executing, automatically enforced throughout the European Union and not requiring member states to take measures for implementation, EU directives lay down certain end results

that must be achieved in every Member State. National authorities have to adapt their laws to meet these goals within a certain timeframe, but are free to decide how to do so and given timeframes are sometimes not met. In every area governed by a European Directive, corporations must act in compliance with the corresponding national regulation representing the implementation of the directive and national regulations may be stricter or contain additional provisions.

The two most important Directives for production plant planning, engineering, assembling, commissioning and operating are the IED (IPPC) Directive Dir. 2010/75/EU - Directive on Industrial Emissions (Integrated Pollution Prevention and Control) and the IEA Directive Dir. 2011/92/EU - Directive on the Assessment of the Effects of certain Public and Private Projects on the Environment. The focus of both Directives and corresponding national regulations is the regulation of emissions during building and operating a manufacturing plant. Both directives have been transferred to comparable national legislation in all European Member States but particularly the IED Directive is frequently under revision.

Industrial installations must use the best available techniques (to achieve a high general level of protection of the environment as a whole) which are developed to a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions which accounts also for small scale plants.

The IED Directive 2010/75 EU governs industrial activities with a major pollution potential, defined in Annex I to the directive (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, rearing of animals, etc.). Fertiliser production is listed in Annex I as well as waste processing. Thus it can be assumed that all phosphate recovery technologies are governed by this directive. Any industrial installation which carries out the activities listed in Annex I to the directive must meet certain basic obligations, including i) preventive measures are taken against pollution; ii) the best available techniques (BAT) are applied; iii) no significant pollution is caused; iv) waste is reduced, recycled or disposed of in the manner which creates least pollution; v) energy efficiency is maximised; vi) accidents are prevented and their impact limited; vii) sites are remediated when the activities come to an end.

Directive 2011/92/EU of the European Parliament and the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, known as the "EIA (Environmental Impact Assessment) Directive", requires that an environmental assessment is performed by the competent national authority for certain projects which are likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location, before development consent is given. Recycling plants do not belong to the projects listed in Annex I and automatically being subject to an EIA. Other projects, listed in Annex II of the Directive, are not automatically assessed: member states can decide to subject them to an environmental impact assessment on a case-by-case basis or according to thresholds or criteria (for example size), location (sensitive ecological areas in particular) and potential impact (surface affected, duration).

Permitting authorities usually are regional regulatory bodies which may take a different position towards a specific project and require an EIA or particularly severe emission limits for pollutants in off-gases or noise levels during operations. In any event, phosphate recycling processes which claim entailing environmental benefits are likely to face more severe emission limits than phosphate processing plants using conventional raw materials. Recyclers are advised to consult with relevant regional authorities prior to taking final decisions with regard to a determined plant location.

4.3 Legislation governing waste and wastewater management

Waste Framework Directive, Landfill Directive, Water Framework Directive, Nitrates Directive, Groundwater Directive, Urban Wastewater Treatment Directive and Sewage Sludge Directive govern the protection of the environment including (agricultural) soils and human health, the protection of inland and coastal water bodies including the management of urban wastewater and the use and treatment of sewage sludge.

The Waste Directive 2008/98/EC sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling and recovery. It tries to explain when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products.

The directive lays down some basic waste management principles: it requires that waste is being managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants and animals, without causing a nuisance through noise or odours and without adversely affecting the countryside or places of special interest. The waste management hierarchy stipulates the priorities by which waste avoidance and treatment options must be selected.

The Waste Framework Directive has been transferred to national law and has been implemented in all Member States under investigation in this report. It governs recovered phosphates if recyclers prefer to stay away from REACH in order to lawfully develop and market a product. In addition, it governs the waste from a manufacturing plant. Some recycling processes produce large amounts of waste which have to comply with the Waste Framework Directive. To a certain extent even the Landfill Directive 1999/31/EC may interfere with the processes a recycler intends to use – if waste materials are produced for which no use is possible, they must be in compliance with landfill categories and minor differences in the waste chemical or physical characteristics may have a large impact on the disposal cost. However, from a legal perspective, disposal obligations may turn out to be the key drivers for phosphorus recovery. Switzerland is expected to introduce legal requirements for the recycling of phosphorus from phosphorus waste streams by 2015.

The Water Framework Directive 2000/60/EC needs to be considered and respected with regard to the intended use of the product and with regard to waste waters from the production process. The directive requires that all surface and ground waters within defined river basin districts must reach at least ‘good’ status by 2015, a highly challenging requirement, throughout all European regions.

In the context of P-REX, the Water Framework Directive and in particular the Nitrate Directive are highly relevant for sludge, digestion residues and organic materials intended for use as fertilizers due to their N content which may contaminate water bodies with nitrates. In addition, one effluent from wet chemical processes is frequently a salt solution (e.g. $CaCl_2$) which must be neutralized and concentrated/dewatered before being reused or disposed of but under some circumstances may be discharged to the sea.

The intention of legislations governing the use of sewage sludge is to build trust in its use and to prevent risks for human health and the environment. The Sewage Sludge Directive 86/278/EEC governs the direct use of sewage sludge on cropland. However, as it was enforced in 1986, it is outdated and as a result most member states have developed more comprehensive regulatory frameworks for the use of sewage sludge as fertiliser which, however, differ widely among the countries under investigation: Switzerland completely banned the application of sewage sludge in 2003 with a transition period of five years. The requirements for sludge application in Czech Republic are very strict and thus it is not very common. In

most Member states, sewage sludge is not subject to the fertiliser regulations, but Germany intends to bring both regulations together by applying equal limits to all materials used as soil improvers or fertilisers. In Spain a series of regulations are presently applicable resulting in a legal framework which is rather unclear. It has led to the situation that Autonomous Communities regulate sewage sludge disposal independently and very unevenly. This lack of legal certainty prevents potential recyclers from having a clear view on rules and therefore is a significant barrier for investments in recovery and recycling processes.

The review of the European Regulations and Directives, as well as the regulations representing the EU-Directives in the member states' regulatory framework, shows that phosphate recycling is largely governed by European legislation. Differences at the national level exist but are rather marginal, referring to certain limits for heavy metals or organic parameters. Such differences, however, may have a decisive role on the feasibility of a certain recovery process in a certain country.

Apart from the investigated legal framework, we may find specific, sometimes hidden regulations in certain countries which may represent a high barrier to recyclers at the time of placing a phosphate recycling product on the market. On the other hand, the lack of an adequate (European) legal framework in some fields resulted in a fragmented legal system, entailing uncertainty, and thus acting as a hurdle to investments in phosphorus recovery. Legal barriers are, however, only a part of the problem of recycling phosphates at large scale. The current field tests exhibit a mix of regulatory barriers, fears and prejudices of stakeholders which prevent even the farm scale test of recycled phosphates.

The conclusion is that stakeholders interested in sustainable phosphorus management will have to continue promoting their solutions at all societal and political levels. Apparently, it will take much more time until the closure of phosphate cycles will be a commonplace.

5 EU Legislation

P-REX is dealing with phosphate recovery from wastewater or waste such as sewage sludge. The present chapter focuses on European Regulations, being automatically enforced in all Member States and European Directives being enforced by corresponding national legislation in EU-Member States and to some extent in Switzerland, despite of the latter not being part of the European Union.

5.1 European Regulations Governing the Product

5.1.1 Product or waste

The first critical question for the recycler is, if the outcome of the intended recovery and recycling process is already a product or if it remains a waste. Applicable regulations largely depend on the answer to this question, because chemical substances, preparations or articles are subject to registration under REACH with the exception of compost, the only product specifically exempt. Waste is per definition not a substance and therefore exempt from registration under REACH but subject to other regulations to be considered if a processed waste is placed on the market.

Consequently, recyclers placing phosphate containing waste materials on the market – such as spreading sewage sludge on cropland – could skip this chapter, regardless of mechanical or chemical treatment or sanitation processes being applied to the recycled material.

Because recovering phosphates in form of a product is economically more promising than in form of a waste (the latter being a common practice with regard to spreading sewage sludge and manure on cropland), the main document focus is on P-recovery to products and the installations where P-recovery and -recycling is performed.

REACH Article 2(2) provides that "waste as defined in Directive 2008/98/EC (originally 2006/12/EC) is not a substance, preparation or article within the meaning of Article 3 of this Regulation." Therefore, REACH requirements for substances, mixtures and articles do not apply to waste.

As soon as a material ‘ceases to be waste’, REACH requirements apply in principle in the same way as to any other material, with a number of exceptions granted conditionally. The point at which waste ‘ceases to be waste’ has been the subject of long debates. According to Article 6 (1) and (2) of the Waste Framework Directive (Directive 2008/98/EC), certain specified waste shall cease to be waste when it has undergone a recovery operation and complies with specific criteria to be developed in line with certain legal conditions, in particular:

The substance or object is commonly used for specific purposes;

A market or demand exists for such a substance or object;

- The substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
- The use of the substance or object will not lead to overall adverse environmental or human health impacts.

If the above mentioned criteria are met and the product is intended for sale for market prices in competition with conventional fertilisers, the product is subject to REACH and to other product related regulations whereas waste related regulations cease to govern processing and handling of products. Waste relat-

ed regulations may, however, be also relevant for product manufacturers because of using waste as a starting material and because of possibly producing waste as a by-product of the recycling process.

5.1.2 REACH

REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. This Regulation (EC) 1907/2006 is a key part of the EU's endeavour to make the use of chemicals safer. REACH attempts to address long-term exposures and its implications for human health and the environment. The regulation creates a single regulatory system dealing with industrial chemicals, and seeks to close the knowledge gap by placing the responsibility on industry to provide safety information on their substances and to manage the risks from chemicals. REACH's philosophy is that no chemical substance in whatever form should be placed on the market without adequate documentation. Each producer and importer of chemicals in volumes of one tonne or more per year must register them with the European Chemicals Agency (ECHA) and submit information on their properties, uses and safe ways of handling them. REACH also calls for the progressive substitution of the most dangerous chemicals by suitable alternatives. The first registration deadline for pre-registered substances closed on 30. November 2010 (Table 6). Approximately 5000 substances were registered with ECHA.

Table 6: REACH Milestones and tasks

Key date	Milestone and task
01.12.2008	Registration required for phase-in substances that were not pre-registered before; under certain conditions – largely starting to produce a new product - late pre-registration is still possible
01.12.2010	Registration deadline for pre-registered substances Supplied at >1000 t/a Very toxic to aquatic organisms (R50), may cause long term adverse effects to the aquatic environment (R53) >100 t/a Carcinogens, mutagens, reprotoxins (CMRs) >1 t/a
31.05.2013	Registration deadline for pre-registered substances supplied at >100 tpy
31.05.2018	Registration deadline for pre-registered substances supplied at >1 tpy

5.1.2.1 Requirements for REACH compliance

If a company produces recovered phosphates either to use or to supply to other people (even if it's for export or under contract) then it's likely that the product will be subject to regulation under REACH.

Since 1 December 2008, chemical substances (including fertilisers) manufactured in Europe in amounts of 1 tonne or more per year have needed to be registered with the European Chemicals Agency (ECHA) in Helsinki (Table 6Table 6). It is only chemicals on their own that are registered, not deliberate mixtures of chemicals (formulations/preparations such as complex fertilisers). Where a chemical is supplied or used as part of a deliberate mixture, for example, it is produced and used in a solvent or as part of a product; it is the individual ingredients that are registered.

There are a few exceptions, including radioactive substances, those in customs warehouses intended for re-export outside the EU/EEA, substances in transit and waste (as defined in EU Directives). Only selected parts of REACH apply to some chemicals, e.g. human and veterinary medicines, food and food addi-

tives. For others, e.g. intermediates, there are reduced requirements under certain circumstances, and some substances are treated as if they are already registered.

Registration means providing a package of technical information on the substance/preparation and its hazards. Registration is phased over a period of years based on tonnage levels and in some cases the hazards of the chemical. However, to take advantage of the phase in time chemicals need to be pre-registered. As an example, many different ashes and their preparations for different purposes are pre-registered.

Companies who manufactured their substance before December 2008 were required to pre-register them with ECHA between June 1st and December 1st, 2008 in order to continue to market and use them legally. Companies who manufacture their substance for the first time after December 1st, 2008 can, in some cases, complete a 'late pre-registration'.

Pre-registration is free and fairly simple. For each chemical a manufacturer needs to supply the following information to the ECHA:

- Name of the substance, including an identifying number (e.g. CAS or EINECS number);
- Registrant's name and address and a contact name;
- Envisaged deadline for registration and tonnage band; and
- (If applicable) identifier information of any structurally similar chemical which registrant may wish to rely on
- To provide useful evidence on hazards as part of your registration package.

A formally compliant pre-registration can only be submitted via ECHA's REACH-IT portal: (http://echa.europa.eu/web/guest/support/dossier-submission-tools/reach-it)

ECHA also provides step by step guidance on how to prepare and submit a pre-registration.

Another benefit of pre-registering a chemical is that registrant will become part of a group of companies who have also pre-registered the same chemical. This group, called a Substance Information Exchange Forum (SIEF) will share information on properties so that only one set of technical information has to be submitted to the ECHA. The SIEF can also work collectively on other aspects of the registration package. Membership of a SIEF will also help to share expertise and spread costs, with members reducing their costs of preparing the REACH dossier.

Consequently, a late pre-registration of the recycling product that a corporation is currently developing may still make sense. Company could sell small quantities (<1t/y) until 2018 and become member of a corresponding SIEF thus postponing the individual registration until large scale manufacturing and sales start. Being a member of a SIEF, company could share the cost of analyses, toxicity tests and compilation of the REACH dossier with other members and benefit from knowledge exchange within the SIEF group.

5.1.2.2 Recovered substances (excerpt from the ECHA Fact Sheet)

For the purpose of REACH, this term refers to substances that, after having being part of waste materials, have ceased to be waste according to the Waste Framework Directive. The "end of waste" criteria are, however, subject to different interpretations. They are in principle subject to REACH registration requirements. Companies recovering substances from waste within the European Economic Area that wish to benefit from the exemption to register recovered substances under Article 2(7) (d) of REACH should

consider the "Guidance on waste and recovered substances" available under the ECHA web-site http://echa.europa.eu/

The guidance document describes the conditions under which recovery operators can benefit from the exemption from the requirement to register a recovered substance. Furthermore the document elaborates on the obligation to share information on recovered substances in the supply chain, a requirement which is not obviated by the exemption. The guidance clarifies that all forms of recovery, including mechanical processing, whenever they result in one or more substances as such or in a mixture or in an article that have ceased to be waste after one or more recovery steps, are considered as a manufacturing process.

For the recovery operator it will be essential to clearly identify whether a particular recovered material is a substance as such, a mixture or an article in order to assess potential registration requirements. A recovery may result in the generation of one or several substances as such or a mixture containing several substances. When the recovered material is to be considered as an article, a general registration requirement of the contained substances would only apply when specific conditions are met.

An identity needs to be assigned to the recovered substance in the same way as for any other substance subject to registration, following the "Guidance on substance identification". Due to the complex composition of the input waste material the recovery operator may need to collect specific information relevant to the recovered substance. Whether the recovered material is a substance or a mixture, the recovery operator has to ensure that the individual substances/mixtures have been registered before.

Once the identity of the recovered substance has been sufficiently established, the legal entities undertaking the recovery can examine whether the conditions to benefit from the exemption under Article 2(7) (d) of REACH are fulfilled:

The recovered substance must be the same as a substance that has already been registered. The sameness should be assessed on the basis of the rules explained in the guidance on substance identification. The decision has to be based on the sameness of the main constituents.

The recovery operator must ensure that certain information on the registered substance is available to him. The information needs to comply with the requirements of Articles 31 or 32 of REACH concerning information provision. The recovery operator must have available one of the following, depending on the case:

- a Safety Data Sheet (SDS) for the registered substance, with, if applicable, the annexed exposure scenario;
- other information sufficient to enable users to take protection measures for the registered substance in case no SDS is required;
- the registration number, if available, the status of the substance under any authorisation, details of any applicable restriction and information to allow appropriate risk management measures to be identified and applied.

The originally registered substance and the recovered substance do not have to be part of the same supply chain leading to generation of the waste.

The main sources of information on the registration status of substances for the recovery operator are: the SIEF (if the substance to be recovered has been pre-registered), ECHA's dissemination website and information provided by recovery associations.

Irrespective of whether or not such an exemption applies, the supplier of the recovered substance has to provide the recipient with relevant and adequate information on how to use the recovered substance safely. Depending on the case this may consist of an SDS (and, where relevant, the annexed ES) or other information to allow safe use of the substance or of the article containing a substance of very high concern. Even if according to Article 31 of REACH an SDS is not automatically required, the Article 32 obligation to provide information to allow safe use will remain applicable.

5.1.3 Classification, Labelling and Packaging

Classification, Labelling and Packaging of chemicals is important in ensuring that people handling and using chemicals are aware of the hazards involved. The United Nations developed an internationally agreed system, known as the Global Harmonised System (GHS) of Classification and Labelling of Chemicals (UNGHS). The EU Regulation on Classification, Labelling and Packaging of chemicals (CLP Regulation (EC) 1272/2008) aligns the existing EU classification system to the UNGHS. All companies manufacturing or importing hazardous substances are required to appropriately classify, label and package them in accordance with CLP by 1 December 2010 and to duly notify the European Chemicals Agency (ECHA). More than 100,000 substances were notified. The data allow ECHA to establish a classification and labelling inventory providing workers and consumers with the information necessary to select safer substances and to limit risk.

If the manufactured chemicals are classified as dangerous, registrant will have to inform (electronically) ECHA of the classification and labelling of these chemicals. This should have been done by 1st December 2010 for chemicals that were already placed on the market or within 1 month of placing them on the market for the first time after December 1st, 2010. This is a duty imposed on manufacturers by the above mentioned European Regulation on Classification, Labelling and Packaging of Substances and Mixtures (CLP Regulation).

If manufacturer supplies safety data sheets with the chemicals or products, he will have to update these with additional information.

5.1.3.1 Safety data sheet (SDS)

Safety data sheets (SDS) are the main tool for ensuring that suppliers communicate enough information along the supply chain to allow safe use of their substances and mixtures.

Safety data sheets include information about the properties of the substance (or mixture), its hazards and instructions for handling, disposal and transport and also first-aid, fire-fighting and exposure control measures. This information can be found in the main body of the safety data sheet or in the annexed exposure scenarios (where applicable). The requirements for the compilation of the safety data sheets are specified in Annex II of REACH.

Some of the recycled phosphates may be hazardous and some of them not. Due to the obligation of the supplier of a recovered substance to provide the recipient with relevant and adequate information on the properties and safe use of recovered substances, compiling safety data sheets in compliance with REACH regulations, is highly recommended, even if it is not mandatory for the specific product or substance. For this purpose, recovered substances should be fully tested for skin and eye irritation, respirable particles and basic ecotoxic properties. Even if the substance is not yet placed on the market, this information will be required by third parties performing specific manufacturing or testing services for safety reasons.

Fertiliser manufacturers usually provide safety data sheets on their web-site which can be used as a template for recyclers in case they identify their product as identical to the fertiliser product manufactured from primary sources.

5.1.4 Admittance and Control of Fertilisers

A product being placed on the market as a fertiliser must comply with the following fundamental principles:

I. Fertilisers must have a value for plant cultivation and/or serve the safeguarding of fertility of soils
II. Determined quality standards have to be met and important product characteristics, for instance nutrient concentrations, types of nutrients and solubility of nutrients must be declared
III. Application of fertilisers must not be detrimental for human health and the environment.

In every member state of the European Union, placing fertilisers on the market is governed by Regulation (EC) 2003/2003 (European Fertiliser Regulation). This regulation is currently under revision and may be replaced in a couple of years. In addition, member states being selected and included in P-REX investigations, have a national Fertiliser Act regulating the principles of fertiliser production, admission and use as well as a Fertiliser Regulation determining the scope, types, characteristics, tolerances and test conditions of fertilisers and soil improvers product. Both regulations, national and EU, determine which fertilisers may be placed on the market and how they have to be labelled. The Fertiliser Acts usually determine the conditions under which non-EC-fertilisers, being placed on the market in other EU member states in compliance with the national regulations, can be placed on the home market. To place on the market encompasses import, supply, storage and sales of fertilisers.

The fertiliser acts usually distinguish between:

“EC Fertilisers”: these must comply with Regulation (EC) 2003/2003 and may be placed on the market within the whole EU without restrictions.

“Other than EC Fertilisers”: these are fertilisers of national importance that may be placed on the market if being in compliance with the national fertiliser regulation. Products that are lawfully sold in other EU countries may also be sold in the “home” state if not declared “detrimental to human health or the environment”, of course with understandable arguments.

Regulation (EC) 2003/2003 lists fertiliser types that can be placed on the market without restrictions. To determine if a recycled product is in compliance with the regulation manufacturer must determine if the substance being produced has its correspondence (is listed) in the regulation. Usually this will not be the case, but some fertilisers, particularly complex ones, are not plainly defined and a recovered product may thus be in compliance with the regulation.

If a product is in compliance with the type description, solubility requirements must be checked because Regulation (EC) 2003/2003 contains detailed solubility requirements for every fertiliser type, including 11 different solubility tests for phosphate fertilisers. Descriptions of tests occupy a large part of the regulation. In addition, definitions and requirements to minimum nutrient concentrations, tolerances, marking, labelling and packaging are part of the regulation.

In contrast, Regulation (EC) 2003/2003 does not foresee maximum concentrations for pollutants such as heavy metals. This issue is under revision. Only in relation to the cadmium content of phosphate fertilisers, stricter limits based on national legislation have been accepted in three Member States (AT, SE, FI) on the grounds of risks to health or the environment (derogation from the Fertiliser Regulation). With its new national fertiliser regulation, Germany has joined the countries with relevant cadmium limits in De-

cember 2008. The derogation applies until harmonised measures on cadmium in fertilisers are adopted at EU level.

Since 2009, a standardized mechanism is in place to propose a new fertiliser as an EC Fertiliser. For this purpose, a technical documentation can be filed with the relevant authorities of a member state for application of the new EC Fertiliser. The Member State concerned will then act as rapporteur for the file to the Working Group on Fertilisers of the European Commission. Details are explained in the Guide to the Compilation of a Technical File on application to designate a fertiliser as 'EC fertiliser. The technical file has to include general information, REACH registration details, safety data sheet, agronomic data, explanation of the methods of analysis and the corresponding results as well as the proposal for inclusion in Annex I to Regulation (EC) 2003/2003.

If a manufacturer intends to file an application for a new EC-Fertiliser, it would be wise to consider, alongside with all other obligations, the following limits for heavy metals and to provide evidence that the product is in compliance with these limits. Alternatively to the limits given in Table 7, limits of the German fertiliser regulation (exhibited in the corresponding chapter of this document) could be considered as a benchmark.

Table 7: Proposed heavy metal limits and limits in EU member states

Component	Proposal of Fertilisers Europe 2009 in mg/kg P_2O_5	Heavy metal limits in Member States in mg/kg P2O5
Arsenic (As)	60	10-60
Cadmium (Cd) Cd for P-fertilisers with >5% P_2O_5	3.0 60 mg/kg P_2O_5	1.5-3.0 20-60 mg/kg P_2O_5
Chromium^{VI} (Cr^{VI})	2	2
Mercury (Hg)	2	1-2
Nickel (Ni)	120	50-120
Lead (Pb)	150	150-200

However, it is difficult to estimate the terms under which such applications will be considered, particularly during the period of transition from the old to the new regulation being currently under discussion. It may also be difficult to convince the relevant authorities of the home-country of a manufacturer as a rapporteur. Applicants should be aware of starting a procedure that last anything between 3 and 10 years.

If and when checking the applicability of an existing fertiliser type to the recycled product, the check should encompass more than one language. Regulation (EC) 2003/2003 is not consistently translated into the different EU languages as the following example shows in Table 8 shows.

Table 8: Example for inconsistent fertiliser description in different languages in Regulation (EC) 2003/2003

Language	Fertiliser Type	Description
English	Triple Superphosphate	Product obtained by reaction of **GROUND MINERAL PHOSPHATE**.
German	Triple-Superphosphat	Durch Aufschluss von **GEMAHLENEN ROHPHOSPHAT** ……..
Spanish	Superfosfato triple	Producto obtenido por reacción del **FOSFATO MINERAL**……

"GROUND MINERAL PHOSPHATE" or **"FOSFATO MINERAL"** could be interpreted as phosphate containing ash or slag (because it is mineral in contrast to organic), either ground (EN) or not ground (ES), **"GEMAHLENES ROHPHOSPHAT"** is explicitly ground rock phosphate and rules out other phosphate containing compounds.

This is just one example of an inconsistency – there may be similar inconsistencies in the description of other fertiliser types not having been checked by the author.

5.1.5 Organic Farming Products

5.1.5.1 Regulation (EC) 834/2007

Regulation (EC) 834/2007 establishes the legal framework for all levels of production, distribution, control and labelling of organic products which may be offered and traded in the EU. It determines the continued development of organic production through the provision of clearly defined goals and principles. General production, control and labelling guidelines were established by the Council Regulation and can therefore only be changed by the European Council of Agricultural Ministers. The previous Regulation (EEC) No. 2092/91 is simultaneously repealed.

The new labelling regulations in connection with the obligatory use of the EU organic logo were postponed until 1 July 2010 by an amendment to the Council Regulation.

The Council Regulation applies to the following agricultural products, including aquaculture and yeast:

i. Living or unprocessed products
ii. Processed foods
iii. Animal feed
iv. Seeds and propagating material

Collection of wild plants and seaweed is also included in the scope of this Regulation. Not included in its scope are products from hunting and fishing of wild animals.

Organic production must respect natural systems and cycles. Sustainable production should be achieved insofar as possible with the help of biological and mechanical production processes, through land-related production and without the use of genetically modified organisms (GMO). In organic farming, closed cycles with the use of the internal resources are preferred to open cycles with the supply of external resources. Ideally, external resources should be limited to organic resources from other organic farms, natural or naturally obtained materials and low soluble mineral fertilisers. In exceptional cases, however, chemical synthetic resources may be permitted if suitable alternatives are lacking. These are only authorised and listed in positive lists in the Annexes of the Commission Regulation after a thorough investigation by the Commission and the Member States. These annexes are part of Regulation (EC) 889/2008.

5.1.5.2 Regulation (EC) 889/2008

In Commission Regulation (EC) No. 889/2008 all levels of plant and animal production are regulated, from the cultivation of land and keeping of animals to the processing and distribution of organic foods and their control. They go into great technical detail and are, for the most part, an extension of the original Organic Regulation, except where this was regulated differently in the Council Regulation.

Multiple Annexes are attached to the Commission Regulation. Within these one can find the following:

- Products permitted in organic farming, such as fertilisers, soil ameliorants and pesticides (Annex II)
- Minimum requirements on the size of housing and exercise areas including pastures for organic livestock, depending on animal species and development stage.
- Non-organic animal feed, feed additives and processing aids for the production of compound feed and premixtures permitted in organic farming.
- Non-organic ingredients, additives and processing aids permitted in organic food production (including yeast production).
- Requirements on the Community logo.

These Annexes and other parts of this Commission Regulation can be supplemented by the Commission so as to keep them up to date in regard to continuing developments in technology, science and the organic market.

Only a few mineral phosphate fertilisers are admitted for use on organic farmland. Cadmium concentrations are limited but with 90 mg/kg P_2O_5 more generous than those in the German, Austrian, Finnish and Swedish fertiliser regulations. Basic slag is allowed as well as aluminium phosphate (only on alkaline soils). Both products have not been available for many years due to raw materials and production processes having changed with time. All in all, only soft ground rock phosphate is available as phosphate source for those farmers not being able to compensate phosphate uptakes from crops with organic phosphates (farmyard manure) from own livestock or livestock from neighbouring farms. Sewage sludge is not allowed (Table 9).

Table 9: Excerpt from Regulation 889/2009 Annex II, part A, fertilisers and soil conditioners, mineral phosphates

Soft ground rock phosphate	Cadmium content less than or equal to 90 mg/kg of P205.
— Aluminum calcium phosphate	Cadmium content less than or equal to 90 mg/kg of P205 Use limited to basic soils (pH >7,5)
Basic slag	Need recognized by the inspection body or inspection authority

DG Agriculture, as responsible authority for Regulation (EC) 889/2008, has convoked an expert group to assess products that have been proposed by stakeholders for being included in Annex II. Similar to Regulation (EC) 2003/2003 for conventional fertilisers, applications can be filed for products for organic farming. Applications must provide a complete technical description of the product and the rationale why the

applicant is of the opinion that the product is appropriate and in compliance with the principles of organic farming. The application must be filed by a member state acting as rapporteur for the product.

It is not clear, however, if such application has real chances for a positive assessment if it is not widely supported by organic farming associations. The first barrier is to convince national authorities to submit the application. We have knowledge of applications that have been filed two or three years ago but no feedback has been received yet. Organic farming associations, for instance Bioland Germany, cannot yet make up their minds to support products made from sewage sludge – although there are numerous supporters among functionaries. One of the main concerns is the image of sewage sludge based products and how consumers may perceive the licensing of these starting materials, even if the product is made from ash. Germany would not submit an application if it is not officially supported by a relevant organic farming association (e.g. Bioland or Demeter).

Even if some of the recycling products apparently would comply with the principles of organic farming – for phosphate fertilisers "non-water-solubility" is a must – placing the product on the organic farming market may be risky and time consuming – again anything between 3 and 10 years may be the timeframe until receiving the approval.

5.1.6 Regulations Governing Waste and Wastewater Management

5.1.6.1 Shipment of Waste

Regulation (EC) 1013/2006 aims at strengthening, simplifying and specifying the procedures for controlling waste shipments to improve environmental protection. It thus reduces the risk of waste shipments not being controlled. It also seeks to include into Community legislation the provisions of the Basel Convention (international treaty controlling the movements of hazardous waste) as well as the revision of the decision on the control of cross-border movements of wastes destined for recovery operations, adopted by the OECD in 2001.

This regulation should ascertain environmental sound waste management regardless of the location of the intended treatment or disposal of waste. It applies to shipments of waste:

i. between Member States, within the European Union (EU) or with transit through third countries;
ii. imported into the EU from third countries;
iii. exported from the EU to third countries;
iv. in transit through the EU, on the way from and to third countries.

The Regulation concerns almost all types of waste shipped. Only radioactive waste and a few other types of waste do not fall within its application, insofar as they are subject to separate control regimes.

The Regulation also reduces the number of lists of wastes whose shipment is authorised from three to two. Wastes subject to notification are set out in the "Amber List" (Annex IV), while wastes subject only to information requirements are set out in the "Green List" (Annex III). Wastes for which export is prohibited are listed separately (Annex V).

5.1.6.2 Shipment procedures

This Regulation also reduces the number of waste shipment control procedures from three to two:

i. the "green listed" procedure applies to non-hazardous waste intended for recovery;
ii. the notification procedure applies to shipments of all waste intended for disposal and hazardous waste intended for recovery.

Whatever the procedure, all persons involved in shipment must ensure that they take all necessary measures in order that waste is managed in an environmentally sound manner throughout the shipment process and when it is recovered or disposed of. The notification procedure requires that the competent authorities of the countries concerned by the shipment (country of dispatch, country of transit and country of destination) give their consent prior to any shipment.

Waste shipments must be the subject of a contract between the person responsible for shipping the waste, or having it shipped, and the consignee of such waste. Where the waste in question is subject to a notification requirement, the contract must include financial guarantees.

Under the notification procedure, the notification must be submitted by the notifier only to the competent authority of dispatch which, in turn, will be responsible for passing it on to the competent authorities of destination and transit. The competent authorities must give their consent (with or without conditions) or express their objections within 30 days. Any changes involving the main aspects of the shipment (quantity, itinerary, etc.) must be the subject of a new notification save in cases where all the competent authorities grant the notifier an exemption from this obligation.

Furthermore, interim recovery and disposal facilities are bound by the same obligations as final recovery and disposal facilities. The authorisation of a shipment involving interim operations can only be sanctioned if the shipment of the waste in question has also been authorised.

If a shipment cannot be completed (including the recovery or disposal of waste) the notifier must take the waste back, normally at his own expense.

The take-back obligation does not apply:

i. if the competent authorities of dispatch, of transit or of destination concerned by the recovery or disposal of the waste consider that the notifier or, if that is impracticable, the competent authority of dispatch or a physical or legal person acting on their behalf, can recover or dispose of the waste in another way in the country of destination or elsewhere;
ii. if the waste has been irreversibly mixed with other types of waste before a competent authority concerned has become aware of the fact that the notified shipment cannot be completed.

5.1.6.3 Other shipment provisions

The Regulation includes other general provisions, such as a ban on the mixing of waste during shipment, the making available to the general public of appropriate information, and the obligation on the part of the notifier, the competent authority, the consignee and the facilities concerned to keep documents and information.

Exports to third countries of waste intended for disposal are prohibited, except to European Free Trade Association (EFTA) countries which are party to the Basel Convention.

Exports of hazardous waste intended for recovery are prohibited, except those directed to countries to which the OECD decision applies.

Imports from third countries of waste intended for disposal or recovery are prohibited, with the exception of imports:

i. from countries to which the OECD Decision applies;
ii. third countries which are party to the Basel Convention;
iii. countries which have concluded a bilateral agreement with the EU or Member States; or
iv. other areas during situations of crisis.

Member States must make provision for the organisation of checks throughout the entire waste shipment and waste recovery/waste disposal process.

The waste shipment regulation applies to phosphate recycling as long as waste material is subject to trans-border shipment, e.g. for treatment in a facility in another member state. Sample shipments for research and analysis purposes up to 25kg are exempt from notification.

For non-experienced companies, e.g. start-ups aiming at the introduction of new technologies, conducting waste shipments is not an easy task. Notification procedures can take time and cause significant delays if, for instance, sewage sludge ash has to cross borders for treatment. Financial guarantees as required by the regulation may exceed the financial power of SMEs, in particular start-ups. Shipment of waste materials across EU-borders may be a difficult and time consuming task and even a barrier to technology start-ups in countries where the company has to rely on waste starting material from other EU Member States or third countries.

5.1.6.4 Animal By-products

Animal by-products are high analysis P-carriers and animal by-product ashes are similar to rock phosphate concentrates in terms of P-concentration and impurities. In addition, they do not contain heavy metals. However, animal by-product ashes do not contain -plant available P-species.

Some of the technologies assessed in P-REX like Mephrec or ASH DEC could use animal by-products, including Cat 1 material (not allowed for any other use than combustion and energy recovery) as valuable raw material source without increasing the risk to human or animal health or the environment. For R&D and test operations, Cat 1 material could be replaced by Cat 3 material not being subject to the strict veterinary controls making it virtually impossible to receive test material from renderers.

In principle, facilities safely destroying organic components such as the Mephrec or ASH DEC reactors could process animal by-products and use them as a renewable energy and phosphate source. These materials are outstanding when used in thermal phosphate recovery processes. Some legal provisions, however, may prevent the use of these materials, e.g. the German fertiliser regulation prohibiting the mix of animal by-products and sewage sludge as starting materials. If using animal by-products as a fuel, ashes will unavoidably be mixed. Thus it is of high importance to consider the real potential and the high degree of safety (as high as combusting animal by-products in cement kilns, power plants or waste incineration plants) when regulations are reviewed. If possible, supportive measures should be introduced such as the obligation to recover the phosphates from such high value secondary source materials.

Regulation (EC) 1069/2009 facilitates the efficient management of animal by-products whilst maintaining the high level of protection that is currently in place against risks to public and animal health and to the environment. This Regulation shall apply to:

i. animal by-products and derived products which are not intended for human consumption;
ii. products intended for purposes other than human consumption:
    a. products of animal origin which may be destined for human consumption;
    b. raw materials for the production of products of animal origin.

This Regulation introduces the notion of an “end point” in the manufacturing of animal by-products, beyond which they are no longer subject to the rules governing this type of product, since potential risks have been eliminated. Instead, the general rules on product safety apply. As an example, where animal fat produced by an incinerating factory is processed and the product of that transformation is used to produce plastics, the probability that the final product might transmit a significant biological risk is very slight.

Products of animal origin may be used outside the food chain for various purposes: skins for leather production, powdered milk to feed animals, and blood products in diagnostic medical devices. Such by-products may be a vector of diseases affecting human beings or animals when they are used in animal feed or to produce technical products.

This Regulation preserves the basic guarantees introduced in 2003 against such risks. In particular, it maintains:

i. a risk-based categorisation of animal by-products which determines whether they may be used as animal feedingstuffs, for the manufacture of technical products or for other purposes, or whether they must be destroyed;
ii. an obligation for Member States and operators to ensure that animal by-products are collected and disposed of as soon as possible;
iii. the exclusion of products that are unfit for human consumption from the feed chain for farmed animals; and lastly
iv. a ban on feeding animals of one species with material derived from the same species ("intra-species recycling ban").
v. a more coherent legal framework

Animal by-products are used to produce cosmetics, medicines and diagnostic medical devices. When they are used for the manufacture of such products, they are subject to other provisions of European law. Slaughterhouses, milk factories and other food establishments manufacturing animal by-products are already bound by European legislation on human food or animal feeding stuffs, and are the subject of inspections in this regard.

This regulation aims at improving coherency between other provisions of European law and the health rules applying to animal by-products. The potential risks are tackled with respect to the appropriate legislation, which avoids operators being exposed to unnecessary constraints.

Being based on experience gained, this Regulation clarifies under which circumstances and in what way environmental legislation shall apply to operations involving animal by-products. This legislation applies for example where the spreading of manure as a fertiliser has effects on soil and the groundwater table.

The current categorisation of animal by-products may now be amended by the Commission under the comitology procedure. Prior to any change, a scientific organisation such as the European Food Safety Authority (EFSA) or the Scientific Committee for Consumer Products (SCCP) must assess the possible risks of a specific animal by-product for public and animal health.

5.2 European Directives Governing the Production Plant

Whereas regulations are self-executing, automatically enforced throughout the European Union and not requiring member states to take measures for implementation, EU directives lay down certain end results that must be achieved in every Member State. National authorities have to adapt their laws to meet these goals, but are free to decide how to do so. Even if directives include deadlines until which Member States have to implement them to their national legislation, some Member States fail to do so within the given timeframe. In general directives are used to bring different national laws into line with each other, and are particularly common in matters affecting the operation of the single market (e.g. product safety standards).

In every area governed by a European Directive, corporations must act in compliance with the corresponding national regulation representing the implementation of the directive. These national regulations may be stricter than the European Directive and contain additional provisions.

5.2.1 Directive on Industrial Emissions (IED/IPPC)

With the Directive 2010/75/EU the European Commission has adopted a new principle – a dynamic regulation trying to closely follow the technical development. In the context of P-REX, the IED Directive is relevant for all phosphate recovery technologies, with particular provisions for those combining energy and nutrient recovery from sewage sludge (Mephrec and ASH DEC), but also for wet chemical processes as proposed by BSH and MAP technologies.

The IED Directive brings together Directive 2008/1/EC (IPPC Directive) and six other directives in a single directive on industrial emissions.

5.2.1.1 Sectors of activity

This directive covers industrial activities with a major pollution potential, defined in Annex I to the directive (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, rearing of animals, etc.). Fertiliser production is listed in Annex I as well as waste processing. Thus it can be assumed that all phosphate recovery technologies are governed by this directive.

The Directive contains special provisions for the following installations:

i. combustion plants (≥ 50 MW);
ii. waste incineration or co-incineration plants;
iii. certain installations and activities using organic solvents;
iv. installations producing titanium dioxide.

This directive does not apply to research activities, development activities or the testing of new products and processes.

5.2.1.2 Environmental requirements

Any industrial installation which carries out the activities listed in Annex I to the directive must meet certain basic obligations:

i. preventive measures are taken against pollution;
ii. the best available techniques (BAT) are applied;
iii. no significant pollution is caused;
iv. waste is reduced, recycled or disposed of in the manner which creates least pollution;
v. energy efficiency is maximised;
vi. accidents are prevented and their impact limited;

vii. sites are remediated when the activities come to an end.

5.2.1.3 Application of best available techniques (BAT)

Industrial installations must use the best available techniques to achieve a high general level of protection of the environment as a whole, which are developed to a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions. The European Commission must adopt BAT conclusions containing the emission levels associated with the BAT. These conclusions shall serve as a reference for the drawing up of permit conditions.

5.2.1.4 Permit conditions

The (operating) permit must provide for the necessary measures to ensure compliance with the operator's basic obligations and environmental quality standards. These measures shall comprise at least:

i. emission limit values for polluting substances;
ii. rules guaranteeing protection of soil, water and air;
iii. waste monitoring and management measures;
iv. requirements concerning emission measurement methodology, frequency and evaluation procedure;
v. an obligation to inform the competent authority of the results of monitoring, at least annually;
vi. requirements concerning the maintenance and surveillance of soil and groundwater;
vii. measures relating to exceptional circumstances (leaks, malfunctions, momentary or definitive stoppages, etc.);
viii. provisions on the minimisation of long-distance or transboundary pollution;
ix. conditions for assessing compliance with the emission limit values.

5.2.1.5 Special provisions

Special provisions apply to combustion plants, waste incineration and co-incineration plants, installations using organic solvents and installations producing titanium dioxide.

The emission limit values for large combustion plants laid down in Annex V to the Directive are generally more stringent than those in Directive 2001/80/EC on large combustion plants A degree of flexibility (Transitional National Plan, limited life time derogation) shall be introduced for existing installations.

5.2.2 Environmental Impact Assessment Directive (EIA)

Directive 2011/92/EU of the European Parliament and the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, as amended, known as the "EIA" (environmental impact assessment) Directive, requires that an environmental assessment to be carried out by the competent national authority for certain projects which are likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location, before development consent is given. The projects may be proposed by a public or private person.

An assessment is obligatory for projects listed in Annex I of the Directive, which are considered as having significant effects on the environment. These projects include for example: long-distance railway lines, airports with a basic runaway length of 2100 m or more, motorways, express roads, roads of four lanes or more (of at least 10 km), waste disposal installations for hazardous waste, waste disposal installations for non-hazardous waste (with a capacity of more than 100 tonnes per day), waste water treatment plants (with a capacity exceeding 150 000 population equivalent).

Other projects, listed in Annex II of the Directive, are not automatically assessed: Member States can decide to subject them to an environmental impact assessment on a case-by-case basis or according to

thresholds or criteria (for example size), location (sensitive ecological areas in particular) and potential impact (surface affected, duration). The process of determining whether an environmental impact assessment is required for a project listed in Annex II is called screening. This particularly concerns for example the following projects: construction of railways and roads not included in Annex I, waste disposal installations and water treatment plants not including in Annex I, urban development projects, inland waterways, canalization and flood-relief works, changes or extensions of Annex I and II projects that may have adverse environmental effects.

The EIA Directive of 1985 has been amended three times, in 1997, in 2003 and in 2009:

- Directive 97/11/EC brought the Directive in line with the Espoo Convention on EIA in a Transboundary Context. The Directive of 1997 widened the scope of the EIA Directive by increasing the types of projects covered, and the number of projects requiring mandatory environmental impact assessment (Annex I). It also provided for new screening arrangements, including new screening criteria (at Annex III) for Annex II projects, and established minimum information requirements.
- Directive 2003/35/EC was seeking to align the provisions on public participation with the Aarhus Convention on public participation in decision-making and access to justice in environmental matters.
- Directive 2009/31/EC amended the Annexes I and II of the EIA Directive, by adding projects related to the transport, capture and storage of carbon dioxide (CO2).

The initial Directive of 1985 and its three amendments have been codified by Directive 2011/92/EU. The environmental impact assessment must identify the direct and indirect effects of a project on the following factors: human beings, the fauna, the flora, the soil, water, air, the climate, the landscape, the material assets and cultural heritage, as well as the interaction between these various elements.

The developer the (natural or legal) person who applied for development consent or the public authority which initiated the project) must provide the authority responsible for approving the project with the following information as a minimum: a description of the project (location, design and size); possible measures to reduce significant adverse effects; data required to assess the main effects of the project on the environment; the main alternatives considered by the developer and the main reasons for this choice; a non-technical summary of this information.

With due regard for rules and practices regarding commercial and industrial secrecy, this information must be made available to interested parties sufficiently early in the decision-making process:

- the competent environmental authorities likely to be consulted on the authorisation of the project;
- the public, by the appropriate means (including electronically) at the same time as information (in particular) on the procedure for approving the project, details of the authority responsible for approving or rejecting the project and the possibility of public participation in the approval procedure;
- other Member States, if the project is likely to have transboundary effects. Each Member State must make this information available to interested parties on its territory to enable them to express an opinion.

Reasonable time-limits must be provided for, allowing sufficient time for all the interested parties to participate in the environmental decision-making procedures and express their opinions. These opinions and the information gathered pursuant to consultations must be taken into account in the approval procedure.

At the end of the procedure, the following information must be made available to the public and transmitted to the other Member States concerned:

- the approval or rejection of the project and any conditions associated with it;
- the principal arguments upon which the decision was based after examination of the results of the public consultation, including information on the process of public participation;
- any measures to reduce the adverse effects of the project.

In accordance with national legislation, Member States must ensure that the interested parties can challenge the decision in court.

5.3 European Directives Governing Waste and Wastewater Management

5.3.1 Waste Framework Directive

Directive 2008/98/EC sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling and recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products.

The directive lays down some basic waste management principles: it requires that waste being managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odours and without adversely affecting the countryside or places of special interest. Waste legislation and policy of the EU Member States shall apply as a priority order the following waste management hierarchy:

i. Prevention (maintaining the product status)
ii. Preparing for re-use
iii. Recycling
iv. Recovery
v. Disposal

The directive introduces the "polluter pays principle" and the "extended producer responsibility". It incorporates provisions on hazardous waste and waste oils (old directives on hazardous waste and waste oils being repealed with the effect from 12 December 2010), and includes two new recycling and recovery targets to be achieved by 2020: 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households, and 70% preparing for re-use, recycling and other recovery of construction and demolition waste. The directive requires that Member States adopt waste management plans and waste prevention programs.

The relevance to P-REX is related to secondary waste from recovery and recycling activities and the “end-of-waste” criteria already explained under the REACH chapter. However, experience tells that different experts have different opinions about the “end-of-waste” status. Particularly in federal republics such as Germany, Switzerland and Austria where regional authorities are entitled to decide about the product or the waste status of a material, a corporation can get different decisions in different Federal States. However, the Waste Framework Directive cannot be blamed for the different interpretations because the criteria are quite clear, here being repeated because of their importance:

i. The substance or object is commonly used for specific purposes;
ii. A market or demand exists for such a substance or object;
iii. The substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
iv. The use of the substance or object will not lead to overall adverse environmental or human health impacts.

Reading these criteria, one should believe that a fertiliser being approved as such with a decree issued by a national authority, confirming that the product has no adverse impact on the environment or human health, should fully correspond to these criteria. However, in Austria one can get a positive judgement in one federal state and a negative one in the next state for the same product under the exactly same circumstances. Experiences and discussions in Germany and Switzerland show that the situation is not much different in these countries.

In addition, phosphate recycling activities have to comply with the WFD in terms of by-products and secondary waste – particularly wet chemical processes produce a large amount of waste (by-products) that has to be managed in line with the national legislation based on the Waste Framework Directive.

5.3.2 Landfill Directive

Directive 1991/31/EC is intended to prevent or reduce the adverse effects of the landfill of waste on the environment.

It defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land. Landfills are divided into three classes:

i. landfills for hazardous waste;
ii. landfills for non-hazardous waste;
iii. landfills for inert waste.

On the other hand, the Directive does not apply to:

i. the spreading on the soil of sludges (including sewage sludges and sludges resulting from dredging operations);
ii. the use in landfills of inert waste for redevelopment or restoration work;
iii. the deposit of unpolluted soil or of non-hazardous inert waste resulting from prospecting and extraction, treatment and storage of mineral resources as well as from the operation of quarries;
iv. the deposit of non-hazardous dredging sludges alongside small waterways from which they have been dredged and of non-hazardous sludges in surface water, including the bed and its subsoil.

A standard waste acceptance procedure is laid down so as to avoid any risks:

i. waste must be treated before being landfilled;
ii. hazardous waste within the meaning of the Directive must be assigned to a hazardous waste landfill;
iii. landfills for non-hazardous waste must be used for municipal waste and for non-hazardous waste;
iv. landfill sites for inert waste must be used only for inert waste.
v. The following wastes may not be accepted in a landfill:
vi. liquid waste;
vii. flammable waste;
viii. explosive or oxidising waste;
ix. hospital and other clinical waste which is infectious;
x. used tyres, with certain exceptions;
xi. any other type of waste which does not meet the acceptance criteria laid down in Annex II.

Further to this, the directive includes provisions for operating permits of landfills that is not further referred to in the context of this report.

In the context of P-REX the landfill directive may apply to secondary wastes as an effluent of recycling and recovery processes if they cannot be recycled. If this is the case, secondary wastes should comply with acceptance standards of waste landfills, if possible as an inert waste material to avoid elevated disposal costs.

5.3.3 Water Framework Directive

In summary, the directive requires that all surface and ground waters within defined river basin districts must reach at least 'good' status by 2015. It will do this for each river basin district by:

- Defining what is meant by 'good' status by setting environmental quality objectives for surface waters and groundwaters.
- Identifying in detail the characteristics of the river basin district, including the environmental impact of human activity.
- Assessing the present water quality in the river basin district.
- Undertaking an analysis of the significant water quality management issues.
- Identifying the pollution control measures required to achieve the environmental objectives.
- Consulting with interested parties about the pollution control measures, the costs involved and the benefits arising.
- Implementing the agreed control measures, monitoring the improvements in water quality and reviewing progress and revising water management plans to achieve the quality objectives.

In the context of P-REX, the Water Framework Directive is only of indirect relevance. The production of recycled phosphates should not have any impact on the quality of aquatic bodies being prevented by other regulations explained in this document. However, when using fertilisers this directive is relevant and it may be considered in the context of fertiliser solubilities and the application (use) recommendations being provided by the manufacturer.

5.3.4 Urban Wastewater Treatment Directive

Directive 91/271/EEC governs the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. Its aim is to protect the environment from any adverse effects caused by the discharge of waste waters.

Industrial waste water entering collecting systems and the disposal of waste water and sludge from urban waste water treatment plants are subject to regulations and/or specific authorisation by the competent authorities.

The directive establishes a timetable, which Member States must adhere to, for the provision of collection and treatment systems for urban waste water in agglomerations corresponding to the categories laid down in the directive. The main deadlines are as follows:

i. 31December 1998: all agglomerations of more than 10,000 "population equivalent" (p.e.) which discharge their effluent into sensitive areas must have a proper collection and treatment system;
ii. 31 December 2000: all agglomerations of more than 15,000 p.e. which do not discharge their effluent into a sensitive area must have a collection and treatment system which enables them to satisfy the requirements in Table 1 of Annex I;
iii. 31December 2005: all agglomerations of between 2,000 and 10,000 p.e. which discharge their effluent into sensitive areas, and all agglomerations of between 2,000 and 15,000 p.e. which do not discharge into such areas must have a collection and treatment system.

Annex II requires Member States to draw up lists of sensitive and less sensitive areas which receive the treated waters. These lists must be updated regularly.

The treatment of urban water is to be varied according to the sensitivity of the receiving waters.

The directive lays down specific requirements for discharges from certain industrial sectors of biodegradable industrial waste water not entering urban waste water treatment plants before discharge to receiving waters.

Member States are responsible for monitoring both discharges from treatment plants and the receiving waters. They must ensure that the competent national authorities publish a situation report every two years. This report must also be sent to the Commission.

Member States must set up national programmes for the implementation of this directive and must present them to the Commission.

For P-recycling this directive does not have direct impacts. The only (theoretical – because none of the P-REX partners being a representative of this technological approach) exception may be if phosphate recovery should be implemented as an end-of-pipe solution at the exit of a wastewater treatment plant. As long as the P-recovery facility is implemented in a side-stream of the wastewater treatment plant, the nutrient and pollutant concentrations in the effluent remain under the responsibility of the sewage plant operator.

5.3.5 Sewage Sludge Directive

The Sewage Sludge Directive 86/278/EEC seeks to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to prevent harmful effects on soil, vegetation, animals and man. To this end, it prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. Treated sludge is defined as having undergone "biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use". To provide protection against potential health risks from residual pathogens, sludge must not be applied to soil in which fruit and vegetable crops are growing or grown, or less than ten months before fruit and vegetable crops are to be harvested. Grazing animals must not be allowed access to grassland or forage land less than three weeks after the application of sludge. The directive also requires that sludge should be used in such a way that account is taken of the nutrient requirements of plants and that the quality of the soil and of the surface and groundwater is not impaired.

The directive specifies rules for the sampling and analysis of sludges and soils. It sets out requirements for the keeping of detailed records of the quantities of sludge produced, the quantities used in agriculture, the composition and properties of the sludge, the type of treatment and the sites where the sludge is used. Limit values for concentrations of heavy metals in sewage sludge intended for agricultural use and in sludge-treated soils are in Annexes I A, IB and IC of the directive.

Although at Community level the reuse of sludge accounts for about 40% of the overall sludge production, landfilling as well as incineration in some Member States are the most widely used disposal outlets despite their environmental drawbacks.

The text above, literally taken from the web-site of DG Environment, explicitly shows the preference of the European Commission towards the application of sludge despite the controversial discussions in some member states. In addition, regulators in Switzerland came apparently to the opposite conclusion that

spreading sludge on cropland, even if all prevention measures are taken, is too risky and thus is was forbidden from January 2006.

The European Commission is currently assessing whether the current Directive should be reviewed – and if so, the extent of this review. For example, Directive 86/278/EEC sets limit values for seven heavy metals. Since its adoption, several Member States, including Germany, have enacted and implemented stricter limit values for heavy metals and set requirements for other contaminants. The current heavy metal limits as depicted in are independent of the nutrient concentration and so generous that virtually all municipal sewage sludges can be used on cropland. Two draft proposals to introduce much stricter limitations (Table 10).

Table 10: Limit values for heavy metal concentrations in sludge for use in agriculture in mg/kg dry matter

Parameter	Pb	Cd	Cr	Cu	Ni	Hg	Zn
EU Directive 86/278/EEC	750-1200	20-40	-	1000-1750	300-400	16-25	2000-4000
EU-draft Directive 2015	500	5	800	800	200	5	2000
EU-draft Directive 2025	200	2	600	600	100	2	1500

For its assessment, the European Commission has launched a study to gather existing information on the environmental, economic, and social as well as health impacts of present practices of sewage sludge use on land. This study will also assess the risks and opportunities that can be foreseen in coming years. The study identified possible options for European policy and estimated their costs and benefits. The Commission has chosen the consultancy team of Milieu Ltd, WRc PLC and RPA Ltd to undertake this study.

The study is available on the DG Environment web-site. It addresses the different sludge treatment options, the estimated development of sludge production in the EU27, the emissions of greenhouse gases as a result of the different treatment options as well as the risks and benefits of sludge spreading to cropland without coming to a determined recommendation.

In the context of the revision process of the Sewage Sludge Directive it has been found that further information are urgently needed about the presence of emerging pollutants in the sewage sludge which could contaminate terrestrial and aquatic environment when the sludge is used in agriculture. Therefore the Commission has dedicated one of the FATE series monitoring projects (monitoring of the fate and impact of pollutants on the terrestrial/aquatic interface) to the sewage sludge. The goal of this exercise is to gain an European-wide snapshot on the occurrence and concentration levels of "classical" inorganic and organic contaminants such as heavy metals, PCBs, PCDD/Fs, and PAHs, but also on less investigated emerging compounds such as, for instance, brominated flame retardants, ingredients of personal care products, pharmaceuticals, some industrial chemicals, etc. in sewage sludge (FATE SEES) and treated bio-waste (FATE COMES).

The DG Environment together with DG Joint Research Centre has organized a workshop summarizing the results of FATE-SEES component which took place in Brussels on 6 June 2012. The presentation of results was followed by presentations of some Member States experience when setting limits for contaminants in sewage sludge. All presentations and a number of additional studies are available on the DG Environment web-site.

Although most studies and presentations come to the conclusion that the risk of spreading manure on cropland is under control, most researchers admit that there are significant gaps of knowledge. It is impossible to know and analyse all organic substances being present in sludge. Most European Member States pursuing an “agricultural use of sewage sludge” policy have imposed much stricter limits than the European Sewage Sludge Directive and have started to monitor and control selected organic compounds. Doing this, significant concentrations of pollutants have been detected that had been neglected in the past, for instance polycyclic musk compounds.

P-REX participants pursuing the use of sludge on cropland should closely monitor the ongoing developments and participate in the national initiatives driving the national legislation. An unanimous European position towards sludge use practices is not foreseeable. All in all, more and stricter regulations are expected in the participating member states.

6 Czech Republic

6.1 Czech Republic

In Czech Republic more than 30'000 tons of phosphorus is used in form of fertilizers. Czech Republic does not have any phosphorus resources and is dependent on imports. Currently there is no legislation which will support P-recycling. There is legislation concerning direct sludge application, but conditions are quite strict, so this possibility is not used very often. This report gives an overview of the current legislation, which has to be taken into account before application of any p-recycling technology. Influence of social factors can be seen in Annex A

6.1.1 Chemicals

Table 11 gives an overview with a short description on legislations which apply to chemicals in Czech Republic.

Table 11: Legislations on chemicals in the Czech Republic

Number	Title	Enforcement	Content
Act 350/2011	on chemical substances and mixtures, and amending certain laws (chemical act	1.1.2012	This Act transposes the relevant EU regulations , follows directly applicable EC regulations about production, classification, testing hazardous properties, packaging, labelling, placing on the market, use, export and import of chemicals
Ordinance 402/2011	on assessment of the hazardous properties of chemical substances and mixtures and packaging and labelling of dangerous chemical compounds	1.1.2012 - 31.12.2015	General procedures for evaluating the hazardous properties of the substance, methods of testing of hazardous substances, conditions of packaging of hazardous substances
Government regulation 295/2011	on method for risk assessment of environmental damage and further conditions of financial security	1.1.2012	This regulation refers to act 167/2008 on the prevention of environmental damage. And set up the conditions for facilities dealing with wastewater to have made the risk assessment for prevention of environmental damage

At a European level the basis for the production, marketing, use and labelling of chemicals (substances, mixtures and preparations) is provided by EC Regulation 1272/2008 and EC Regulation 1907/2006. This is concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), established by the European Chemicals Agency (ECHA). Among others these regulations are supplemented by the Czech Act 350/2011 on chemical substances and mixtures, amending certain laws and by Government Regulation 295/2011 on the method of assessment of the risks of environmental damage and further conditions of financial security. Additional information is provided by Ordinance 402/2011 on assessment of the hazardous properties of chemical substances and mixtures and packaging and labelling of dangerous chemical compounds. This ordinance will be effective by May 31, 2015.

Labelling (CLP) is governed by Act 350/2011 until 2015. From 2015 to 2017 it will be possible to label both under Act 350/2011 and by EC Regulation 1272/2008. After 2017 it is only possible to label under EC Regulation 1272/2008.

6.1.2 Wastewater regulation ¨

Table 12 gives an overview on the wastewater regulations in the Czech Republic.

Table 12: Regulations on wastewater in the Czech Republic

Number	Title	Enforcement	Content
Act 185/2001	Waste act	1.1.2002	Regulates obligations in the management with selected products, wastes and devices (including sludge); defines sludge management obligations at WWTPs.
Act 254/2001	Water act	1.1.2002	Establishes the obligation to make wastewater harmless if discharged into surface water or groundwater
Ordinance 61/2003 as amended by ordinance 23/2011	On the indicators and values of permissible pollution of surface water and wastewater, requirements for permits to discharge wastewater into surface water and sewerage systems and sensitive areas	1.3.2003/4.3.2011	Establishes emission limits and conditions of wastewater discharge
Ordinance 382/2001	On conditions of use of treated sludge on agricultural land	2.12.2011	Established conditions for using sludge on agricultural land

6.1.2.1 Act 185/2001 - Waste Act

Act 185/2001 regulates "obligations in the management with selected products, wastes and devices; defines sludge management obligations at WWTPs".

6.1.2.2 Responsibilities resulting from Waste Act

The Waste Act deals with requirements for utilization of waste on soil according to the waste law and it’s implementing regulations.

Conversion, reprocessing or other ways of waste management with expected phosphorus content which will be utilized for straight application on soil or through technology that is subject to responsibilities and requirements stated in the Waste Act and its implementing regulations. The definition of waste is stated in §3 of the Act. This law says that "waste is every moveable property, which human wants to be deprived of or has an intention or responsibility to get rid of."

Recently two more subsequent definitions were involved in the Waste Act: side product (§3 of the Act, paragraph 5) and end of waste (§3 of the Act, paragraph 6). These definitions are described in detailed way in the Act. Unclear situation prevails in REACH Regulation 1907/2006 regarding treated waste. The regulation is based on pure chemicals. Three prescription in the form of regulation related to transition

from waste to non-waste have been issued by European Commission yet, i.e. directly applicable in the Member States of EU. The next prescription, related to biologically degradable group of waste, which sludge from wastewater treatment plant are included in, is already in the process of preparation. Regulations for transition from waste to non-waste, its composition and transboundary transport is expected to be clearly given after it is published.

The §2 Scope of the Act has a connection with waste usage. It is noted there, that the Act relates to all waste handling, with these exceptions:

"Excavated sediments from water reservoirs and watercourses, where the owner has demonstrated that they comply with pollution limits for their use for filling underground areas and land surface modifications set out in Schedule 9 to the Act, and sediments from water reservoirs and watercourses used on agricultural land under special legislation (Act 334/1992, the protection of agricultural land, as amended. Act 156/1998 on Fertilizers)".

This means that the sediments that lie underneath the boundary value and characteristics listed in Annex 9 of the Act do not fall under the obligations set out in the Waste Act.

The basic duty of the originator and the beneficiary is the classification of waste under the Waste Catalogue (§ 5). Another duty of the classification of waste is done by category (§ 6). At the moment management is very important especially in connection with the inclusion of the catalogue of waste. Although the waste is classified by catalogue number as others, it is necessary to examine its true nature. An example may be sludge from a municipal wastewater treatment plant, which is simply classified as non-hazardous waste). After verification the hazardous properties, which are mostly identified as dangerous property "infectivity", the waste it has to be classified as a hazardous waste. Act in Chapter II. states "the basic duties related to hazardous properties verification". "The process of elimination of dangerous properties itself" is specified in Ordinance 376/2001 Coll., in the classification of hazardous waste properties. It may be considered how to manage the waste after completing basic tasks leading to the knowledge of the actual characteristics of the waste. Material use is a preferred method, where the use on land belongs to. These are the following ways:

- Application on agricultural land
- Use of waste on the ground surface
- Use of biologically degradable waste on specified areas

6.1.2.3 Implementing regulations to the Act on Waste - Use on the land

This Act is concerned with sludge from municipal wastewater treatment plants by application on land (Ordinance 382/2001, in the case of the other sludge, it is necessary to appeal on elimination of hazardous properties (Ordinance 376/2001).

Terrain surface application of other wastes is regulated in Ordinance 294/2005. Quality requirements for land application of compost or digestate are defined in Ordinance 341/2008.

6.1.2.4 Ordinance 382/2001 Conditions of use of treated sludge on agricultural land

This regulation implemented EU Directive 86/278/EEC from 12. 6. 1986 because of the protection of the environment and especially the soil, when sewage sludge has agriculture applications. The directive describes the application of suitable sludge on land. The requirements of the directive have been tightened by Czech regulation on the monitoring of selected organic contaminants and microorganisms.

"The quality of the sludge has to be monitored based on indicators and limits" is stated in the Ordinance. "The duty to monitor the phosphorus content in sludge and soil" is also stated in this legal regulation. Biogenic elements only need to be monitored in the case of sludge that is directly applied to the agricultural land. Sludge that is treated in some way before usage on land is processed according to different prescription. Requirements in the decree on processing sludge use is important from the perspective of the producer responsibility for waste sludge quality

6.1.2.5 Environmental protection in the case of handling waste, including reprocessing waste or other materials containing phosphorus.

Most activities affect water quality in some way. For the production, processing or other tasks an important rule is the Government Regulation 61/2003, which regulates "indicators and limits for surface water and wastewater permissible pollution, the necessities of permissions for wastewater discharge into surface waters and sewers and sensitive areas".

This prescription conceptually defines "the types of water pollution sources, emission standards and limits" as well as lists with "all monitored indicators and values of permissible pollution".

Government Regulation 295/2011 on the method of risk assessment of environmental damage and further conditions of financial security determines the method of risk assessment of environmental damage, assessment criteria of sufficient financial backing and detailed conditions of implementation and the way of financial security to undertake preventive measures and corrective measures. The requirements of this regulation should provide funds e.g. for the possible removal of the detected contamination. A risk assessment and validity for individual operations is specified in the regulation.

6.1.2.6 Act 254/2001 - Water Act

Act 254/2001 water act establishes "the obligation to make wastewater harmless if discharged into surface water or groundwater".

6.1.2.7 Ordinance 61/2003 as amended by Ordinance 23/2011

Ordinance 61/2003 as amended by Ordinance 23/2011 describes the indicators and values of permissible pollution of surface water and wastewater, requirements for permits to discharge wastewater into surface water and sewerage systems and sensitive areas.

The ordinance establishes emission limits and conditions of wastewater discharge. The concentration of phosphorus is monitored and regulated in wastewater treatment plant above 2000 population equivalents.

6.1.2.8 Municipal wastewater

An overview of all emissions standards concerning municipal wastewater, is shown in Table 13.

Table 13: (1a) Emission standards: admissible values (p) 3),maximum admissible values (m).4) average values 5) concentration of indicators of pollution of discharged wastewater in mg/L

Capacity of WWTP (PE)[1)]	COD_{Cr}		BOD_5		TSS		$N\text{-}NH_4^+$		N_{total}[2), 7),8)]		P_{total}	
	p[3)]	m [4)]	p[3)]	m [4)]	p[3)]	m[4)]	p[5)]	m [4),6)]	average [5)]	m [4),6)]	average [5)]	m [4)]
< 500[1)]											-	-
500 - 2 000	125	180	30	60	35	70	-	-	-	-	-	-
2001 - 10 000	120	170	25	50	30	60	15	30	-		3[8)]	8[8)]
10 001 - 100 000	90	130	20	40	25	50	-	-	15	20	2	6
> 100 000	75	125	15	30	20	40	-	-	10	20	1	3

1) Category of WWTP expressed in population equivalent. Population equivalent is defined by production of pollution 60 g BOD_5 per day. Number of population equivalent is counted from maximum weekly average inlet to WWTP during a year, except of unusual situation, pouring rain and floods.
2) Total nitrogen is an indicator, which includes all forms of nitrogen.
3) Admissible values "p" are not arithmetic average per year and may be exceeded in permitted extent.
4) Maximum admissible values "m" must not be exceeded.
5) Values are arithmetic average per year and must not be exceeded.
6) Value is valid for the period in which temperature of discharged wastewater is above 12 °C.
7) Requirements for nitrogen can be controlled by daily average, if it guarantees the same level of water protection. In this case the daily average must not exceed 20 mg/L of total nitrogen in all samples, if the temperature of discharged wastewater is equal or above 12 °C.
8) This emission limit is set for WWTP with technology for phosphorus removal

6.1.3 Fertilizer law and regulation

In the Czech Republic fertiliser regulations do not support phosphate recycling. Table 14 lists the regulations which have to be complied with in order to place new products on the market.

Table 14: Regulations on Fertilizer in the Czech Republic

Number	Title	Enforcement	Content
Act 156/1998	Fertilizer act	1.9.1998	Sets out conditions for fertilizer launch to the market, storage conditions of fertilizers, soil conditioners, supplementary plant preparations and substrates; conditions for agrochemical testing of agricultural land; conditions for testing of soil character of forest land and some conditions for treated sludge application; conditions for launching on the market, storing and using of sediments, conditions of notification/registration of fertilizers. Also defines supervisory authorities.
Ordinance 274/1998	on storing and method of use of fertilizer	30.11.1998	Regulates methods of storage of different type of fertilizer and method of use (e.g. fertilizer must not be directly discharged into groundwater. Also defines the condition to keep records of fertilizer use. Annex 4 to this Ordinance is form for mandatory reporting on the use of treated sludge, this report is mandatory for agricultural entrepreneurs.
Ordinance 474/2000	On requirements for fertilizers	1.1.2001	Regulates the limits of hazardous elements in fertilizers Regulates the tolerance of measured values of content of nutrients from the declared values Defines types of fertilizers including their composition, production method, minimum content of nutrients, etc.

6.1.3.1 Act 156/1998 - Fertilizer act

Type of product needs has to be defined:

Act 156/1998 sets out conditions for fertilizer launches to the market, storage conditions of fertilizers, soil conditioners, supplementary plant preparations and substrates; conditions for agrochemical testing of agricultural land; conditions for testing of soil character of forest land and some conditions for treated sludge application; conditions for launching on the market, storing and using of sediments. It also defines supervisory authorities (Central Control and Testing Institute of Agriculture) referred to by "institute" below.

There are two options how to place fertilizers on the market:

- Notification of fertilizers and soil conditioner.
- Distributors, importers or suppliers, who are about to launch fertilizers or soil conditioners (which corresponds to the type specified in the decree) on the market are obliged to send notification to the institute before launching products on the market in the Czech Republic
- Registration of fertilizers
- The institute decides on the registration of a fertilizer on request of a distributor, importer or supplier. The application for registration shall contain name and type of the fertilizer and its composition, scope and way of fertilizer application and conditions for storage, etc. It is mandatory to provide samples to the Institute for testing, while applying for registration. The institute will perform professional analysis of the fertilizer. The decision on registration is valid for 5 years and the application for renewal must be submitted no later than six months before the registration expires. Registered fertilizers are listed in the list of fertilizers managed by the institute. It is forbidden to use words ecological and biological for labelling of fertilizers (including abbreviations eco and bio)

There are some additional regulations which have to be compiled and taken into account when willing to produce new fertilizers.

- Ordinance 274/1998 and Ordinance 474/2000 supplement the Fertilizer act. Ordinance 274/1998 regulates methods of storage of different types of fertilizer and methods of its use (e.g. fertilizer must not be directly discharged into groundwater and also defines the condition to keep records of fertilizer use. Annex 4 to this Ordinance is a form for mandatory reporting on the use of treated sludge, a report mandatory for agricultural entrepreneurs. Ordinance 474/2000 regulates the limits of hazardous elements in fertilizers and defines type of fertilizers. See limit values below.
- Limit values for fertilizers with phosphorus component
- Mineral fertilizers with phosphorus component where the mass fraction of the total phosphorus as P_2O_5 is 5% or more

mg/kg of fertilizer, soil conditioner, supplemental plant product				
cadmium	lead	mercury	arsenic	chromium
100	10	1.0	10	50

- mineral fertilizers with phosphorus component where the mass fraction of the total phosphorus as P_2O_5 is less than 5%, other mineral fertilizers which do not content phosphorus, soil conditioners and supplemental plant products:

mg/kg P_2O_5	**mg/kg of fertilizer**			
cadmium	lead	mercury	arsenic	chromium
50	15	1.0	10	150

6.1.4 Soil and chemical input to the soil

One way how to recycle phosphorus is the direct use of sediments and sludge on agricultural land. Requirements on sediments and sludge use are set out in ordinances below.

6.1.4.1 Ordinance 257/2009

Sediment application on agricultural land

The ordinance regulates the conditions and methods of use of sediments on agricultural land, the method of keeping records on application of sediments, limit values of hazardous elements and hazardous substances (Table 15) in sediment and soil where is it applied, requirements of other physico-chemical and biological characteristics of soil and sediment, and soil analysis procedures, including sampling methods.

Table 15: Limit values of hazardous elements and hazardous substances in sediment (mg/kg of dry matter)

Number	Indicator	Limit value
1	As	30
2	Be	5
3	Cd	1
4	Co	30
5	Cr	200
6	Cu	100
7	Hg	0.8
8	Ni	80
9	Pb	100
10	V	180
11	Zn	300
12	BTEX	0.4
13	PAHs	6
14	PCB	0.2
15	hydrocarbons C_{10} - C_{40}	300
16	DDT including metabolites	0.1

6.1.4.2 Ordinance 382/2001

This Ordinance describes conditions for application of treated sludge on agricultural land.

Most of the sludge in the Czech Republic is landfilled or composted, because of strict requirements on direct usage.

Concentration of hazardous elements both in soil and sludge has to be analysed and observed before sludge application. Limiting values can be found in Table16 Table17 and Table18. Treated sludge can be used on agricultural land under the following conditions:

- Sludge has to be incorporated into the soil within 48 hours after its placement onto the soil
- The need to supply nutrients to the soil on the land designated for placement of sludge have to be documented by analyses of agrochemical soil characteristics defined in the registration list of sludge in agriculture according to Annex 1;
- It is not allowed to use more than 5 t of sludge dry matter per hectare during 3 consecutive years. This amount may be increased up to 10 t of dry matter of sludge during 5 consecutive years, if the applied sludge contains less than half of the quantity limit of each hazardous substances and elements. Proper dose of dry matter is calculated from the nitrogen content. The dose of nitrogen supplied by the sludge must not exceed 70% of the total amount of nitrogen required for crop fertilization. Sludge dose (amount and duration of use) is governed by the requirement of plant nutrients with regard to the accessible nutrients and organic component in the soil, as well as the site conditions;
- The dose of sludge determined under the conditions referred to in paragraph c) needs to be applied to the land in one agrotechnical operation and in one continuous period of time under favourable physical and humidity conditions;
- The minimum content of dry matter of sludge is 5%, when it is applied by ploughshare applicator; the minimum content of dry matter of sludge is 18%, when it is applied by mechanical spreader
- The producer of the sludge has to write a program for using sludge on agricultural land, this program must contain:
    - evaluation of sludge regarding its use on agricultural land
    - a list of selected areas for sludge application, including indicators for their evaluation
    - the hydrological conditions in the area of sludge application
    - use of sludge in crop rotation
    - proposal for sludge and soil monitoring
    - plan for sampling
    - measures for protection of the health during working with sludge

Table16: Limit values of concentration of elements in soil

Hazardous element	Limit values of concentration of elements in soil (mg/kg of dry matter)	
	Common soil	Sands, loamy sands, gravel sands
As	20	15
Cd	0.5	0.4
Cr	90	55
Cu	60	45
Hg	0.3	0.3
Ni	50	45
Pb	60	55
Zn	120	105

Table17: Limit values of concentration in sludge

Hazardous substance	Limit values of concentration in sludge (in mg/kgTSS)
As	30
Cd	5
Cr	200
Cu	500
Hg	4
Ni	100
Pb	200
Zn	2500
AOX	500
PCB (sum of 6 congeners – 28+52+101+138+153+180)	0.6

Table18: Microbiological conditions for sludge use on agricultural land

Category of sludge	Permissible values of microorganisms in 1 g TSS of applied sludge		
	thermotolerant coli-	*Enterococci*	*Salmonella sp.*
I.	< 103	< 103	negative detection
II.	103 - 106	103 - 106	negative detection

Explanation: Category I – Sludge which can be generally applied to the agriculture lands Category II – Sludge which can be applied to the agriculture lands for technical plants. Regulates the sampling procedures of sludge and soil and methods of analysis of sludge and soil

6.1.5 Regulation governing the manufacturing facility

Another import part in the legislation is the regulation governing the manufacturing facilities. Some regulations can be seen in Table 19.

Table 19: Regulation governing the manufacturing facilitiy

Act 201/2012	On air protection	1.9.2012	This Act implements Directive 2010/75/EU on Industrial emissions. Regulates admissible levels of pollution and air pollution. Sets up the method of assessing acceptable levels of pollution and air pollution and their evaluation
Act 100/2001 as amended	On environmental impact assessment	1.1.2013	Defines conditions of assessment the impacts on public health and the effects on the environment, including impacts on animal species and plants, ecosystems, soil, rock environment, water, air, climate and landscape, natural resources, property and cultural heritage, as defined by specific legal regulations.
Government regulation 272/2011	On health protection from the adverse effects of noise and vibration	1.11.2011	Regulates hygienic limits of noise and vibration. Sets out method of measurement and assessment of noise and vibration for day and night time.

6.1.5.1 Act 201/2012 on air protection (implements Directive 2010/75/EU on Industrial Emissions)

Under this act air protection means “the prevention of air pollution and reducing the level of pollution in order to reduce the risks to human health caused by air pollution, reduce environmental load by substances transferred in the air and damaging ecosystems and create conditions for the regeneration of the environment affected by atmospheric pollution”.

This Act transposes the relevant EU legislation and regulates,

- permitted levels of pollution and air pollution,
- method of assessing acceptable levels of pollution and air pollution and their evaluation

The emission limits can be found below in Table 20.

Table 20: Emission limits and permitted number of exceeds per calendar year

Emission limits and permitted number of exceeds per calendar year			
Pollutant	Time of average	Immission limit	Maximum number of exceeds
Sulphur dioxide	1 hour	350 µg/m^3	24
Sulphur dioxide	24 hours	125 µg/m^3	3
Nitrogen dioxide	1 hour	200 µg/m^3	18
Nitrogen dioxide	1 calendar year	40 µg/m^3	0
Carbon monooxide	Maximum daily eight hours average	10 µg/m^3	0
Benzene	1 calendar year	5 µg/m^3	0
Particles PM10	24 hours	50 µg/m^3	35
Particles PM10	1 calendar year	40 µg/m^3	0
Particles PM2,5	1 calendar year	25 µg/m^3	0
Lead	1 calendar year	0,5 µg/m^3	0

Emission limits must be met at every chimney flues or exhaust in the air. Emission limits are divided into:

General emission limits set out in an implementing regulation for pollutants

Specific emission limits set out the implementing legislation or authorization according to § 11

Regional Office permits operation of a stationary source listed in Annex 2 to this Act (Table 20).

Table 21: Annex 2- Stationary sources

	Type of stationary sources	A	B	C
2.6	Wastewater treatment plants; equipment for operation of technologies producing wastewater more than 50 m^3/day			x
6.18	Fertilizer production plant	X		x

Legend: Column A – dispersion study is required; Column B - compensatory measures are required; Column C - operating procedure as part of the permit of operation is required

Specific emission limits will be set out for stationary sources.

In the Act 100/2001 as amended on environmental impact assessment are set out the conditions on assessment of the impact on the environment and on public health.

There were assessed impacts on public health and environmental impacts, including impacts on flora and fauna, ecosystems, soil, rock environment, water, air, climate and landscape, natural resources, property and cultural heritage, as defined by specific acts and their interaction and context.

In Annex 1 to this Act are listed:

- projects always subject to assessment
    - WWTP above 100 000 PE
    - Production plants for biocides, pesticides and industrial fertilizers
- projects requiring screening procedure
    - WWTP from 10 000 PE to 100 000 PE

6.1.5.2 Government regulation 272/2011 on health protection from the adverse effects of noise and vibration

This regulation implements decree to Act 258/2000 on protection of public health and sets out the hygienic limits of noise outside and inside of buildings. There are different limits for noise from different sources of noise and for different areas (protected outside area, protected outside area of buildings, protected area inside buildings).

In Government decree 268/2009 on technical requirements for buildings are set out under this condition:

Any building has to ensure, that noise and vibration, which affect people and animals, were on the level that does not threaten health, ensure quiet night and is suitable for environments people or animals, and even to neighboring land and buildings.

6.1.5.3 Conclusion

Phosphorus recycling from waste water can be achieved in many ways. The simplest method is the application of quality sludge from wastewater treatment plants on land. However, this option is not widely used in Czech Republic due to very strict requirements on the sludge content. Another option is to use processed organic waste (compost) which fulfils the requested quality as a fertilizers. A significant way

may be to extract phosphorus from waste by processing technologies, which comply with requirements of relevant legislation which is the obligation arising from the Waste Act mentioned above. Evaluation of the product composition may depend on the further use. If used as a fertilizer, the requirements of the Fertilizer Act and supplementing Ordinances apply. As the current legal framework is designed for conventional fertilizers, hurdles for recycling fertilizers are identified as e.g. limit values arbitrarily tailored to conventional fertilizers. For example limits for Cd are 10 times higher than for Pb because Cd concentrations are high in most phosphate rocks. Future limits should be mainly based on exposure and health assessments and to a lesser extent on the concentrations in raw materials.

7 Germany

The next part of this report is concerned with legal issues and topics in Germany. A Table of laws and regulations applied in Germany can be found in Annex B.

7.1 Legislation Governing the Production Plant

The Directive on Industrial Emissions 2010/75/EU has been implemented in Germany by the Act on the Prevention of Harmful Effects on the Environment caused by Air Pollution, Noise, Vibration and Similar Phenomena (Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge), in short Federal Immission Control Act (Bundes-Immissionschutz-Gesetz BImSchG, 15.03.1974) and its implementing and administrative regulations.

7.1.1 Federal Immission Control Act (BImSchG)

The purpose of this Act is to protect human beings, animals and plants, soil, water, the atmosphere as well as cultural objects and other material goods against any harmful effects on the environment and to prevent the emergence of any such effects.

In the case of installations subject to an operational permit, including chemical and fertiliser manufacturing plants, this Act shall also

- ensure integrated prevention and control of any harmful effects on the environment caused by emissions to air, water and soil by securing the participation of the waste management sector in order to achieve a high level of protection for the environment as a whole and
- ensure protection and the taking of precautions against any hazards, significant disadvantages and significant nuisances caused in any other way.

Some plants, including those producing chemicals and fertilisers are not only subject to approval under planning regulations, but also require immission control approval in accordance with Section 4 BImSchG. A full list of these plants is given in the regulation on plants requiring approval (4th BImSchV). The operator's responsibilities set out in Section 5 BImSchG apply to plants requiring immission control approval. This states that such plants must be constructed and operated in such a way that no environmental damage from gaseous emissions, liquid effluents and noise can be caused, and that precautions are taken to prevent any harm to the environment.

The operator's responsibilities set out in Section 22 BImSchG apply to plants not requiring immission control approval. This states that these plants must be constructed and operated in such a way that environmental damage from gaseous emissions, liquid effluents and noise is prevented, where the state of technology allows; any unavoidable environmental impact must be kept to a minimum.

The immission control standards for assessing noise immissions from plants are laid down in the Sixth General Administrative Regulation to the Federal Immission Control Act (Technical instructions on protection against noise – TA Lärm, 26.08.1998), based on Section 48 BImSchG.

The following implementing regulations at federal state level shall be observed if and when applying for a construction and operational permit for a fertiliser manufacturing plant, including plants to recover or recycle phosphates from wastewater and its downstream products.

7.1.2 Technical Instructions on Air Quality Control (1. BImSchVwV, TA Luft)

The Technical Instructions on Air Quality Control (TA Luft) are the instrument for German national authorities to control air pollution. They contain provisions to protect citizens from unacceptably high pollutant emissions from installations as well as requirements to prevent adverse effects on the environment. In addition, it lays down emissions limit values for relevant air pollutants from installations. Existing installations must also be upgraded to the best available technology.

The provisions of TA Luft govern the proceedings of applications for a permit to construct and operate a new installation or to alter the location, nature or operation of an existing installation, if no specific requirements are set in other relevant regulations of the Federal Immission Control Act. Phosphate recycling plants may be subject to the provisions of TA Luft but authorities tend to apply the much stricter limits of 17th BImSchV (for waste incineration plants), at least for thermal processes.

7.1.3 Technical Instructions on Noise Abatement (6. BImSchVwV, TA Lärm)

The Federal Immission Control Act and the Technical Instructions on Noise Abatement (TA Lärm) are the German instruments for protecting the population from noise from commercial activities. In line with this legislation, licenses for the operation of industrial or commercial installations are only issued if there are no adverse effects on the environment due to noise.

According to Section 6 BImSchG (the Federal Immission Control Act), a permit may be granted for a plant requiring immission control approval where it can be shown that the obligations arising from Section5 BImSchG, including those relating to protection against noise, have been met. The licensing procedure satisfies the requirements of the European Industrial Emissions Directive.

In practice, noise emission limits are set by the German Federal State Authorities when a corporation files and application for a permit. Whereas general limits are stipulated in the TA-Lärm, regulators may apply stricter limits in the context of the actual application because of, for instance, accumulation of noise emitting installations (Table 22).

Table 22: Guiding noise immission limits according to Technical Instructions on Noise Abatement in Germany

Noise immission limits outside of buildings	
In industrial areas	70 dB(A)
In commercial areas,	
day	65 dB(A)
night	50 db(A)
In core areas, village areas and mixed areas	
day	60 dB(A)
night	45 dB(A)
In general living areas and small settling areas	
day	55 dB(A)
night	40 dB(A)
In pure living areas	
day	50 dB(A)
night	35 dB(A)
In SPA areas, hospital areas and recreational areas	
day	45 dB(A)
night	35 dB(A)
Singular, short time noise peaks must not exceed the stipulated immission limits by 30 dB(A) during the day and by 20 dB(A) during the night.	

7.1.4 Fourth Regulation on Installations Requiring a Permit (Verordnung über genehmigungsbedürftige Anlagen, 4. BImSchV, 24.07.1985)

Plants listed in Annex I of the Regulation on installations requiring a permit (4th BImSchV) require immission control approval before they can be built and operated (Sections 4, 6 BImSchG). These include combustion facilities, chemical (including fertiliser) or agricultural plants.

Along with the BImSchG, the regulation laying down the approval procedure (9th BImSchV) must be observed by the regulating authorities. The 9th BImSchV also determines if and when an Environmental Impact Assessment (Umweltverträglichkeitsprüfung) has to be performed. In the case of applying for a permit for a fertiliser plant (including a plant recycling phosphates to fertilisers) an Environmental Impact Assessment is not mandatory but may be required by the Federal State authorities responsible for the operating permit. The relevant clause is called “examination in the individual case” (Prüfung im Einzelfall) and the applicant may ask to perform this examination upfront of a licensing procedure or during the licensing procedure.

The Federal States are responsible for implementing the approval procedure. If an existing plant is to be modified, the change must be notified (Section 15 BImSchG); in some cases, this change may also require approval, which must be granted before the change is made (Section 16 BImSchG). Even where no special approval is required for a specific plant, air and noise immission control requirements still have to be met (Sections 22 ff. BImSchG) in compliance with the 1st BImSchV (TA-Luft) and the 6th BImSchV (TA-Lärm).

Experience teaches that German federal state regulating authorities tend to apply the 4th BImSchV to phosphate recycling plants. It is thus treated in the same way as a chemical fertiliser plant. Gaseous emissions will, however, be governed by the 17th BImSchV, the regulation for incineration facilities (at least as long as thermal processes are applied but probability is high that all recycling plants will be governed by this regulation). Environmental authorities usually want to see the strictest regulations applied to new technologies and probably they are right because it would not make much sense to prevent phosphate depletion by using an environmentally harmful technology. There is no guarantee that lower limit value may be set by federal state regulation authorities for a new facility recycling phosphates from waste.

7.1.5 Seventeenth Regulation on Waste Incineration Facilities (Verordnung über Abfallverbrennungsanlagen, 17. BImSchV, 23.11.1990)

The Regulation on Incineration Plants and other Combustible Substances establishes a limitation of air emissions and further appropriate conditions for combustion in waste incineration and co-incineration plants. It was changed on 14.08.2003. The regulation fixes the conditions for the incineration of solid and liquid waste and other substances which are not regular fuel according to the 4th BImSchV. Having regard to the potential hazardous waste, the 17th BImSchV requires more stringent conditions concerning the limitation of air emissions, the operation and monitoring of waste incinerators and co-combustion plants Table 23.

Table 23: Current gaseous emission limit values (17th BImSchV) for incineration plants in Germany in mg/Nm³ dry

Emission limit values	Daily average value	Half hour average value	Average value over sample taking period
Total particle content	10	30	
Organic matter, as C total	10	20	
Gaseous inorganic chlorine compounds, as HCl	10	60	
Gaseous inorganic fluorine compounds, as HF	1	4	
Sulphur dioxide and sulphur trioxide, as SO_2	50	200	
Nitrogen monoxide and dioxide, as NO_2	200	400	
Mercury and its compounds, as Hg	0.03	0.05	
Carbon monoxide, as CO	50	100	
Cd and TI and their compounds, as Cd and TI total			0.05
Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn and their compounds			0.5
As, B(a)P, Cd and their compounds			0.05
Dioxins/Furans as sum acc. to Annex I as TEQ in ng/Nm³ dry			0.1

In addition to rather rigid limit values, 17th BImSchV requires continuous monitoring of the emissions. Continuous monitoring is not a problem but makes rather expensive equipment necessary.

The 17th BImSchV is most relevant for thermal processes such as the Mephrec and the ASH DEC technologies, wet chemical processes will have to cope with the wastewater and waste regulations. The quality of wastewater being discharged into public sewers by specified industries is governed by the German Waste Water Regulation (AbwV).

7.1.6 Regulation on Requirements for the Discharge of Waste Water into Waters

(Waste Water Regulation – AbwV, 17.06.2004) Activities liable to cause lasting or significantly harmful changes to the physical, chemical or biological composition of the groundwater are considered to requiring a permit. These also include safety measures in plants that handle substances harmful to water.

The Waste Water Regulation (AbwV) determines the minimum requirements needing to be considered if a permit is given to discharge waste water into water bodies from discharging sources as listed in the annexes to the regulation.

Annex 22 determines the requirements to the chemical industry:

7.1.7 Scope of application

(1) This Appendix shall apply to waste water originating primarily from the production of substances using chemical, biochemical or physical techniques, including the related pre-treatment, intermediate treatment and after-treatment.

(2) This Appendix shall not apply to waste water discharges of less than 10 m^3 per day. Furthermore, this Appendix shall not apply to waste water originating in production of soda or of potash fertilisers.

(3) For waste water derived from formulation (i.e. the manufacture of substances and preparations by blending, dissolving or bottling) which is discharged without being blended with other waste water falling under the scope of application of this Appendix, only Part B of this Appendix shall apply. Part B shall apply to the site of waste-water origin.

7.1.8 General requirements

The contaminant load shall be kept as low as the following measures permit, after investigation of the situation in each individual case:

- Use of water-saving techniques, such as counter-current washing
- Multiple use and recirculation, e.g. with washing and purifying processes
- Indirect cooling, e.g. to cool vapour phases instead of using jet condensers or jet coolers.
- The use of waste water-free techniques to generate vacuums and for waste air purification
- The retention or recovery of substances via the preparation of mother liquor and by means of optimised techniques
- The use of low-pollutant raw and auxiliary materials.

Proof of compliance with the general requirements shall be furnished in the form of a waste water register.

7.1.9 Requirements for waste water at the point of discharge

The following requirements apply to the waste water at the point of discharge into the water body:

1. Chemical oxygen demand (COD)

For waste water flows COD concentration of which at the site of occurrence of waste water is

a) more than 50,000 mg/l, a COD concentration of 2,500 mg/l shall apply
b) more than 750 mg/l, a COD concentration equivalent to a 90% reduction in COD shall apply
c) 750 mg/l or less, a COD concentration of 75 mg/l shall apply
d) less than 75 mg/l, the actual COD concentration at the site of occurrence shall apply.

The requirements shall also be deemed to have been met provided a COD concentration of 75 mg/l in the qualified random sample or 2-hour composite sample is adhered to, with due regard for Part B.

2. Total nitrogen as the sum of ammonia, nitrite and nitrate nitrogen (Ntot) 50 mg/l in the qualified random sample or 2-hour composite sample.

A higher concentration of up to 75 mg/l may be specified in the water discharge licence, provided a 75 % reduction in the nitrogen load is adhered to. The set value shall also be deemed to have been met, provided the level defined as "total bonded nitrogen (TNb)" is adhered to.

3. Total phosphorous 2 mg/l in the qualified random sample or 2-hour composite sample.

This requirement shall also be deemed to have been met provided the level defined as "phosphorous compounds as total phosphorous" is adhered to.

4. Toxicity

Toxicity to fish eggs Tegg = 2

Toxicity to daphnia TD = 8

Toxicity to algae TA = 16

Toxicity to luminescent bacteria TL = 32

Mutagenic potential (umu test) TM = 1.5

The requirements refer to the qualified random sample or the 2-hour composite sample.

(2) If process-integrated measures are applied to reduce the COD load by arrangement with the water authority, then the decisive load prior to implementation of the measure shall be used as a basis.

(3) For chemical oxygen demand (COD), the total load in 0.5 or 2 hours shall be limited in the water discharge licence. The total load is the sum of the individual loads from the individual waste water flows. The total load which must not be exceeded refers to the concentration in the qualified random sample or 2-hour random sample and the volumetric flow of waste water in 0.5 or 2 hours corresponding to sampling.

7.1.10 Requirements for waste water prior to blending

The following requirements apply to waste water prior to blending with other waste water:

1. Adsorbable organic halogens (AOX)

   a) Waste water from the manufacture of epichlorhydrin, propylene oxide and butylene oxide: 3 mg/l

   b) Waste water from the two-stage manufacture of acetaldehyde : 80 g/t

   c) Waste water from the single-stage manufacture of acetaldehyde : 30 g/t

   d) Waste water from the manufacture of AOX-relevant organic colorants and aromatic intermediate products, where these are predominantly used to manufacture organic colorants : 8 mg/l

   e) Waste water from the manufacture of AOX-relevant active pharmaceutical ingredients :8 mg/l

   f) Waste water from the manufacture of C1 chlorinated hydrocarbons by means of methane chlorination and methanol esterification, and of carbon tetrachloride and perchloroethane by means of perchlorination: 10 g/t

g) Waste water from the manufacture of 1,2 dichloroethane (EDC), including further processing to vinyl chloride (VC): 2 g/t

The load level refers to the production capacity for purified EDC. The capacity should be specified with due regard for the EDC portion which is not cracked in the VC unit linked to the EDC production unit and which is returned to the production cycle in the EDC purification plant.

h) Waste water from the manufacture of polyvinyl chloride (PVC) : 5 g/t

i) Waste water flows with an AOX concentration of more than 0.1 mg/l and less than 1 mg/l without targeted measures: 0.3 mg/l

j) Waste water flows from the manufacturing, further processing and application of substances which are not separately regulated elsewhere with a concentration of more than 1 mg/l is exceeded or less than 1 mg/l via targeted measures: 1 mg/l or 20 g/t

The load level refers to the capacity of the organic target products. It does not apply to the application of substances.

2. Other substances can be seen in Table 24.

Table 24: Other limits of substances which are required for waste water before blending

	Qualified random sample or 2-hour composite sample mg/l	
	I	II
Mercury	0.05	0.001
Cadmium	0.2	0.005
Copper	0.5	0.1
Nickel	0.5	0.05
Lead	0.5	0.05
Total chromium	0.5	0.05
Zinc	2	0.2
Tin	2	0.2

The requirements in column I apply to waste water flows from the manufacturing, further processing or application of these substances. The requirements in column II refer to waste water flows not originating from the manufacturing, further processing or application of these substances but which are nevertheless contaminated with such substances below the concentration levels in column I.

(2) Upon compliance with the AOX requirements and the general requirements pursuant to Part B, the requirements of Appendix 48, part 10 shall also be deemed to have been met.

(3) The AOX requirements shall not apply to iodo-organic substances in waste water from the manufacturing and bottling of X-ray contrast media. (4) For adsorbable organic halogens (AOX) and the substances limited in paragraph (1), number 2 above, the total load per parameter in 0.5 or 2 hours shall be limited in the water discharge license. The respective total load is derived from the sum of the individual loads of the separate waste water flows. The total load which must not be exceeded refers to the concentration in the qualified random sample or 2-hour composite sample and the volumetric flow of waste water in 0.5 or 2 hours corresponding to sampling.

(5) A waste water flow may only be blended with other waste water, subject to the furnishing of proof that the load of total organically bonded carbon (TOC) in this waste water flow ascertained for the site of occurrence is reduced by 80 % overall. This requirement shall not apply where the residual TOC load discharged from the respective waste water flow into water bodies does not exceed 20 kilograms per day or 300 kilograms per year or 1 kilogram per tonne of production capacity of the organic target product. When proving the reduction in load, in the case of physico-chemical waste water treatment plants, the TOC elimination level of such plants shall be used as a basis, whereas in the case of biological waste water treatment plants, the result of a study pertaining to number 407 of the Annex to Article 4 shall be used as a basis.

7.1.11 Requirements on the waste water at the site of occurrence

(1) For chromium VI, a concentration of 0.1 mg/l in the random sample shall be adhered to.

(2) For volatile organically bonded halogens, a concentration of 10 mg/l in the random sample shall be adhered to. This requirement shall be deemed to have been met, provided it is achieved prior to the inlet into a sewage system without prior risk of leakage losses and without the waste water having been diluted.

In order for standards to be met, the corresponding legal limits need to be monitored regularly. For that reason, comprehensive self-monitoring obligations are imposed on the enterprises. In addition, the water authorities make unannounced inspections at irregular intervals. At the same time, random tests are performed to see whether the results of self-monitoring are reliable. If a company does not observe the legal limits, it faces fines and penal consequences. Furthermore, it is in the dischargers' own interest to meet the nationwide uniform, state-of-the-art standards, since the wastewater charge increases by a multiple if the standards are not met.

Under the devolution of competences laid down in the German constitution, water management is a matter for the Federal States. This means that the legal implementation of water management procedures is left to each of the 16 Federal States. The practical and judicial competences may therefore vary from one federal state to another. In particular, it is up to the individual Federal States to decide which authorities should be responsible for implementing the Water Management Act, what procedures should be followed (including the involvement of the general public) and what means should be used to enforce the laws. The Federal States can also determine whether applications must be submitted within specified deadlines and how long the proceedings should last.

Regulations on the discharge of industrial wastewater are at least as strict and usually costly to meet as regulations on the gaseous emissions. Engineers of thermal processes usually try to avoid having to cope with wastewater regulations by designing a wastewater free process. In most cases it is economically beneficial to accept a lower energy yield and to dry the liquid effluents instead of discharging them. Wet processes don't have that choice.

7.2 Legislation Governing Waste and Wastewater Management

7.2.1 Act for Promotion of a Closed Substance Cycle Economy (Kreislaufwirtschaftsgesetz KrWG, 29.02.2012)

Avoidance - recovery - disposal. This is the principle of the waste hierarchy which is the basis for waste management in Germany.

The German government wants to develop waste and closed cycle management into a sustainable resource-efficient materials flow management over the next years. By strictly separating wastes, through pre-treatment, recycling and the recovery of energy, Germany aims to make full use of substances and materials bound in wastes and therefore make landfilling of wastes superfluous. Significant ecological progress was made with the entry into force of the ban on landfilling untreated household wastes or general waste from industry on 1 June 2005.

Product responsibility is at the heart of waste management policy in Germany. It puts the idea into practice that waste avoidance is best achieved by holding the generator of waste responsible. This way, producers and distributors must design their products in such a way as to reduce waste occurrence and allow environmentally sound recovery and disposal of the residual substances, both in the production of the goods and in their subsequent use. The legal bases for this are the Act for Promoting Closed Substance Cycle Economy and Ensuring Environmentally Compatible Waste Disposal and the Federal Immission Control Act.

The general provisions contained in the Act are set out in more concrete terms in a number of ordinances. In particular, these include the provisions on extended producer responsibility (for packaging, batteries, end-of-life vehicles, waste oil, electrical and electronic appliances). The statutory requirements governing the environmentally compatible recovery of waste are specified by the Ordinance on Biowaste, the Commercial Waste Ordinance, the Waste Wood Ordinance or the Ordinance on Underground Waste Stowage, while the requirements governing the environmentally compatible disposal of waste are specified by the Landfill Ordinance in particular.

Environmental policy is based on: the precautionary principle, the polluter pays principle and the principle of co-operation. These principles are reflected in extended producer responsibility, which the manufacturer and seller of a specific commodity bear. As producers of a commodity they are required to consider the environmental impacts and possible risks of a product during its entire lifecycle (precaution). In collaboration with the other parties involved – producers, distributors, consumers, disposal and recycling companies, as well as government offices (cooperation) – the producer is required to create a system which minimises the adverse environmental impacts and maximises the recovery of resources (recycling, reuse).

For that reason, waste management policy in Germany centres at the concept of extended producer responsibility. In this way, even during the production phase, the foundations are laid for the effective and environmentally compatible prevention and recovery of waste. Manufacturers and distributors must design their products in such a way as to minimise the amount of waste produced during manufacturing and subsequent use, so as to focus on high-quality and comprehensive recovery of waste, and, finally, to facilitate ecofriendly removal of those components of the waste which can no longer be reused.

Part 1 of the Act largely determines the wastes being subject to this regulation and defines the notions used in the Act. It contains the “end-of-waste” definition, largely the same as in the corresponding EU-Directive explained earlier in this document.

In addition, the difference between waste and by-product is defined whereby by-product refers to a substance or article that is

- Further used
- Not needing a pre-treatment exceeding the usual industrial processing

- Manufactured as an integrated part of an industrial process
- The intended use being lawful and in compliance with all regulations for the protection of human and animal health as well as the environment.

Part 2 is dedicated to the definition of the waste hierarchy and the obligations of producers and owners of waste, including public waste management corporations. In section 2 of part 2, the principles of the closed substance cycle economy are explained. One of these principles is that valuation is prioritized in comparison to disposal, as long as the protection of human health and the environment is safeguarded. Mixing of waste is prohibited – apart from some exceptions. If waste has been mixed it has to be separated again, if technically possible and economically reasonable.

One can easily interpret these paragraphs in a way that phosphate recycling is obligatory – but the notions about the technical feasibility and the economic reasonableness gives room for alternative opinions as long as no industrial plants are available. However, within this framework it is easily possible to introduce an obligation to phosphate recycling, if it is politically desired.

Paragraph 11 of section 2 contains the regulations concerning bio-waste and sewage sludge with regard to the mandatory separate collection (bio-waste) and the cautiously "recommended" recycling of sewage sludge. However, there is a strong focus on quality management and risk abatement.

Section 3 determines the obligations with regard to waste disposal. Section 4 regulates the duties of public waste management companies.

Part 3 deals with the product stewardship. The corresponding paragraphs explain how the producer of a substance or an article is responsible to contribute to the targets of the closed cycle economy. This section can also be seen as a milestone because it introduces far reaching responsibilities of the producer with regard to closing substance cycles. Similar to the above mentioned obligations to recycling, the wording determines rather principles without defining real life obligations. However, one can easily figure out the direction of the political intentions.

Part 4 determines the obligations of the national and Federal State authorities with regard to waste management planning and the permission of waste management facilities. It also reiterates the polluter pays principle providing detailed regulations on who bears the cost of waste management measures.

Parts 5, 6, 7, 8 and 9 deal with controlling, regulations for waste management companies, regulations for waste management organisation within corporations and regulations on penalties.

Annex 1 determines waste disposal processes, Annex 2 defines valuation processes and Annex 3 regulates the criteria to determine the state-of-the-art and Annex 4 gives examples of measures that can assist in avoiding waste.

7.2.2 Commercial Waste Ordinance (GewAbfV, 19.06.2002)

The Commercial Waste Ordinance of 2002 stipulates that commercial municipal waste and certain construction and demolition waste should be stored separately if at all possible and that as much commercial waste should be recovered as possible.

In accordance with the Ordinance on Environmentally Compatible Storage of Waste of 2001, as of 1 June 2005 it is prohibited to landfill untreated bio-degradable wastes. The residual wastes that arise from households and industry are to be treated in a way which prevents biological conversion processes from occurring in landfills. This presupposes that the residual waste is pre-treated by thermal or high-end me-

chanical-biological methods. Such pre-treatment turns fermenting, rotting and foul-smelling residues into slag or a substance resembling soil which is no longer harmful to the environment.

Germany thus goes far beyond the goal set in the EU's Landfill Directive, which envisages reducing to 35% the volume of biodegradable municipal waste deposited – but not until 2016.

By 2020 as much municipal waste as possible is to be recovered in Germany and the number of above-ground landfills for recyclable materials is to be further reduced. In order to achieve that goal, among other things, residual waste processing procedures need to be developed so that only such sub-stances are produced that do not need to be stored but can be recycled, thus conserving raw materials.

7.2.3 Landfill Ordinance (DepV, 27.04.2009)

The Landfill Ordinance of 2009, which transposed the EU Landfill Directive into German law, sets out legally binding, high standards for landfill sites depending on the type of waste deposited there and the concomitant risks for the environment. By 2009 at the latest all landfill sites must fulfil these require-ments. Those landfills which are incapable of meeting the requirements have been closed.

The Landfill Ordinance requires that especially hazardous waste be disposed of below ground in deep salt mines. This ensures that such waste and the pollutants it contains will be permanently sealed from the biosphere.

The 2009 Landfill Ordinance also contains provisions governing the conditions under which waste may be used as substitute construction materials in above-ground landfills. Comparable regulations were in-troduced for underground waste processing in the Underground Waste Stowage Ordinance, which came into effect in 2002.

7.2.4 Regulation on the Environmental Impact Assessment (UVPG, 12.02.1990)

The UVPG of Germany describes the standing of the Environmental Impact Assessment (EIA) in Part 1, article 2, paragraph 1: *The environmental impact assessment is a depending part of regulatory proceed-ings aiming at the decision on the permissibility of installations. If the decision on the installation is based on multiple proceedings, all part assessments of these proceedings will be condensed into a total assessment of all environmental impacts.* This limits the scope and relevance of the EIA significantly: It aims to assess environmental impacts, but the results of the EI will only contribute the clearance decision. Furthermore, the insights derived from the EIA will be only one of several proceedings contributing to the clearance decision. The relevant authorities have an obligation to take the result of the EIA into consid-eration for the final decision; however, a negative outcome of the EIA does not necessarily mean that the project will be stopped. The German EIA is not a legally binding instrument and will be reviewed in combination with other assessments, surveys and opinions.

Another important aspect of the German UVPG is the role that the German Federal States play. This is demonstrated in the screening decisions, which are – under certain conditions - made on the regional lev-el: *The Federal States regulate by size- or performance values, by a general or location related pre-assessment of the individual case or by a combination of these proceedings under which conditions an environmental impact assessment is performed (article 3).* In article 4, the UVPG is submitted by subsidi-arity to other national and regional laws: *This regulation applies as far as national or federal state regu-lations do not more precisely determine the environmental impact assessment or do not comply with this regulation in their requirements. Regulations with more advanced requirements remain untouched.* The UVPG therefore defines minimum standards similar to the EIA directive; nevertheless, it does not lead to

a legally binding, single proceeding in the way EIAs are done elsewhere. This weakens the importance of the EIA significantly and gave rise to criticism as well as a wide-spread mocking in Germany.

Nevertheless, the UVPG has led to significant simplifications in project clearance procedures and in effect, it does help to reduce several individual proceedings into a single, centralised one. This, however, applies only in some cases and is arranged through the section in article 2 quoted above; as well as the combination of sub-proceedings for a final report (required according to article 11) and by defining one authority as the main one to decrease the bureaucratic efforts involved (article 14): *Does an installation need permits from multiple Federal State authorities, Federal States determine one authority in charge. The authority in charge must perform its tasks in cooperation with – at least – the licensing authorities and the nature conservation authority, whose areas of competences are relevant to the installation.* This authority in charge has to provide for the orchestration of individual sub-proceedings.

In practice, EIPs are rather time consuming proceedings having the potential to delay a project for one or even more years, depending on the public perception of the project. It needs thorough preparation, extensive information of stakeholders and may cause significant expenses because of the necessary involvements of external experts, particularly for a start-up company. As mentioned above, phosphate recycling plant proposers have to proceed with a pre-assessment of the individual case leading to the decision if an EIA is needed or not. If a company performs the pre-assessment upfront of the licensing proceeding, it gets the decision before starting the comprehensive proceedings, but it loses time from the beginning. If the proposer performs the pre-assessment during the licensing proceeding, he may be facing additional requirements coming up during the proceeding. The decision is difficult.

7.3 German regulations governing direct sludge application

7.3.1 Ordinance on Biowaste (BioAbfV, 21.09.1998)

The Ordinance on Biowaste (Bioabfallverordnung) regulates untreated and treated biowaste and biowaste mixtures intended for use as fertiliser on agricultural, silvicultural and horticultural applications on soils as well as the treatment and assessment of such biowaste and biowaste mixtures.

It ensures that only biodegradable waste with low pollutant content is utilised as a fertiliser or soil improver after composting or fermentation. The aim is to eliminate the accumulation of pollutants in the soil. In addition, composted or fermented and subsequently composted biowaste is an important source of humus.

Biodegradable substances must be collected separately if they are to be turned into biowaste composts and fermentation residues with low levels of pollutants. If farmers were to use composted waste as a fertiliser, up to 10% of mineral fertilisers could be replaced. Around nine million tonnes of bio-waste is currently collected separately as green waste or via the bio-bin in Germany each year and processed into compost and fermentation residues. An average of around 50% of the population in Germany collects biowaste using bio-bins. A study conducted on behalf of the Federal Environment Ministry (BMU) found that the collection of biowaste can still be improved significantly. In response, the draft Act amending the Closed Substance Cycle and Waste Management Act provides for the introduction, from January 2015 onwards, of separate biowaste collection across the entire territory of the country. The details of such a scheme can be stipulated by statutory ordinance. The German government – together with the governments of Austria, Spain, Portugal and eight other countries – is committed to the creation of a European regulatory regime governing biowaste. According to a proposal put forward by the German Federal Envi-

ronment Ministry, there is also to be a transitional phase across Europe after which only biodegradable waste from separate collection may be used in the manufacture of compost fertilisers. In addition, minimum requirements are to be imposed on pollutants and foreign materials in compost.

The supplemented and amended EU Waste Framework Directive strengthens biowaste recovery by introducing a specific provision (Article 22). Under this, the member states are to promote the separate collection and environmentally sound recovery of biowaste. Moreover, the European Commission is called on to carry out an evaluation of environmental policy regarding bio-waste management and to formulate requirements upon biowaste treatment as well as quality standards for composts and fermentation residues.

7.3.2 Ordinance on Sewage Sludge (AbfklärV, 15.04.1992)

The German Sewage Sludge Regulation governs the use of sewage sludge in agriculture and horticulture on a national level. It defines

- Limit values for pollutants
- Requirements for application
- Requirements for documentation
- Requirements for the analysis

Additionally provisions under fertiliser law apply, following the strategy that eventually all substances aiming at plant nutrition and soil improvement in Germany will be governed by the fertiliser regulation.

During the current 17th parliamentary term the Federal Environment Ministry aims to amend the Sewage Ordinance of 1992 in order to better safeguard the interests of precautionary soil protection.

7.3.3 Inorganic pollutants

Table 25: Limits for heavy metals (in mg/kg) in German sewage sludge (source DWA)

Parameter	Pb	Cd	Cr	Cu	Ni	Hg	Zn
Proposed Sewage Sludge Regulation	120-150	2.5-3	100-200	700-850	80-100	1.6-2	1500-1800
Present Sewage Sludge Regulation	900	10	900	800	200	8	2500
EU Directive 86/278/EEC	750-1200	20-40	-	1000-1750	300-400	16-25	2000-4000
EU-draft Directive 2015	500	5	800	800	200	5	2000
EU-draft Directive 2025	200	2	600	600	100	2	1500

Table 25 shows that the current German regulation already sets much stricter limitations to heavy metal concentrations than the current EU-Directive. And a new regulation is under preparation setting lower limits for certain heavy metals, particularly for the those pollutants that cannot be considered as a trace nutrient or at least as a non-hazardous compound such as cadmium and lead. Compared to the present

fertiliser regulation, the limits are still high if considering the low nutrient values of sewage sludge and – consequently – the much higher application rates.

7.3.4 Organic pollutants

Limit values for PCBs, PCDD/Fs and AOX are defined in the German legislation on sewage sludge, however:

- A large number of substances is used in everyday life
- Information on hazards to human health and the environment is insufficient
- The number of organic pollutants that could be found in sewage sludge is huge (Table 26)
- Analysing all possible pollutants is not feasible
- Control of the organic pollutants by „separate collection“ as applied to biowaste is not possible
- For many substances it is not clear if they present a risk, which amount is a problem and how much can actually be found in sewage sludge

Table 26: Limits for organic pollutants (in mg/kg) in German sewage sludge (source DWA)

Parameter	PCB	PCDD/F	AOX	B(a)P	PFT
Proposed Sewage Sludge Regulation	0.1	30 ng	400	1	0.2-0.1
Present Sewage Sludge Regulation	0.2	100 ng	500	-	-

In a first effort to limit hazardous organic pollutants such as the carcinogenic PCBs (chlorinated diphenyls), PCDD/F (dioxins and furans), AOX (absorbable organic halogen compounds) have been included to the present sewage sludge regulation. Two more organic compounds are proposed for inclusion in the new regulation: B(a)P the highly carcinogenic and mutagenic Benzo(a)pyrene and PFT, perfluorinated tensides, a persistent pollutant with a largely unknown toxicity potential. A historical review of all those organic compounds that are now subject to regulation teaches that decades have passed from the first discovery to the assessment as pollutant and – finally – to the limitation of its production, use and up-take through the food and feed chain. One can easily figure out that a similar time span will pass until we will be aware of new hazardous substances being transferred to wastewater and sludge today. Consequently, all efforts for pre-caution and regulation will always be late and may be too late one day to prevent negative consequences for human health and the environment.

For this reason, some of the German Federal States (Bayern, Baden Württemberg, Berlin and Nordrhein Westfalen) are trying to put an end to the use of sludge on cropland. These Federal States try to avoid the use of sludge in agriculture and promote more sophisticated, safe methods for phosphate recovery as investigated in P-REX. Despite these efforts, Germany as a whole is not likely to stop the practice of spreading sewage sludge to cropland. The pressure leads, however, to increased risk awareness and more frequently review and tighten regulations.

7.4 Conclusion

The report shows that at least 20 regulations have to be considered at the European and the national level if planning a phosphate recycling project in Germany. There are far more regulations only governing peripheral areas of such an activity which have not been included in this document. For instance, health

and safety regulations governing building and operations of a recycling and fertiliser manufacturing plant have not been considered as well as regulations relevant for the actual production, management and trading of a business placing recycled fertilisers on the markets.

Most of the regulations are inspired by the high level of human health and environmental protection in Europe. Even if these regulations are perceived as a barrier to new businesses, it would not be appropriate to claim their softening or abolition.

Historically, these high levels of protection have supported large part of the waste management industry currently employing hundreds of thousands of people in the markets being investigated by P-REX. Within the framework of P-REX we can observe that those countries being at the forefront of more advanced and stricter waste management exhibit higher economic growth and employment rates.

The political challenge is to facilitate business development in favour of closed substance cycling economies without reducing or softening regulations and hampering the high levels of protection.

8 Spain

Phosphorus is an essential part of agriculture today. There are no substitutes for its application in animal feed and soil fertilizing. The shortage in the production and the losses at every step of the phosphorus cycle, contributes to concerns about future supplies and water and soil pollution, both in the EU and worldwide.

When there is no direct economic driving force, regulations can be a stimulating factor to improve the efficiency of the phosphorus life cycle and promote recycling. Unfortunately Spain has not adapted its fertilizer regulation to the efforts for phosphate recycling. The goal of this report is to present the laws that significantly affect the recycling process and also to provide background for the policy brief.

Spanish legislation, unlike other legislative bodies like the German or Austrian, has no specific laws or provisions that regulate the process of direct use of sewage sludge on agricultural land. Nor has the EU-level legislation. There are, however, European regulations on chemicals and fertilizer products, among which are the products obtained from phosphorus, whether organic or inorganic, simple or compound. The European directives directly applicable in Spain and all EU countries regulate the characteristics, composition and fertilizer use.

This report will analyze the way in which European directives and regulations have been transposed into the Spanish law, and in some cases developed by lower-level legislative bodies, as in the case of some regulations developed by the Autonomous Communities (Spanish regions).

This report will also analyze legislation that deals with the treatment plant construction, location, operation, technical and safety requirements, etc. In this case it will also be referred to the European Directive and the Spanish rule that incorporates it. The laws applied in Spain can be found in Annex C.

On another note, Spain announced in 2009 national objectives for phosphorus recovery[1] for recycling from sewage. The analysis will show that these objectives are quite ambitious. Unfortunately the government didn't establish appropriate means for monitoring compliance with these objectives. The legal fragmentation involving autonomous communities hinders comparison of actual data with the objectives. In addition to this, sewage sludge is applied to soils without a previous complete and specific characterization, because is time consuming and expensive and because current Spanish regulations permit sewage sludge use in agriculture with only one analysis of all parameters of sewage sludge every six months in spite of the variability of the different parameters of the sludge.

The provisions contained in the National Waste Plan 2007-2015 (PNIR) are a mere recital of the wishes of the legislature. Lacking funds and control mechanisms these provisions are empty of content, leaving compliance to be decided by autonomous regions, municipalities and private companies.

There are some questions that remain unanswered. To the known problems inherent to any study in Spain (dispersion of administrative responsibilities, multiplicity of responsible institutions) must be added the tension that exists nowadays between the national authorities and some autonomous regions, like Cataluña and the Basque Country.

[1] in the frame of the Plan Nacional Integrado de Residuos (PNIR) 2008 - 2015

8.1 Brief notes on the methodology followed in the writing of this report

The main sources of information for the preparation of this report are both Spanish legislative and European Union collections in the field of fertilizers and other issues relevant for the P -REX project such as recycling infrastructure regulations or rules implementing sewage sludge in agriculture.

The document contains several excerpts from laws translated into English from Spanish, in which all Spanish laws are written. Considering that the aim of this paper is simply to present the features of the Spanish legal system with regard to the use of sewage sludge there have been avoided those considerations that are not relevant. For these reasons we cannot assert that there has been made a literal and complete translation of the legal principles analyzed. The working process has implied doing a selection of those parts most relevant to the project, which have been translated.

As there are not literal translations we cannot use the resource to present it as if it were a direct quote , and we have chosen to present these texts in italics.

8.2 Spanish regulations governing the product

8.2.1 Chemicals

The basis for the production, marketing, use and labeling of **chemicals** (substances, mixtures and preparations) is provided at the European level by Regulation (EC) 1907/2006 (REACH Regulation[2]) and Regulation (EC) 1272/2008 (the CLP Regulation), supplemented in Spain by:

- Real Decreto 1802/2008, de 3 de Noviembre, by amending the Regulation on notification of new substances and classification, packaging and labeling of dangerous substances, approved by Real Decreto 363/1995, de 10 de Marzo, in order to align its provisions with REACH.
- Real Decreto 363/1995, de 10 de Marzo, by approving the Regulation on notification of new substances and classification, packaging and labeling of dangerous substances.
- Real Decreto 255/2003, de 28 de Febrero by approving the Regulation on classification, packaging and labelling of dangerous preparations and correction of errors in Real Decreto 255/2003.

Consequentially, legal obligations as explained under chapter 1 of this document apply to manufacturers and importers of chemical products, including fertilizers, in Spain. In the context of phosphorus recycling, following the guidelines of ECHA and the national contact points will safeguard compliance with Spanish chemical regulations.

8.3 Law enforcement and control in Spain

Regulation (EC) No 1907/2006 of 18 December 2006 concerning the registration, evaluation, authorization and restriction of chemical substances and mixtures (REACH), establishing the new European policy on marketing of chemicals with the clear objective of ensuring a high level of protection of human health and the environment, as well as free movement within the internal market of substances on their own, in mixtures or in articles, and enhance competitiveness while and innovation, also pretending to promote

[2] REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. This Regulation (EC) 1907/2006 is a key part of the EU's endeavor to make the use of chemicals safer.

alternative methods for assessing the hazards of chemicals. Moreover, the Regulation (EC) No 1272/2008, of December 16, 2008 on classification, labeling and packaging of substances and mixtures, establishes new criteria to adapt the Community scheme of classification, labeling and packaging of substances and mixtures the United Nations (GHS, GHS). To ensure compliance with the obligations arising from these EU regulations, they impose on the Member States to adopt effective measures for monitoring and control, and to establish a system of penalties for violations and to take all necessary measures to ensure its application.

The National Gazette has published the "Ley 8/2010, de 31 de marzo", establishing the system of penalties provided by the Regulations (EC) concerning the registration, evaluation, authorization and restriction of chemical substances and mixtures (REACH) and on the classification, labeling and packaging of substances and mixtures (CLP), which modifies and provides, together with the system of exchange of information between the central and regional administrations, regulations-on these materials, lists of offenses resulting from either typing and grading penalties. However, the sanctions regime relating to the classification, labeling and packaging of substances shall not apply until December 1, 2010, and applicable to mixtures shall apply only from the June 1, 2015.

This law provides protection for the public health, workers and the environment by discouraging manufacturers, importers or companies using chemical substances and mixtures, from breaching its obligations under the REACH and CLP regulations. Such punitive system is an essential tool to prevent unfair competition between companies.

The law provides for substantial penalties depending on the severity of the consequences and the circumstances of the offenses committed, with fines of up to EUR 1.2 million. Moreover, in the most serious cases the penalty could include the temporary closure of the facilities.

Frequent situations like suppliers not delivering data sheets security1 (FDS) to users, or labels that are not updated, are subject to punishment, so that workers can have the opportunity to report these facts to the labor and health inspectors.

This also corresponds to the autonomous regions to establish the division of responsibilities between different government bodies (health, environment, industry, work, etc.) regarding monitoring, inspection and control. However, today the regions have not developed this policy and therefore it is still not very clear what administrative body must intervene in the event that an infringement has occurred.

The Directorate General Inspectorate of Labour and Social Security and the regional labor authorities are responsible for enforcing this law by health inspectors. These inspectorates should have prepared their legal and technical criteria. The autonomous regions need to develop own standards and distributing skills. Where to obtain the financial resources to organize or strengthen its inspection system is a matter that the law does not resolve.

8.3.1 Tips for the recycler

The fact that fertilizers have their own regulation, does not imply that they are exempted from REACH. If the raw materials are mixed without any chemical reaction, the users of these substances should be considered as downstream users, if the provider is originally from the European Union.

If the provider is not in the EU and does not have a unique representative within the EU to register substances, the company that manufactures fertilizers would be considered importer to the REACH and should pre-register / register the imported substances.

If the provider - non-member of the EC- does not appoint a unique representative in the EU which registers substances, the manufacturer of fertilizers should act as an intermediate user.

8.4 Fertilizers

The agricultural soil is an inestimable and limited resource. The irreversible degradation of this resource supposes not only destroying the most valued good of the farmers, but mortgaging the agricultural opportunities of future generations. For this reason, the protection of the soil constitutes a priority target, to guarantee its fertility and its agronomic, present and future value.

The introduction of new products that contain nutrients for the plants and fertilizer capacity must be controlled, taking into account the health and safety of people and environment. Therefore the use of new ingredients in fertilizers is regulated, so that they do not have possible harmful effects in water, soil, flora, fauna and human being.

8.4.1 European regulations and its transposition to the Spanish Law

The European Union approved in 2003 the Regulation EC 2003/2003 of the European Parliament and of the Council relative to the fertilizers, and the Regulation EC 1774/2002 of the European Parliament and of the Council, by which the sanitary norms applicable to the animal by-products not destined for the human consumption are established, forcing Member states to modify its regulation on fertilizer products.

The first of the community dispositions, referred exclusively to the «fertilizers CE», gathers in one normative the previous legislation and repeals certain instructions that were containing it. Likewise, it declares the free circulation of the «fertilizers CE» and fixes a series of common dispositions on its composition, identification, labeling and packaging.

Also, the Regulation EC 2003/2003 foresees that there exists Member states who complement its development in certain aspects, such as the expression of the contents in main and secondary nutrients; the possibility of prohibiting the circulation and sale of potentially dangerous fertilizers for health and environment; the adoption of control measures to evaluate the quality of fertilizers; laboratory control authorization; the possibility of imposing validations and the determination of a sanctioning diet.

These aspects need to be regulated in a few cases by law and by different norms having a regulatory status.

The Fertilizer Regulation EC 2003/2003 and the Real Decreto 824/2005, on fertilizers are centered on exclusively defining the characteristics and prerequisites these products must fulfill. Only those products fullfilling the specifications indicated in the annexes I of both dispositions, can be used in agriculture as fertilizers or amendments. These laws regulate also its identification and labeling and establish the measurements for its control.

All products/fertilizers must fulfill three basic requirements:

- Contributing nutrients to the plants in an effective way (fertilizers) or improving soil properties (amend).

- To have suitable methods for taking samples and analysing them in order to be able to verify its composition and qualities.
- In normal use conditions, they do not to have harmful effects on health or environment.

8.5 **Real Decreto 824/2005**

The Real Decreto 824/2005 takes as its primary objective to establish the basic norm in Spain on products fertilizers, regulating concrete aspects of the Regulation (CE) nº 2003/2003. Its development was entrusted to the Member states. The Real Decreto 824/2005 is relevant for the recycler because it contains the definitions and concept of what fertilizers are, its identification and labeling, its protocols for being registered and controlled by the authorities. Moreover the Real Decreto 824/2005 establishes different categories and types of fertilizers and describe their characteristics and requirements to comply with the law. 21 fertilizers containing phosphorus that are defined by the law (Table 27-Table 36)

Other objectives of this Real Decreto are:

- To define and to typify the products/fertilizers, different from the “Fertilizers CE”; whose commercialization is allowed in Spain, especially fertilizers having an organic origin and all the amendments.
- To guarantee the contents and typical product properties protected by this regulation.

The Real Decreto 824/2005 begins with an explanatory preamble and consists of 7 chapters, which are detached in 33 articles, in addition to additional dispositions (5), transitory (2) and ends (3), and complements itself with 7 annexes.

Aspects emphasized from the regulation EC 2003/2003 and of the real decreto 824/2005:

As important aspects of both legislations it would be necessary to emphasize the following issues:

- A series of concepts are established with its definitions, such as:
    - Fertilizer or amendment.
    - Compost
    - Contents, composition and tolerances.
    - Norms and methods of analysis.
    - Manufacturer
- Identification and labelling of the authorized types of fertilizers.
- Specific regulation of some fertilizers
- Fertilizer products record creation with compulsory registration of the fertilizers and amendments that use organic matter in its manufacture.
- Establishment of a procedure to control, by the Autonomic and Central Administration, the normative texts in the Regulation (CE) and in the Real Decreto.
- Adaptation to the technical progress and to the advance in the scientific knowledge of both dispositions, by means of a Committee that is present at the Commission in the review of the Regulation and an Experts' Committee that advises the Government of Spain in the update of the Real Decreto.

CE fertilizers and other products (except those of compulsory registration in the Record) can be commercialized freely in Spain, if they have the contents and characteristics specified and are identified and labelled correctly.

The European and Spanish rules regulate the characteristics that the fertilizers and amendments must fulfill to be used in agriculture. Except for some special cases, general rules that limit or fix the doses do not exist.

Table 27: National inorganic fertilizers, Phosphatic

No..	**Type designation.**	**Information on production and essential components.**	**Minimum content of nutrients (percentage by weight).** **Information on assessment of nutrients.** **Other requirements**	**Other data on the type designation or labeling.**	**Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.**
1	Phosphoric acid	Product obtained by acid phosphate rock, like backbone containing orthophosphoric acid	- 40% P_2O_5 soluble in water. - Phosphorus in the form of phosphorus pentoxide (P_2O_5) of orthophosphoric acid		Phosphorus pentoxide (P_2O_5) water soluble

Table 28: Organic fertilizers, Phosphatic

No..	**Type designation.**	**Information on production and essential components.**	**Minimum content of nutrients (percentage by weight).** **Information on assessment of nutrients.** **Other requirements**	**Other data on the type designation or labeling.**	**Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.**
1	Organic fertilizer phosphate of animal origin	The solid product obtained by treatment of bone	- P_2O_5 25% Total	Minimum and maximum humidity	- P_2 O_5 Total - and K2O Total (if more than 1%)

Table 29: Organic fertilizers NPK

No..	Type designation.	Information on production and essential components.	Minimum content of nutrients (percentage by weight). Information on assessment of nutrients. Other requirements	Other data on the type designation or labeling.	Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.
	NPK organic fertilizer of animal origin	The solid product obtained by treatment of animal excrement,-with or without bed without mineral acids. They include composted offal	- $N + P_2O_5 + K_2O = 6\%$ - C/N not more than 10 - Each nutrient must be at least 1.5% - Organic N must be at least 50% of total N, with a minimum of 1%. - The N nitric should not exceed 1.5%	- Minimum and maximum humidity	- Total N and organic N - P_2O_5 Total - K_2O Total - Organic C - C / N - Humic acids (if more than 1%)
	Organic fertilizer NPK plant and animal origin	The solid product obtained by treating animal manure mixed with animal and plant organic matter	- $N + P_2O5 + K_2O = 4\%$ - C/N not exceeding 15 - Each nutrient must be at least 1%		

Table 30: Organic fertilizers NP

No.	Type designation.	Information on production and essential components.	Minimum content of nutrients (percentage by weight). Information on assessment of nutrients. Other requirements	Other data on the type designation or labeling.	Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.
1	NP organic fertilizer of animal origin	Solid product obtained by treatment with or without mixing, animal organic material	- $N + P_2O_5 = 8\%$ - 3% total N - 4% Total P_2O_5 - C/N not more than 6	-Minimum and maximum humidity	- Total N and organic N - Total P2O5 - Organic C - C/N - Total K2O (if more than 1%) - Humic acids (if more than 1%)
2	Organic fertilizer NP plant and animal origin	Solid product obtained by treatment with or without mixing, animal or vegetable organic matter.	- $N + P_2O_5 = 6\%$ - 2% total N - 3% Total P_2O_5 - C/N not exceeding 12		

Table 31: Organic- mineral fertilizers- solid NPK

No..	**Type designation.**	**Information on production and essential components.**	**Minimum content of nutrients (percentage by weight).** **Information on assessment of nutrients.** **Other requirements**	**Other data on the type designation or labelling.**	**Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.**
1	Organic-mineral fertilizer NPK	Product obtained by mixing or combining organic manure with mineral fertilizers	- N + P_2O_5 + K_2O: 12% - N Total: 2% - Organic N: 1% - P_2O_5 3% - K_2O: 3% - Organic C: 8%		- Total N and organic N. - Other forms of N (if more than 1%) - Water soluble P_2O_5
2	Organic-mineral NPK fertilizer with peat	Product obtained by mixing or combining peat and mineral fertilizers with or without organic amendments	- N + P_2O_5 + K_2O: 12% - N Total: 2% - Organic N: 0.5% - P_2O_5 3% - K_2O: 3% - Organic C: 8%		
3	Organic-mineral fertilizer NPK with lignite or leonardite	Product obtained by mixing or combining organic manure with mineral fertilizers, with lignite or leonardite	-K_2O: 12% - N Total: 2% - Organic N: 1% - P_2O_5 3% - K_2O: 3% - Organic C: 8%		

Table 32: Organic- mineral fertilizers, liquid NPK

No..	Type designation.	Information on production and essential components.	Minimum content of nutrients (percentage by weight). Information on assessment of nutrients. Other requirements	Other data on the type designation or labelling.	Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.
1	Organic-mineral LIQUID fertilizer NPK	Product in solution or suspension from a mixture or combination of organic manure with mineral fertilizers	- N + P_2O_5 + K_2O: 8% - N Total: 2% - Organic N: 1% - 2% P_2O_5 - K_2O: 2% - Organic C:%	- pH	- Total N and organic N. - Other forms of N (if more than 1%) - Water soluble P_2O_5 - P_2O_5 soluble in water and neutral ammonium citrate - Water soluble K_2O. - Organic C - HumIc acids (if more than 1%)
2	Organo-mineral NPK liquid fertilizer with peat	Product in solution or suspension from a mixture or combination of peat and mineral fertilizers, organic manure with or without	- N + P_2O_5 + K_2O: 8% - N Total: 2% - Organic N: 0.5% - 2% P_2O_5 - K_2O: 2% - Organic C: 4%		

Table 33: Organic- mineral fertilizers, solid NP

No.	Type designation.	Information on production and essential components.	Minimum content of nutrients (percentage by weight). Information on assessment of nutrients. Other requirements	Other data on the type designation or labelling.	Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.
1	Organic-mineral fertilizer NP	Product obtained by mixing or combining organic manure with mineral fertilizers	- N + P_2O_5: 8% - N Total: 2% - Organic N: 1% - 3% P_2O_5 - Organic C: 8%		- Total N and organic N - Other forms of N (if more than 1%) - Water soluble P_2O_5 - P_2O_5 soluble in water and neutral ammonium citrate - Organic C - Total K_2O (if more than 1%) - Humic acids (if more than 1%)
2	Organic-mineral NP fertilizer with peat	Product obtained by mixing or combining peat and mineral fertilizers with or without organic amendments	- N + P_2O_5: 8% - N Total: 2% - Organic N: 0.5% - P_2O_5 3% - Organic C: 8%		
3	Organic-mineral fertilizer NP with lignite or leonardite	Product obtained by mixing or combination of organic manures and mineral fertilizers, with lignite or leonardite	- P_2O_5 3% - Organic C: 8% - N + P_2O_5: 8% - N Total: 2% - Organic N: 1% - P_2O_5 3% - Organic C: 8%		

Table 34: Organic- mineral fertilizers, liquid NP

No..	Type designation.	Information on production and essential components.	Minimum content of nutrients (percentage by weight). Information on assessment of nutrients. Other requirements	Other data on the type designation or labelling.	Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.
1	Organic-mineral LIQUID fertilizer NP	Product in solution or suspension from a mixture or combination of organic manure with mineral fertilizers	- N + P_2O_5: 6% - N Total: 2% - Organic N: 1% - 2% P_2O_5 - Organic C: 4%	- pH	- Total N and organic N - Other forms of N (if more than 1%) - Water soluble P_2O_5 - P_2O_5 soluble in water and neutral ammonium citrate - Organic C - Total K_2O (if more than 1%) - Humic acids (if more than 1%)
2	Organic-mineral NP liquid fertilizer with peat	Product in solution or suspension from a mixture or combination of peat and mineral fertilizers, with or without organic manure	- N + P_2O_5: 6% - N Total: 2% - Organic N: 0.5% - 2% P_2O_5 - Organic C: 4%		

Table 35: Organic- mineral fertilizers, solid PK

No..	Type designation.	Information on production and essential components.	Minimum content of nutrients (percentage by weight). Information on assessment of nutrients. Other requirements	Other data on the type designation or labelling.	Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.
1	Organic-mineral fertilizer PK	Product obtained by mixing or combining organic manure with mineral fertilizers	- P_2O_5 + K_2O: 8% - P_2O_5: 3% - K_2O: 3% - Organic C: 8%		- Water soluble P_2O_5 - P_2O_5 soluble in water and neutral ammonium citrate - Water soluble K_2O - Organic C
2	Organic-mineral PK fertilizer with peat	Product obtained by mixing or combining peat and mineral fertilizers with or without organic amendments	– P_2O_5: 3% – K_2O: 3% – C orgánico: 8%		

Table 36: Organic- mineral fertilizers, liquid PK

No..	Type designation.	Information on production and essential components.	Minimum content of nutrients (percentage by weight). Information on assessment of nutrients. Other requirements	Other data on the type designation or labelling.	Nutrient content to be declared and guaranteed. Forms and solubilities of the nutrients.
1	Organic-mineral LIQUID fertilizer PK	Product in solution or suspension from a mixture or combination of organic manure with mineral fertilizers	- P_2O_5+ K_2O: 6% - P_2O_5: 2% - K_2O: 2% - Organic C: 4%	- pH	- Water soluble P_2O_5 - P2O5 soluble in water and neutral ammonium citrate - Water soluble K_2O - Organic C - Total N (if more than 1%)
2	Organo-mineral PK liquid fertilizer with peat	Product in solution or suspension from a mixture or combination of peat and mineral fertilizers, with or without organic manure	- P_2O_5+ K2O: 6% - P_2O_5: 2% - K_2 O: 2% - Organic C: 4%		

In addition to the two norms that are exhibited in a more detailed way, the Regulation EC 1881/2006 of the Commission, of December 19, 2006, by which the maximum content of certain pollutants is fixed, it is established in its article 9 that the Member states will control the nitrates content in vegetables which may contain them at increased levels, in particular in green sheet vegetables. In particular, it establishes limits for spinach and lettuces, which are controlled as a final product, by the Autonomous regions and the Spanish Agency of Food security and Nutrition (AESAN).

8.5.1 Real Decreto 261/1996

The Real Decreto 261/1996, of February 16, treats on the protection of the waters from the contamination produced by the nitrates proceeding from agrarian sources. It is a transposition of the Directive

91/676/EEC. This Real Decreto is relevant for the recycler because it establishes limitations regarding the use of certain types of fertilizers and its doses in vulnerable areas.

The most essential points that are gathered in this Real Decreto are:

- Objective: to correct the contamination of the waters caused by the nitrates of agrarian origin.
- Code of Good Agrarian Practices: all the CC.AA. (autonomous communities) have prepared and communicated to the European Commission, across the ancient Department of Agriculture, Fishing and Feeding, its respective codes, for the purpose of reducing the contamination produced by the nitrates of agrarian origin. These codes of good agrarian practices are not compulsory, being the proper farmers who decide voluntarily putting it in practice.
- Performance Programs: for the areas that are designated as vulnerable, the CC.AA. establish these programs that are mandatory and 2 of the R.D contemplate a series of measurements gathered in the annex. 261/1996. This law establishes the need to protect both the quality of water supply and environmental quality, reduce water pollution by nitrates from agricultural sources and act preventively against future contamination. It would be necessary to stand out:
    - Periods in which the application of certain types of fertilizers is prohibited.
    - Limitations in the subscriber doses, considering type of soil, cultivation and rotation, agricultural practices, contributions for animal feces, etc. it is not allowed to incorporate any more than 170 kg/year of nitrogen proceeding from the ordure.
    - Muck-collectors

The Spanish Administration is forced to inform periodically to the European Commission about the measurements and control panel according to this Board.

8.6 **Spanish regulations governing the manufacturing facility**

Directive 2010/75/EU Directive on Industrial Emissions 20/12/10

The new Directive 2010/75/EU of November 24, on industrial emissions (integrated prevention and control of pollution) entered into force on January 6, 2011. Member States will have two years to adopt the necessary laws to ensure compliance. The aim of this new standard is to achieve a higher level of environmental protection and simplify the legal and administrative burdens. This law is relevant for the recycler because it establishes the characteristics, permit conditions, control and compliance protocols for the recycling infrastructures.

The new legal text consolidates and amends six existing Directives:

- Directive on the Prevention and Control IPPC Integrated Pollution
- Directive on Large Combustion Plants (LCP)
- Waste Incineration Directive
- Directives of Volatile Organic Compounds (VOCs)
- Three Directives on Titanium Oxide (TiO_2)

The transposition of Directive 2010/75/EU to the Spanish legislative was completed by Law 5/2013, of 11 June amending the current Law 16/2002 and the Real Decreto 815/2013, of 18 October.

The main changes introduced by the Directive:

1. - BAT reference documents and exchange of information (Article 13.5): the Commission (assisted by a committee composed of representatives of Member States) passes through the comitology process chapter of the BREF conclusions about BAT, thereby strengthening the role of the BREFs and BAT. Thus, the BAT conclusions shall be the reference for setting permit conditions.

2. - VLE / Repeal (Art. 15.3 and 15.4): the competent authority shall set permissions with VLEs to ensure that emissions do not exceed the emission values associated with BAT (BATAEL) and appearing on the BAT conclusions. However, it may give exemptions in certain cases, by establishing less stringent ELVs that deviate from the BATAEL if adequately justified the costs would be disproportionately higher than the environmental benefits due to geographical location or local environmental conditions or specifications installation.

3. - VLE sector at European level (European Safety Net ancient) (art. 73): The Commission may, by a legislative proposal of minimum requirements Union limit values and standards monitoring and enforcement if it deems necessary after an evaluation of the status of implementation of BAT for the activities to be approved for BREF in the three years preceding that assessment.

4. - Update permit conditions (art.21.3): permit conditions must be updated within 4 years from the adoption of the BAT conclusions.

5. - Flexibility for Large Combustion Plants (art. 31-35): make certain GICs flexibility mechanisms that facilitate compliance with the new VLE gradually: rates of desulphurization, National Transitional Plan, limited lifetime exemptions and exemptions for district heating and small isolated.

6. - Soils (art. 22) requires a baseline report when you use or produce relevant hazardous substances. After the termination of a facility the operator shall assess the state of contamination of soil and water and compare it to the baseline report. When the comparison indicates contamination, the operator shall take appropriate steps to address that pollution so as to restore the site of the installation to the initial state.

7. - Control requirements (monitoring of soil and groundwater) (Art. 16.2): Establishing a requirement for periodic monitoring at least every five years for groundwater and ten years for soil.

8. - Report on Compliance (Article 14.D): the operator must inform the competent authority at least once a year to verify compliance with the permit conditions.

8.7 Transposition on Urban Wastewater Treatment Directive (Dir. 91/271/EEC)

The Directive 91/271/EEC, as amended by Directive 98/15/EC, defines the collection, treatment and discharge of urban waste water. This Directive has been transposed into Spanish law by the R. D. Ley 11/1995, the R. D. 509/1996, which develops, and R. D. 2116/1998 amending the previous one.

Meanwhile, Decision 93/481/EEC establishes models presenting information that Member States shall transmit to the European Commission established programs for the development and implementation of the directive.

Decision 93/481/EEC develops the content of Directive 91/271/EEC in particular with regard to the content of Section 4 of Article 17, as to the methods and ways of presenting information relating to the adoption of the programs for the implementation of the directive.

The information is divided into two main parts, firstly the aforementioned collecting systems, and other treatment facilities. For each develops an inventory of the current situation based on expected performance programs in four differing time horizons, by region (sensitive, less sensitive and normal), where to

apply and pour point characteristics (fresh water, estuaries and coastal waters). Finally, it establishes a questionnaire concerning application programs regarding the disposal and use of sewage sludge and a calendar with the investments budgeted in all the programs implementation of the Directive.

The transposition of Directive 91/271/EEC to the Spanish law is contained in the Real Decreto -Ley 11/1995, of 28 December (BOE no. 312 de 30 de diciembre), laying down the rules the treatment of urban wastewater. The Real Decreto 509/1996, de 15 de marzo (BOE no. 77 de 29 de marzo) developed the aforementioned content, by incorporating content Annexes of Directive 91/271/EEC, which initially had not been incorporated.

To incorporate Directive 98/15/EC into Spanish law, it was necessary to amend Table 2 of Annex I of Real Decreto 509/1996, of March 15, which was conducted by Real Decreto 2116/1998 of 2 October (BOE no. 251, October 20).

8.8 Spanish regulations governing direct sludge application

Spanish common legal framework governing the application of sewage sludge to agricultural soils determines heavy metal limit values not to be exceeded. It also establishes the appropriate treatments for the sludge (biological, chemical, thermal, long-term storage or any other procedure appropriate) so as to reduce significantly, its' fermenting capacity and the health hazards of its use, so they can be used in the agriculture.

Despite some common grounds the planning and management of sludge in Spain is different between regions: some have specific plans, other regions include sludge management in waste management plans or in municipal waste plans, whereas others apply the Royal Decree 1310/1990 through its Ministries of Agriculture or from the services of waste or sanitation of the Ministries of Environment. This situation is not desirable, not only for environmental reasons but also for reasons of administrative efficiency. It is a fact that these differences sometimes even give some confusion to the stakeholders in the recycling process regarding the relevant department for sludge control or management.

Spanish legislation:

- Real Decreto 1310/1990, de 29 de octubre, by which regulates the use of sewage sludge in agriculture.
- Orden de 26 de octubre, 1993, on the use of sewage sludge in agriculture (for its importance we will analyze it in deep)
- Draft Order on the use of sewage sludge in agriculture
- II National Plan of Sewage Sludge Wastewater (2007-2015).
- Real Decreto 261/1996, de 16 de febrero on the protection of waters against pollution caused by nitrates from agricultural sources.

Waste Management

- Ley 22/2011, de 28 de julio, of waste and contaminated soil.
- Real Decreto 1481/2001, de 27 de diciembre, regulating waste disposal by landfill.
- Real Decreto 653/2003, de 30 de mayo, on waste incineration

8.8.1 Real Decreto 1310/1990

The Real Decreto 1310/1990, of October 29, regulates the use of the sewage sludge in the agrarian sector. It is a transposition of the advisory board 86/277/CEE).

The most important points of this Real Decreto are the following ones:

- Objective: to regulate the use in the agrarian activity of sewage sludge protected by the papers established in the proper Real Decreto 1310/1990.
- Prohibitions. The following ones are established:
    - sewage sludge application in prairies, pastures and other land used as pasture ground for cattle, is restricted to a period at least three weeks in advance of commencement of direct use.
    - sewage sludge application in horticultural and fruit cultivation, during its vegetative cycle, with the exception of fruit-bearing trees, or a period of less than ten months before the compilation and during the compilation itself. Also horticultural or fruit cultivation which commercially used fruits or vegetative part are in direct contact with the soil.
- Limitations. The following ones are established:
    - Only sewage sludge can be used as far as its heavy metal content does not exceed limits indicated in annex I B of the Real Decreto. These limits (in mg/kg of dry matter) change with the pH of the soil where they are applied.
    - The soils on which they can be applied must have a low concentration of heavy metals (specifications in the annex I).
    - The maximum quantities of sewage sludge that will are allowed to be applied to the soil per hectare and year must ensure that intake levels of heavy metals established in annex I C are not exceeded.
- Documentation required: any sewage sludge product must be accompanied by the corresponding papers sent by the holder of the sewage treatment plant, indicating the process of treatment and its composition (dry matter, organic matter, pH, N, P and heavy metals).

The users must have the documentation which is required by each Autonomous region.

As in the previous legal disposition, the Real Decreto regulates the legislations for the farmers who should apply sewage sludge. The maximum concentrations for certain elements are also described in Real Decreto 1310/1990.

8.8.2 Tips for the recycler

The main problem with this law is that it is ambiguous or unclear in many respects. In other respects it is inadequate. It has led to the Autonomous Communities regulating independently and very unevenly. This lack of legal certainty prevents potential recyclers from having a clear view on rules and therefore represents a significant barrier for investments in recycling processes.

Since the adoption of this Real Decreto, new technology and knowledge have been developed that comply with the requirements of Directive 86/278/EEC. It is necessary to improve the fertilizing value of sludge on agricultural soils. Also there is new knowledge about the environmental and public health risks involved by indiscriminate use of fertilizers not subject to proper treatment. All this makes it necessary to adapt the legislation to the new context.

There is a project for updating this normative on the use of sewage sludge in agriculture. Its main characteristics are:

- It aims to improve the information about treatment, production and traceability of the sewage sludge
- The function of a "sludge manager" is created
- The concept of sewage sludge is refined
- New microbiological parameters are included
- An obligation to declare the sludge management in the region of destination where the sludge is applied

8.8.3 Orden de 26 de octubre de 1993 sobre utilización de lodos de depuración en el sector agrario.

(This Act was recently repealed by Order AAA/1072/2013, of June 7, on utilization of comtaminated soils in the agrarian sector. Nonetheless a brief analysis of the repealed law is necessary considering it has been in force since 1986 and has undoubtedly helped to shape the current Spanish use of sewage sludge.)

The Order of October 26, 1993, on the use of sewage sludge in agriculture is a very ambiguous normative, unclear in many respects, and clearly insufficient.

This lack of quality has resulted in the regions regulating independently different aspects of the use of sewage sludge and very unevenly.

Due to the long period of time since the entry into force of this order and taking the technical developments that have occurred in production, processing and agricultural land application of sewage sludge into account, it is necessary to review the contents of the law, adapting it to the new reality.

On the other hand the National Integrated Waste Plan for the period 2008-2015, approved by Resolution of the Council of Ministers of December 26, 2008 and published in the Official Gazette by Resolution of January 20, 2009, the Secretary of State for Climate Change, establishes quality objectives for sewage sludge from urban wastewater, from its origin to its final destination, protecting the environment and especially soil environment. These objectives include qualitative improvements of sludge management systems and control improved agricultural applications ensuring proper use of the sludge.

In 2013 the Ministry Of Agriculture, Food and Environment launched a Draft Order on the use of sewage sludge in agriculture. It aims to improve the information about treatment, production and traceability of sludge. It creates the "sludge operator figure", and narrows the concept of treated sludge, including microbiological parameters. This law also obligates to state management in the Autonomous Region of destination where sludge is applied. This new law needs to be discussed and approved by Spanish legislators.

Its objectives are to regulate the use of sewage sludge in agriculture, to determine the information that needs to be provided to the government by producers and operators of sewage sludge, and to establish identification documents for the sludge.

8.9 The National Waste Plan

The National Waste Plan (PNIR 2008 - 2015) tried to give some light to the stakeholders in the recycling process and to ensure proper management of all sewage sludge from its origin to its final destination, protecting the environment and especially the soil. The recycler must comply with all the terms regarding the National Waste Plan in reference to the sludge management logistics, final destiny and use.

The new plan is developed under the Directive 2008/98/EC on waste (Waste Framework Directive) of the EU and outlines some of the considerations presented in this Directive, such as energy recovery and waste hierarchy. By a biannual review the Waste Framework Directive plan will be adapted to new needs arising. Such review shall be in accordance with the energy recovery objectives and will be reviewed in accordance with the future Law on energy efficiency and renewable energy and the renewable energy plan Table 37.

Its objectives are (Qualitative):

- Improve the information system of sludge management. Accurately assess the contribution of sludge to GHG emissions.
- Improve the control of agricultural applications ensuring the proper use of sludge on the soils.
- Clarify the powers to authorize and control the operations of sludge management.
- Promote coordination among various governments and private agents and involved in sludge management (Department of Environment, Agriculture, Sanitation and Water Quality).
- Apply the policy of waste management of sludge management. Intensify cooperation between those responsible for sanitation and waste management.
- Continue to influence prevention of pollution at sewage sludge origin.
- Ensure the storage capacity of the sewage sludge, especially those intended for agricultural recovery and secure infrastructure for the treatment and disposal.
- Minimize energy consumption from non-renewable sources in the treatments applied to the sludge.
- Select appropriate treatments according to the final destination (soil, energy recovery, landfill), at reasonable costs and environmentally sustainable.
- Avoid sludge transport over long distances.
- Minimize the amount going to landfill

Table 37: Quantitative objectives of the NWP for the residues management until 2015

	2015 (%)
Sewage sludge application to agricultural land	67
Other uses or means of valorization	18
Incineration	3
Deposit at dumpsite	12
Correct environmental management of the residues from the incineration process	100 (of the ashes generated)

Measures to be taken by the legislators and the central and regional government bodies:

- Review and amendment of the annexes of the Order of 26 October, 1993, on the use of sewage sludge in agriculture, the Ministry of Agriculture, Fisheries and Food, on the provision of information about sewage sludge management by those responsible for the sewage. Such review shall ensure:
    - More information on the treatment of wastewater.

  - Traceability of sludge, to know the quantities of sludge produced and the quantities that go to different destinations based on their characterization.
  - The correct application of sludge to agricultural soils clearly identified, depending on the dose to be taken into account both the analytical characteristics of the sludge as nutrient and soil physical characteristics.

- Coordination between the competent departments of Environment, Agriculture and Water Quality in the different administrations . Create an interadministrative and intersectoral work group for this purpose.
- Setting standards and guidelines to improve the management of sludge.
- Pilot programs for the implementation of preventive interventions. Voluntary agreements with municipalities or autonomous communities for this purpose.
- Drafting and approval of technical manuals:
  - Code of best practice for the application of sludge to soil.
  - Technical manual on possible treatments of sewage sludge, indicating their advantages and disadvantages and recommendations for each case study
  - Sludge storage.
- Establishment of comprehensive plans for fertilization.
- Dissemination of results of the R + D + innovation.
- Fostering technological improvements and the acquisition of practical experience or through Software R & D + innovation of the Administrations.
- Making an economic study on the management of sewage sludge, in all its forms.

8.10 **Orden AAA/1072/2013, de 7 de junio, sobre utilización de lodos de depuración en el sector agrario**

This Order responds to the need to accommodate new technical developments that have occurred in production, processing and agricultural use of sewage sludge in Spain. This order is developing one of the measures determined by the National Waste Plan for the period 2008 - 2015, as is the need to review and amend the annexes of the Order of 26 October, 1993, on the use of sewage sludge in agriculture.

This law is important for the potential recycler because updating of the contents of the National Sludge Register and the information that wastewater treatment facilities must provide stands within its objectives; information about the treatment of sewage sludge and the application of the sewage sludge on agricultural soils.

This new Order is intended to update the contents of the National Register of sludge and the information to be provided by wastewater treatment facilities, facilities for the treatment of sewage sludge and managers that perform on-farm application of sewage sludge in accordance with the provisions of Real Decreto 1310/1990, of 29 October which regulates the use of sewage sludge in agriculture.

Throughout its six items and its four annexes the Order establishes the information to be forwarded to the competent body of the Autonomous Region by the owner of a WWTP and that correspond with that contained in Annex I. During transport, sewage sludge must be accompanied by an identification document

containing the information of Annex II. Managers must complete the information contained in Annex III for all sludge applications carried out.

The Order also updates the information required in the National Register of sludge, whose management has been entrusted to the Directorate General of Quality and Environmental Assessment and Natural Environment through the Directorate General Waste.

This Order came into force in June 15, 2013. For this reason Order of 26 October, 1993, on the use of sewage sludge in agriculture is repealed.

9 Switzerland

In the last following chapter the legal situation in Switzerland is described. Swiss and European legislation is compared.

9.1 Legislation Governing the Product

Swiss regulations are largely similar to EU regulations. REACH regulations have a direct impact on the chemicals industry in countries outside the EU. The Swiss chemical industry is thus particularly affected as the EU is Switzerland's principal trading partner in this domain. In this view, the Federal Council intends to enter into negotiations with the EU with the aim of safeguarding Switzerland's environmental and public health interests under REACH, as well as its economic interests.

Since February 2009 (2nd revision of the Ordinance on Chemical Products Chem V), Swiss manufacturers can already optionally classify, label and package their chemical products destined for professional customers according to the guidelines of the EU CLP Regulation. The simultaneous application ensures that chemical products with GHS-labels (substances/commercial mixtures) are also permitted in Switzerland.

On 18 August 2010, the Federal Council formally approved the negotiating mandate, after having conducted the pertinent consultations with the cantons as well as with the Foreign Affairs Committees of the parliamentary chambers.

9.1.1 Fertiliser regulations

In contrast to REACH, Switzerland has largely adopted EU-fertiliser regulations and accepts placing on the market of all EC fertilisers and fertilisers as listed in Annex 1 to the fertiliser book regulation (DüBV) after a simple registration of the corporation that manufactures or imports those fertilisers.

Swiss fertiliser legislation is largely based on three regulations: DüV aiming at admission and use of fertilisers, DüBV aiming at types, properties, solubilities, tolerances, packaging and labelling of fertilisers and CemRRV in its Annex 2.6 aiming at the limitation of detrimental effects of fertilisers on human health and the environment. The ChemV is relevant to new substances being the result of recycling activities and being an ingredient to recycled phosphate fertilisers (Table 38). In Annex D an addition to this table can be found.

Table 38: Swiss legislation with relevance for fertilisers, soil improvers and substrates

Title	Abbreviation	Enforcement	Focus
Dünger-Verordnung	DüV	10.01.2001	Admission, import and use of fertilisers
Düngerbuch Verordnung	DüBV	16.11.2007	Types and designations of fertilisers
Chemikalien-Risikoreduktions-Verordnung, Annex 2.6	ChemRRV	18.05.2005	Prevention of detrimental effects on human health and the environment
Chemikalien Verordnung	ChemV	18.05.2005	Protection from hazardous materials

There is, however, a significant difference between the German and the Swiss approach to recycled fertilisers – Switzerland has special requirements to recycled fertilisers being much more severe than the rather generous (with the exception of cadmium) requirements to fertilisers based on natural resources.

Although BLW (Federal Office for Agriculture) is the regulatory body for admission of new fertilisers, the BAFU (Federal Office for Environment) is usually involved in the assessment of new applications. Until recently, the BAFU has insisted that fertilisers from recovered phosphates are placed on the market as recycling fertilisers being fully in compliance with the respective pollutant limits.

Currently, however, some federal state authorities such as AWEL Zürich, the former head of the waste department of BAFU, Hans-Peter Fahrni, currently acting as a consultant and the leading Swiss manufacturer of recycled phosphate (BSH) are intensively lobbying for licensing recycled mineral phosphate fertilisers as conventional mineral fertilisers. BAFU has not published an official statement with regard to this approach.

Depending on the final appropriation of the product by the relevant authorities, pollutant concentrations in the recycled products must not exceed the values listed in Table 39 and Table 40. It can be assumed that all recycled phosphate fertilisers will be in compliance with the requirements of mineral fertilisers, even without any removal of heavy metals from sewage sludge, sewage sludge ash or other starting materials.

Table 39: Pollutant limits in mineral fertilisers according to ChemRRV

Pollutant	Limit value in g/ton dry matter (g/ton P)
Cadmium	50
Chromium (Cr)	2000
Vanadium (V)	4000

In turn, most recycled phosphate fertilisers will encounter problems to comply with the limit values of Table 40 for recycled fertilisers.

Table 40: Pollutant limits in recycled fertilisers according to ChemRRV

Pollutant	Limit value in g/ton dry matter
Lead (Pb)	120
Cadmium (Cd)	1
Copper (Cu)	100
Nickel (Ni)	30
Mercury (Hg)	1
Zink (Zn)	400

Organic fertilisers and soil improvers such as compost and digestion residues are subject to additional guidance values Table 41.

Table 41: Additional pollutant guidance values for digestion residues and compost according to ChemRRV

Pollutant	Value in g/ton dry matter
Polycyclic aromatic hydrocarbons (PAHs)	4
Dioxins (PCDD) and furans (PCDF)	20 ng I-TEQ

9.2 Legislation Governing the Production Plant

9.2.1 Federal Act on Environmental Protection

The Act USchG, 07.10.1983 shall protect humans, animals and plants as well as their communities and habitats from detrimental or disturbing influences and permanently preserve the natural resources, particularly the biological diversity and the soil fertility.

The act stipulates the *polluter pays* principle. It provides comprehensive definitions on what are "detrimental or disturbing influences" and who are the regulating bodies to decide about these influences.

The Federal Act on the Protection of the Environment outlines the main principles applicable to

- Emissions, immissions and radiation, including those from industrial installations
- Hazardous substances
- Handling of organisms
- Waste management, such as prevention, disposal, financing, recycling and the clean-up of contaminated sites.
- Soil protection

The Environmental Protection Act lays down that legitimate regulatory bodies (as usual in Switzerland nominated by the Federal States called "Kantone") examine at an early stage the environmental compatibility of a project before deciding on planning, building or modifying installations.

Installations which may substantially strain environmental areas and consequently need project- or location specific measures, to ascertain the compliance with regulations on the environmental protection, are subject to an EIP. The Swiss Federal Council determines the types of installations being subject to an EIP, he may determine thresholds above which the assessment needs to be performed. The Council examines the types of installations and the threshold values periodically and adapts them if appropriate.

In addition the Act includes environmental taxes, liabilities and implementing rules.

The Federal Act on Environmental Protection provides the legal framework for a number or ordinances. Those being most relevant for developers of phosphate recycling facilities are explained on the following pages.

9.2.2 Air Pollution Control

Swiss performance as regards air quality is among the best. Switzerland has met or will shortly meet all its international commitments for atmospheric emissions reduction. Since the early 1980s it has achieved remarkable declines in emissions of the main air pollutants (SO_x, NO_x, VOCs, CO, particulates, heavy metals) and substantial improvements in air quality. These results are largely attributable to a consistent and ambitious federal strategy for air pollution abatement and to efficient implementation of regulatory measures by the cantons. Associated with the country's economic characteristics (low energy intensity, economic stagnation in the 1990s) and energy structure (almost entirely hydro and nuclear power, relatively high energy prices), this environmental policy has ensured that Switzerland's emissions per unit of GDP are the lowest or among the lowest in the OECD area. In addition, considerable progress has been made with the Energy 2000 action programme, which is contributing to a decline in emissions of CO_2 and conventional pollutants.

However, the very ambitious targets set at national level for 1995 (Act 16.12.1985/15.07.2010) with respect to NO_x and VOC (volatile organic pollutants) emissions have not been achieved. Despite remarkable reductions of 26 % in NO_x emissions and 37 % in VOC emissions since 1985, ozone concentrations over the country as a whole are still too high. A 70-80 per cent reduction of such emissions would be necessary to solve the problem of summer smog more or less permanently; this now seems possible for VOCs by the end of the decade, but difficult in the case of NOx. The essentially regulatory approach to air management is now being reinforced by economic incentive measures (redistributed charges on VOCs and on high-sulphur heating fuel). It would be advisable to facilitate this development by securing a broader consensus on air management policy both within the administration and among the public.

Transferred to the Ordinance on Air Pollution Control these principles require new stationary installations being equipped and operated in such a way that they comply with the limitation of emissions specified in Annex 1.

Additional or different requirements apply in the case of the following installations:

i. installations listed in Annex 2: the requirements specified therein;
ii. combustion installations: the requirements specified in Annex 3;

Emissions for which no limitation is specified in this Ordinance or for which a particular limitation is declared not to be applicable, shall be limited preventively by the authorities as far as is technically and operationally feasible and economically acceptable.

Emission limitation measures are technically and operationally feasible if they:

a) have been successfully tested at comparable installations in Switzerland or abroad or
b) have been successfully applied in experiments and can be transferred to other installations from a technological perspective.

If an individual planned installation is expected to cause excessive ambient air pollution levels even though the preventive emission limitation requirements are met, the authorities shall order additional or stricter emission limitation requirements for the installation concerned. The emission limitation requirements are to be supplemented or tightened to such an extent that no excessive ambient air pollution levels are caused.

Emissions shall be captured as fully and as close to the source as possible and shall be removed in such a way as to prevent excessive ambient air pollution levels. They shall generally be discharged above roof level via stacks or waste air ducts.

Similar to the provisions in Germany, developers of phosphate recycling technologies should comply with the limits as stipulated in Annex 3 for combustion installations – the most stringent ones. The respective values are given in Table 42.

In comparison to the German limits the lower limits for nitrogen oxides and the separate limits for ammonia reflect the special efforts of Switzerland to reduce NO_x emissions. These limits, however, represent a challenge to thermal facilities because ammonia is usually used to reduce NO_x emissions.

Table 42: Current gaseous emission limit values for incineration plants in Switzerland in mg/Nm³ dry (including a comparison to German limit values)

Emission limit values	CH Daily average value	D Daily average value
Total particle content (dust emissions at the stack)	10	10
Organic matter, as C total	20	10
Gaseous inorganic chlorine compounds, as HCl	20	10
Gaseous inorganic fluorine compounds, as HF	2	1
Sulphur dioxide and sulphur trioxide, as SO_2	50	50
Nitrogen-oxides (nitrogen-monoxide and nitrogen dioxide), expressed as nitrogen dioxide, at a mass flow of 2.5 kg/h or more	80	200
Ammonia and ammonium compounds, expressed NH_3	5	-
Mercury and cadmium and their compounds, expressed as metals, in each case	0.01	0.03[1]
Carbon monoxide, as CO	50	50
Lead and zinc and their compounds, expressed as the metals, in total	1.0	1.0[2]
Dioxins and furans, expressed as the sum of the toxic equivalents in accordance with EN 1948-167 (ng/Nm³ dry)	0,1	0.1

[1] The German value refers to Cd and TI and their compounds, as Cd and TI total

[2] The German value refers to Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn and their compounds

9.2.3 Legislation on Waste

In Switzerland, the legal framework for the production, trade and management of waste comprises, among others, the following statutes and ordinances. This legal framework applies in particular to waste producers, such as industrial companies, waste carriers and waste disposal companies which run dumping sites.

- The Technical Ordinance on Waste (TVA, 10.12.1990) cements the principles of the Federal Act on the Protection of the Environment, and primarily sets out the rules on waste disposal and requirements for dumping sites.
- The Ordinance on the Movement of Waste regulates the import, export and movement of waste in Switzerland.
- The Ordinance on the Carriage of Dangerous Goods by Road implements the European Agreement Concerning the International Carriage of Dangerous Goods by Road and complements the Ordinance on the Movement of Waste.
- The Ordinance on the Risk Prevention Officer for the Carriage of Dangerous Goods by Roads, Railroads and Waterways lays down the tasks and training of persons that are responsible for preventing and reducing environment-related dangers caused by packaging, loading, transporting and unloading of dangerous goods.
- The Ordinance on the Lists regarding Movements of Waste classifies the different kinds of waste and defines different kinds of disposal procedure.
- Cantonal and communal statutes and ordinances on waste also apply.

Within the scope of this study, we mainly refer to the obligations of industrial waste producers as being relevant for phosphate recycling companies. The Federal Act on the Protection of the Environment outlines the main principles applicable to waste, such as prevention, disposal, financing, recycling and the clean-up of contaminated sites.

9.2.4 Disposal obligations

Depending on the particular category of waste, the obligations of waste producers vary with regard to disposal, transportation and dumping. For example, with respect to the obligation to dispose of waste, the provisions of the Federal Act on the Protection of the Environment distinguish between municipal waste and other waste.

The producers and owners of industrial waste (usually industrial companies producing it) must take the necessary measures to dispose of such waste properly. For this purpose, the owners may contract either with communities and their publicly owned waste disposal companies, or with private waste disposers. Instead of placing orders with a private waste disposal contractor, the owners of industrial waste may use a specific market platform to find the most cost-efficient way to dispose of waste. The purpose of this platform is to facilitate waste disposal based on the principles of the free market system. Comparable to a stock exchange, waste disposal companies – as demanders of waste – tender bids for a certain amount of waste and waste producers accept the best price. As a result, the accepted price reflects the market price of waste disposal (Abfallbörse Schweiz AG www.abfallboerse.ch).

The Federal Act on the Protection of the Environment not only governs municipal and other waste, but also contains rules for special waste, which is also governed by the Ordinance on the Movement of Waste (“Verordnung über den Verkehr mit Abfällen”). The statutes define different categories of waste depending on the level of its hazardousness.

In view of the legally defined waste categories, Swiss industrial companies must consider all specific obligations set forth by the applicable laws when they organise their waste management and the disposal of their waste. Among others, the Swiss regulations impose the following obligations on the producers of waste:

- Waste producers must dispose of special waste in an environmentally friendly way and are not allowed to mix it with other types of waste.
- Prior to transferring waste, the owner must clarify whether it is special waste or whether it falls into another category of particular waste.
- Waste producers must transfer special waste and other waste of a particular category to companies which have permission to accept and handle such waste.
- Waste producers and, as the case may be, waste disposal companies must use, for each transport of special waste, certain accompanying documents containing specific information on the concerned waste. International accompanying documents that are in line with the Basel Convention and OECD rules must be used for cross-border movements (import, export and transit).
- Waste producers must label packages and containers with special waste in a particular way.
- Waste producers must give additional information on the composition of waste to waste carriers and to waste disposal companies, if such information is necessary to protect employees and the environment, and to enable the involved parties to dispose of special waste in an environmentally friendly manner.

The costs to comply with such obligations are part of the waste producers' waste management costs. These costs are included in the calculations of the market price of waste disposal. In other words, the 'polluter pays' principle applies to waste disposal that is organised under the rules of a free market. Therefore, waste producers bear the costs of appropriate waste disposal and also the costs of preventing environmental damage from inappropriate waste disposal.

The TVA is currently under revision. According to the information of December 2012, it shall be ready for being submitted to the legislative consultation process by summer 2014 and be enforced in 2015.

The revised TVA shall include an obligation to recycle relevant mass fractions of phosphates from secondary sources, e.g. from sludge incineration ash. Two options shall exist: direct recovery of phosphates or traceable disposal of the phosphate containing waste (above a certain concentration threshold) in a separate compartment to enable phosphate recovery in the future. Details are still under discussion.

9.2.5 Responsibility and liability of industrial waste producers

With regard to the domestic and cross-border transport of special waste, waste producers, waste carriers and waste disposal companies must comply with the obligations provided for by the applicable Swiss laws and international treaties. The majority of these obligations are mandatory. A contractual transfer of such obligations is not legally possible. Private law agreements over waste, such as purchase or transport contracts, do not release waste producers, carriers or disposers from their legal obligations.

Under the above-mentioned market platform, industrial waste producers may dispose of their waste in a cost-efficient way and based on private law agreements. By doing so, however, they are not automatically released from their responsibilities and liabilities under public laws on waste disposal. Consequently, should such waste cause environmental damage, the 'polluter pays' principle would apply and the producer of the concerned waste might be liable. Depending on the particular case, the waste producer might be able to recourse to its contracting parties, such as waste carries and disposers, if they did not carry out their obligations properly.

Finally, the laws governing waste disposal provide for penalties in the case of non-compliance. For instance, if special waste is not labelled properly for its transfer or if it is transferred to a company that is not authorised to receive such waste, the transferor can be fined. The same applies if, for instance, dangerous goods are transferred without prior clarification that the transport of special waste fulfils all requirements of the applicable laws (in particular of the Ordinance on the Carriage of Dangerous Goods by Road) and neglects specific security and documentation obligations.

9.2.6 Environmental Impact Assessment

The Swiss Environmental Impact Assessment Ordinance (UVPV, 19.10.1988) aims at the assessment of new installations listed in Annex 1 of the ordinance. Relevant modifications of existing installations are subject to an EIA if – before and/or after the assessment are/become an installation listed in Annex 1. Installations not being subject to the EIA are nonetheless assessed in accordance with the EIA ordinance but without a report being edited.

The assessment aims to ascertain that the project is in compliance with environmental protection regulations. Part of these regulations is the Environmental Protection Act (USG, 07.10.1983), regulations on the protection of nature and homeland, protection of landscape, protection of waters, conservation of forests, hunting, fishing and genetic engineering.

The EIA is performed by the Federal State authority being the legitimate decision maker on the operational permit of an installation within the corresponding licensing proceedings. The proceedings relevant for the assessment are determined in the Annex.

Who wants to build or modify an installation being subject to this regulation has to edit a report on the impact of the installation on the environment.

The applicant (project developer) elaborates:

a. A preliminary examination which reveals the potential impacts of the installation on the environment
b. A specification which reveals which environmental impacts of the installation will be investigated within the report framework and determines the local and temporal boundaries of the investigations.

The applicant submits preliminary examination and specification to the legitimate authority. The authority forwards the documents to the Department of Environmental Protection that gives its view and advises the applicant.

If the environmental impact of the project and the environmental protection measures are comprehensively investigated and demonstrated within the preliminary examination, the preliminary examination can be accepted as report.

The report has to comply with the requirements of article 10/b paragraph 2 of the Environmental Protection Act. In particular it has to provide all the information the authority needs to examine the project in accordance with article 3. The report must investigate and assess all environmental impacts of the planned installation with regard to every single impact and all impacts together. It must also demonstrate how the environmental investigations have been considered which have been performed within the framework of spatial planning.

The applicant has to file the report together with the relevant documentation with the legitimate authorities at the beginning of the proceedings for obtaining the permit.

The legitimate authority performs the assessment on the following foundations:

a. Report
b. Statement of the authorities being in charge of the permit acc. To Art 21 or of a subsidy acc. to Art 22.
c. Evaluation of the report by the Department for Environmental Protection
d. Submissions from the Department for Environmental Protection
e. Results of possible own assessments or assessments of experts
f. Possible statements from other persons, commissions, organisations or authorities as far as they serve as foundation for the assessment.

Subject of the assessment: The legitimate authority examines if the project complies with the regulations for the protection of the environment (Art 3). If the project does not comply with the corresponding regulations, the authority evaluates, if it could be licensed with requirements or conditions.

The legitimate authority regards the results of the assessment when taking the decision on the application.

Publication of the decision: The legitimate authority publishes where the report, the evaluation of the Department of Environmental Protection, the results of a possible hearing of BAFU as well as the decision, as far as it concerns the results of the assessment can be recognized by the public. Certain restrictions apply with regard to obligations to confidentiality. The documents can be recognized by the public during 30 days.

If the legitimate authority figures out other permits being necessary for the materialization of the project, it makes the report and documents of the EIA available to the authorities in charge of the subsequent permits.

Annex 1 lists the plants requiring a permit before it can be built and operated. Among them are plants with an operational surface of more than 5.000 m^2 or a production capacity of more than 1000 tonnes per year for synthesis of chemical products. It is not clear if phosphate recycling plants would be considered as such plants. However, it would be wise to consider an EIA if a corporation intends to implement a phosphate recycling plant in Switzerland.

9.3 Legislation Governing Waste and Wastewater Management

9.3.1 Protection of Waters

The purpose of the Federal Waters Protection Act, GSchG, 24.01.1991 is to protect waters against harmful effects. In particular it aims: a. to preserve the health of people, animals and plants; b. to guarantee the supply and economic use of drinking water and water required for other purposes; c. to preserve the natural habitats of indigenous fauna and flora; d. to preserve waters suitable as a habitat for fish; e. to preserve waters as an element of the landscape; f. to ensure the irrigation of agricultural land; g. to permit the use of waters for leisure purposes; h. to ensure the natural functioning of the hydrological cycle.

Scope: This Act applies to all surface and underground waters.

Polluter pays principle: Anyone who causes measures to be taken under this Act must bear the costs.

Principle: It is prohibited to introduce into a body of water, either directly or indirectly any substances which may pollute it; the infiltration of such substances is also prohibited. It is also prohibited to store or spread such substances outside a body of water if there is a genuine risk of water pollution.

Disposal of wastewater: Polluted waste water must be treated. It may only be discharged or infiltrated into a body of water with the authorisation of the cantonal authority. Non-polluted waste water must be discharged by infiltration according to the instructions of the cantonal authority. If local conditions do not permit this, such non-polluted water may be discharged into surface waters; in this case retention measures must be taken if possible so as to ensure a steady discharge in the event of high inflow. The discharge of water that is not shown on a communal drainage plan approved by the canton requires the consent of the cantonal authority.

The Water Protection Ordinance GschV, 28.10.1998 aims at the protection of surface and sub-surface waters from detrimental influences and enables their sustainable use. For this purpose all measures being taken in accordance with this ordinance have to consider the ecological targets for waters.

Legitimate authorities license the discharge of polluted wastewaters into surface or sub-surface waters if the discharge is in compliance with Annex 3 of the ordinance. Authorities may require additional measures if appropriate.

Legitimate authorities license the discharge of polluted wastewaters as specified in Annex 3.2 into the public sewage system if the discharge is in compliance with this Annex. Authorities may require additional measures if appropriate.

Special provisions apply for livestock farms in Switzerland. Use and trade of farmyard manure is strictly regulated by the Ordinance on the Protection of Waters.

The ecological targets for surface waters are to keep natural hydrological cycles and provide a favourable habitat for fish and other living organisms.

9.3.2 Provisions for the discharge of industrial wastewaters

Who discharges wastewater has to apply the best available technologies in production processes and in the treatment of wastewaters to avoid polluting waters. In particular he has to make sure that:

a) To discharge the minimum of wastewater and the minimum of substances potentially polluting waters as technically feasible and economically viable
b) To keep clean wastewater and cooling water separately from polluting wastewater
c) Not to dilute and not to mix polluted wastewater with other wastewater to comply with regulations; diluting wastewater is permitted if appropriate for wastewater treatment and the amount of pollutants is not increasing in comparison to separate wastewater treatment

In addition, compliance with the general requirements (Annex 2.2) and the special requirements for determined branches (Annex 2.3). Phosphate recycling is not listed in Annex 2.3 but regulatory bodies may stipulate specific requirements for chemical processes. General requirements are depicted in

Table 43 below.

Table 43: General provisions for industrial wastewater discharge in Switzerland

Parameter	Discharge to surface waters	Discharge to public sewer plants
pH value	6.5-9.0	6.5-9.0, other values are admissible if beneficial to the mixture in the sewer system
Temperature	Max. 30°C, higher temperatures for short time in summer admissible	Max. 60°C, max. Temperature of 40°C in the sewer system after mixture of effluents
Transparency after Snellen	30 cm	
Total un-dissolved matter	20 mg/l	
Arsenic (As)	0.1 mg/l	0.1 mg/l
Lead (Pb)	0.5 mg/l	0.5 mg/l
Cadmium (Cd)	0.1 mg/l	0.1 mg/l
Chromium (Cr)	2 mg/l Cr total (Cr^{vi} 0.1 mg/l)	2 mg/l Cr total
Cobalt (Co)	0.5 mg/l	0.5 mg/l
Copper (Cu)	0.5 mg/l	1 mg/l
Molybdenum (Mo)	-	1 mg/l
Nickel (Ni)	2 mg/l	2 mg/l
Zinc (Zn)	2 mg/l	2 mg/l
Cyanides (CN)	0.1 mg/l CN	0.5 mg/l CN
Total hydrocarbons	10 mg/l	20 mg/l
Volatile, chlorinated hydrocarbons	0.1 mg/l Cl	0.1 mg/l Cl
Volatile, halogenated hydrocarbons	0.1 mg/l X	0.1 mg/l X

9.3.3 Swiss regulations governing sludge application on cropland

The use of sludge as a fertiliser has been banned throughout Switzerland by amending the Regulation on Materials as from May 1st, 2003. The ban was introduced in stages: from May 2003, sludge was no longer allowed being used in the production of fodder crops and vegetables. A period of transition until 2006 had been accorded for other types of cultivation and a few cantonal authorities had extended this period until

2008. This decision was part of the Federal Council's implementation of precautionary provisions for the protection of soils and public health.

The decision was driven by the fact that although sludge contains plant nutrients such as phosphorus and nitrogen it also comprises a whole range of harmful substances and pathogenic organisms produced by industry and private households. For this reason, most Swiss farmers had already avoided using sludge as a fertiliser since they were aware of the risk of irreversible damage to the soil, the danger to public health and possible negative effects on the quality of the food they produce.

For this reason the Federal Council banned the use of sludge as a fertiliser, although in those days this meant breaking a nutrient cycle which is in itself useful. Prevention – a key principle of the law on health and the environment – required, however, that any consequences for the environment which could be damaging or negative needed being limited as early as possible even there was no conclusive scientific evidence for such damage being caused (text largely taken from BAFU web-site).

The ban on the use of sludge did not mean a general stop to recycling substances for use as fertilisers, but rather a further improvement of the quality of other fertilisers from recycled sources such as compost or fermentation residues so that they could be safely used as fertilisers or soil improving agents in agriculture. In comparison, compost is highly suitable for recycling as a fertiliser since it is based on vegetable matter, which means that, in contrast to sludge, there is no risk of undefined pollutants from waste water.

In order to improve the quality of compost, the Swiss Association of Compost and Fermentation Plants (ACFP), together with the Swiss Agency for the Environment, Forests and Landscape (SAEFL), the Swiss Federal Office for Agriculture (FOAG), cantonal environmental offices, research institutes and the agricultural sector, have set up a special monitoring office whose job has been to ensure that all the 300 or so compost plants in Switzerland comply with the legal minimum quality standards. Furthermore, the ACFP had drawn up more stringent quality criteria for the use of compost in agriculture, market gardening and greenhouse cultivation.

9.4 Conclusion

The Swiss economy is strongly interconnected with the EU market and thus many EU regulations are also of relevance for Switzerland. Switzerland has largely adopted EU-fertiliser regulations and accepts placing EC fertilisers on the market of after registration. As of 2003 there is a ban of applying sewage sludge to arable land. Moreover, Switzerland has special requirements to recycled fertilisers being much more severe than the rather generous requirements to fertilisers based on natural resources. For example, levels of Cd must be fifty times lower in recycling fertilizers in comparison to conventional fertilizers. Very low limits, however, must be regarded as a significant hurdle and may exclude recycling fertilizers from the market. Different limits for conventional and recycling fertilizers must be regarded as an unequitable differentiation which is hoped to be corrected in the future.

On the other hand, Switzerland is expected to be the first country to introduce legal requirements for the recycling of phosphorus. The Technical Ordinance on Waste (TVA) is currently under revision and is expected to be enforced in 2015. The revised TVA shall include an obligation to recycle relevant mass fractions of phosphates from secondary sources, e.g. from sludge incineration ash. Two options shall exist: direct recovery of phosphates or traceable disposal of the phosphate containing waste (above a certain concentration threshold) in a separate compartment to enable phosphate recovery in the future. Details are still under discussion.

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Annex

Annex A Societal and policy barriers in the Czech Republic

Societal and policy barriers were identified through brainstorming of experts with long – term experiences in the branch of phosphorus recycling. Suggestions and ideas were divided into five groups, namely insufficient knowledge, public doubts, market barriers, legislation barriers and policy barriers. Solutions for all barriers were identified.

Insufficient knowledge

Generally the most important obstacle is the lack of knowledge about phosphorus recycling processes and the essential role of the element itself. This topic is quite new and that is why education of the public through mass media and seminars and teaching these technologies in the universities should be implemented. Open discussions on the internet, specialized forums, workshops and webinars could be beneficiary for promotion of the information.

For the new recycling products there are no established ways for its handling (for example sludge handling) and no management and statistics for setting of future scenarios for phosphorus handling. A possible solution is creation of the clear statistic describing current status and trends into the future.

Phosphorus is considered as a pollutant in relation with increasing eutrophication of water bodies caused by water bloom or cyanobacteria proliferation. A possible solution is successful elimination of the causes of the entry of phosphorus into the environment. The benefits of removal and recovery of phosphorus from wastewater should be shown in a broader context. For example using PR and marketing to show phosphorus as an essential nutrient which is necessary to prevent starvation.

It is important to stress the awareness that phosphorus is a commodity. The lack of awareness may arise because of a lack of information about recovery and recycling methods and their costs. A possible solution is to show estimated costs and cost-effectiveness. This could be an encouragement for implementation of new technology.

The technological know-how of life cycle of phosphorus as a commodity is also on a very low level (what will happen after phosphorus recycling). A possible solution is performing a phosphorus mass flow analysis for the Czech Republic. It could be improved by propagation of technological solutions, their comparison, and their implementation into current processes, which will also have benefits regarding other streams (e.g. removal of nutrients, waste water treatment, or incineration of municipal waste). Most recyclers do not understand the fertilizing and agriculture sector since they are coming from other business sectors. Information about required purity of product is often missing. Cooperation and contact with farmers and asking for their requirements on quality of fertilizers and soil conditioners is the crucial step.

Public doubts

Public doubts are connected with the way of human thinking. A large conservativeness in Central and Eastern Europe leads to difficulties with promoting new technologies. This can be overcome by

mass-media campaigns, presentations of successful business cases, influencing key persons to change their conservative thought, highlighting advantages and opportunities, presentation on conferences, etc.

An obvious obstacle is the bad perception of products from wastewater and a fear of diseases coming from the idea that products could be infected by faeces or harmful bacteria. The attitude to recycled phosphorus from wastewater is similar to that towards recycling of urine. Urine is considered as even more

dirty than wastewater; people no not want to use anything connected to urine and there is lack of producers of special sanitary equipment for urine recycling. The solution could be in sharing information through excursions, open days and promoting new attitude, e.g. wastewater should not be called wastewater but used water instead. The distribution of a recycled product together with the analysis of certified laboratory and presenting of fields fertilized with those products could be a good step to improve this situation. It could be helpful to give the focused gifts on seminars and conferences. Fear of impact on the environment can be reduced by health certificates and safety proof.

A very specific problem is the formation of groups of interests, which fight against societal development (composting, sludge incinerator). It is unclear how to struggle with it.

Market barriers

The price of technology and products is a recent problem, since people asks for as low prices as possible. Wide-spread interest of WWTP operators in P recycling should be encouraged through marketing support (e.g. economic advantage, incentives, grants enabling refund of technology from profit).

Another problem are strong lobbying groups, which prevent other technologies to enter the market. For example the strong lobby of the laundry industry in the Czech Republic causes that laundries are not obliged to remove phosphorus from their wastewater. A solution would be to remove these lobbying groups or somehow to fight with them. A lobby of mineral fertilizers producers against mineral phosphorus recycling could be addressed by offering better product quality than other competitors.

When a new product enters the market it has to compete with established products. A well prepared marketing strategy and a proper, innovative and interesting product can help to overcome the difficult beginnings.

Societal barriers

Legislators currently make plans only for the duration of their election period – the best would be to make long-term conception for decades in advance (long-term planning instead of short-term), because of gradually decreased sources of phosphorus. It looks like it is difficult to do without lobbying.

Phosphorus scarcity has not received yet any explicit mention within official reports of the UN's Food and Agricultural Organization, the International Food Policy Research Institute, the Millennium Ecosystem Assessment, the Global Environmental Change and Food Systems Programme, the International Assessment of Agricultural Knowledge, Science and Technology for Development or the recent High-level Conference on World Food Security. Strong promotion of information and discussions must be carried.

People consume more food than necessary which means that more phosphates are needed. Phosphorus management should be integrated into existing discussions. For example, the issue of phosphorus scarcity could be given a higher profile in leading interdisciplinary international networks such as the Earth System Science Partnership (ESSP) which is addressing other important global biogeochemical cycles (GCP, 2008). The ESSP Global Environmental Change and Food Systems (GECAFS) program is an obvious place where this could occur.

Annex B Germany

Title	Number/Abbreviation	Enactment/Implementation
Act for Promotion of a Closed Substance Cycle Economy	KrWG,	29.02.2012
Commercial Waste Ordinance	GewAbfV,	19.06.2002
Federal Immission Control Act	BImSchG	15.03.1974
Fourth Regulation on Installations Requiring a Permit	4. BImSchV,	24.07.1985
German Waste Water Regulation	(AbwV).	17.06.2004, last revision 1.3.2010
Landfill Ordinance	DepV,	27.04.2009)
Ordinance on Biowaste (	BioAbfV,	21.09.1998
Ordinance on Sewage Sludge	(AbfKlärV,)	15.04.1992
Regulation on the Environmental Impact Assessment	UVPG,	12.02.1990
Seventeenth Regulation on Waste Incineration Facilities	17. BImSchV,	23.11.1990
Technical Instructions on Air Quality Control	1. BImSchVwV, TA Luft	24.07.2002
Technical Instructions on Noise Abatement	6. BImSchVwV, TA Lärm	
Technical instructions on protection against noise	TA Lärm	26.08.1998

Annex C Spain

Title/Description	Number/Abbreviation	Ienactment/Implementation
Establishing the basic norm in Spain on products fertilizers	Real Decreto 824/2005	
II National Plan of Sewage Sludge Wastewater (2007-2015)		
Industrial emissions	Ley 5/2013,	11.06.2013
National Waste Plan 2007-2015	(PNIR)	
On waste incineration	Real Decreto 653/2003	30.05.2003
production, processing and agricultural use of sewage sludge in Spain	Orden AAA/1072/2013, de 7 de junio	07.06.2013
Protection of the waters from the contamination produced by the nitrates proceeding from agrarian sources	The Real Decreto 261/1996,	16.02.1996
Regulating waste disposal by landfill.	Real Decreto 1481/2001	27.12.2001
Regulation on classification, packaging and labelling of dangerous preparations	Real Decreto 255/2003	28.02.2003
Regulation on notification of new substances and classification, packaging and labeling of dangerous substances,	Real Decreto 1802/2008	03.11.2008
Regulation on notification of new substances and classification, packaging and labeling of dangerous substances	Real Decreto 363/1995	10.03.1995
The protection of waters against pollution caused by nitrates from agricultural sources	Real Decreto 261/1996	16.02.1996
Transposition on Urban Wastewater Treatment Directive	R. D. Ley 11/1995, R. D. 509/1996, R. D. 2116/1998	
Use of sewage sludge in agriculture	Real Decreto 1310/1990	29.10.1990
Use of sewage sludge in agriculture	Orden de 26	10.1993
Waste and contaminated soil.	Ley 22/2011	28.07.2011

Annex D Switzerland

Title/Description	Number/Abbreviation	Enactment/Implementation
	Act 16.12.1985	15.07.2010
Environmental Protection Act	USG	07.10.1983
Federal Waters Protection Act, ,	GSchG	24.01.1991
Movements of Waste		
Ordinance on the Carriage of Dangerous Goods by Road		
Ordinance on the Movement of Waste		
Ordinance on the Risk Prevention Officer for the Carriage of Dangerous Goods by Roads, Railroads and Waterways		
Regulation on Materials		01.05.2003
Technical Ordinance on Waste	TVA	10.12.1990
The Federal Act on the Protection of the Environment	USchG,	07.10.1983
The Swiss Environmental Impact Assessment Ordinance (,	UVPV	19.10.1988
The Water Protection Ordinance	GschV,	28.10.1998