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Report of the
Ad-hoc working group
Evaluation of Options for the Sustainable Use of Secondary Phosphorus Reserves

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¹ The term 'animal meal' is no longer used in the laws on animal by-products. In accordance with the terminology of Regulation (EU) No 142/2011 a distinction is made between 'processed animal protein' (exclusively from Category 3 material) and 'meat-and-bone meal' from Category 1 and Category 2 material.

0 Summary

Given the predicted rise in global population to 9 billion people in 2050 (U N forecast) along with the rising aspirations of more affluent societies, the demand for phosphorus worldwide is set to grow significantly. Taken as a whole, the phosphorus reserves currently being mined industrially contain increasingly high levels of contaminants. The processes of extraction in phosphorus producing countries and subsequent processing into mineral fertilisers entail considerable adverse environmental effects and consume large amounts of energy. For this reason it will become necessary in the future to recover more phosphorus from waste and other materials so that mineral phosphorus fertilisers – especially those manufactured from primary resources – can be substituted by recycled products. A further aim should therefore be to make efficient use of the secondary sources of phosphorus available in Germany. Establishing suitable processes for phosphorus recovery will make it possible to minimise future dependencies, secure food for the population and reduce the environmental impacts associated with phosphorus extraction. The main sources for phosphorus recovery are waste water, sewage sludge, sewage sludge ash and animal by-products (e.g. animal meal).

At present numerous phosphorus recovery processes are under development. However up to now, large-scale implementation has only proven successful and economically viable in a few cases. So further work is necessary to solve the technical problems that still exist and to improve economic viability.

In its resolution of 12th November 2010 the Conference of Environment Ministers of Germany (UMK) commissioned the Bund/Länder Working Group of Waste (LAGA) to assess the options for phosphorus recovery. Having completed its work, LAGA submits the following assessments:

1. Recovery precept for phosphorus from relevant material flows

Recovery precepts are fundamentally expedient and necessary, especially for municipal waste water and sewage sludge and for animal by-products.

2. Recovery quota based on state of the art technology

In principle recovery quotas make sense in conjunction with the implementation of recovery precepts. However, recovery quotas assume a state of the art technology level, which is not yet available for many relevant cases.

3. Setting an admixture quota for phosphorus obtained from secondary sources in mineral phosphorus fertilisers

The introduction of an admixture quota is not recommended at present because this would require altering the defined properties of fertilisers. However, other instruments are conceivable which, much as an admixture quota, would ensure that secondary phosphorus enters the market. Such instruments can only be introduced at EU level rather than at national level.

4. Promoting the establishment and continued development of suitable phosphorus recovery processes

The establishment and development of suitable phosphorus recovery processes is necessary and should continue to be supported. The setting up of a phosphorus information and monitoring platform is recommended in order to assemble research findings and make them available to interested parties.

5. Evaluation of the technical feasibility and economic viability of suitable recovery processes, in particular when incorporated into the normal operation of sewage treatment plants

Operational aspects of phosphorus recovery processes that are suitable for incorporation into the normal operation of certain sewage treatment plants have already proven promising in practice. It should generally be possible, from the point of view of both economic viability and available support, to integrate phosphorus recovery processes when major renovations are carried out and new treatment plants are built.

6. Evaluation of secondary products in relation to their use (in the case of fertilisers, the criteria of efficacy and harmlessness in particular)

As yet there are insufficient data available for drawing valid conclusions regarding fertilising effect, impact on environmental media, and consumer protection. That is why further studies – especially field trials – are needed. Almost all measurements to date of contaminants in recycled phosphorus products have been assessed as uncritical.

7. Dilution ban for matrices with a phosphorus content above 5% (mono-incineration, retrievable storage in a separate facility, inclusion of the phosphorus parameter in the Ordinance on Underground Waste Stowage)

A dilution ban for matrices with a phosphorus content above 2% is recommended so that phosphorus is not withdrawn from material cycles. Combined incineration of such matrices should be replaced by mono-incineration unless the phosphorus is recovered beforehand. As long as ash from mono-incineration is not processed directly into fertiliser, separate long-term storage facilities for this ash are under consideration so that the phosphorus can be recovered at a later date. To this end, it is necessary in the short term to develop processes which enable mono-incineration ash to be stored in an economically efficient way while ensuring that no changes to it occur that would be detrimental when recovering the phosphorus at a later stage. Following this, a decision should be taken on whether separate storage of this ash is to be made mandatory. Consideration should be given to the possibility of including phosphorus in the Ordinance on Underground Waste Stowage.

8. Greater use of phosphorus from all categories of animal meal, provided the animal meal is not being used in other ways

Given the presently untapped phosphorus potential which exists in Category 1, the legal amendments necessary for this should be discussed concerning their practicability.

9. Observation and evaluation of developments in phosphorus recovery in other countries

In recent years the development of phosphorus recovery processes has gained considerable momentum internationally. Projects and initiatives of this sort are now being carried out in numerous countries. We should continue to observe these developments and evaluate them with regard to introducing them in Germany.

1 Task of the Ad-hoc working group

As yet politicians and the public are little aware of the problems associated with phosphorus (P) as a resource. In the long term declining quality in raw mined phosphorus along with depleting reserves capable of being mined economically will result in a shortage of phosphorus on the world market. Further growth in the world's population, rising demand for food and the rising aspirations of more affluent societies are likely to generate problems with the supply of phosphorus in a few decades' time which can be foreseen and prevented now. In addition, the extraction of raw phosphorus in phosphorus producing countries and the process of converting it into mineral fertilisers entail considerable and ever-increasing adverse environmental effects. It is necessary for this reason to make policymakers and the public more aware of the environmental aspects of importing conventional mineral phosphorus fertilisers and to stimulate interest in the importance of having an adequate supply of phosphorus. In the current situation, it is important to develop appropriate measures for the partial substitution of phosphorus imports through phosphorus recovery in order to safeguard an environmentally sustainable supply of phosphorus in the long term.

The fragmentation of knowledge about the phosphorus market among various policy areas such as economics, foreign trade, agriculture, industrial production and the environment (waste management sector) makes it necessary to gain a synoptic understanding of the interests of all involved parties and to develop an integrated approach.

In 2008 the German federal states Baden-Wuerttemberg and Bavaria took the initiative to develop a joint strategy for the German government and the *Federal States* on phosphorus recycling. Owing to this initiative an initial report was presented at the meeting of the Conference of Environment Ministers of Germany (UMK) on 12th November 2010. The UMK took note of the report produced by Baden-Wuerttemberg, Bavaria, Berlin, North Rhine-Westphalia, Rhineland-Palatinate and the federal government ("Bund") under agenda item 30 (Sustainable use of phosphorus from waste water, sewage sludge and other substances) and commissioned the Bund/Länder Working Group of Waste (LAGA) to produce a review.

Subsequently LAGA established by means of circular resolution 2011/01 of 21st February 2011 the ad-hoc working group 'Evaluation of options for the sustainable use of secondary phosphorus reserves'. In accordance with the resolution of the 75th

Conference of Environment Ministers of 12th November 2010 in Dresden, the task of the working group is to evaluate the following practical options together with the working groups on water issues (LAWA), and soil quality (LABO) as well as the agricultural and horticultural experts:

1. Recovery precept for phosphorus from relevant material flows (e.g. waste water including sewage sludge, animal meal, surplus liquid manure, sewage sludge ash)
2. Recovery quota according to the state of art technology
3. Setting an admixture quota for phosphorus obtained from secondary sources in mineral phosphorus fertilisers
4. Promoting the establishment and continued development of suitable phosphorus recovery processes
5. Evaluation of the technical feasibility and economic viability of suitable recovery processes, in particular when incorporated into the normal operation of sewage treatment plants
6. Evaluation of secondary products in relation to their use (in the case of fertilisers, the criteria of efficacy and harmlessness in particular)
7. Dilution ban for matrices with a phosphorus content above 5% (mono-incineration, retrievable storage in a separate facility, inclusion of phosphorus in the Ordinance on Underground Waste Stowage)
8. Greater use of phosphorus from all categories of animal meal, as long as the animal meal is not being used in other ways
9. Observation and evaluation of developments in phosphorus recovery in other countries

The working group investigated the options listed above in joint sessions and in several sub-committees and produced the following assessment by 13th January 2012.

2 Structure of phosphorus use in Germany

- (1) Phosphorus occurs naturally in the earth's crust (content in the earth's crust: approx. 0.09%) exclusively in bound form, mostly in the form of phosphate². The main group of minerals for the production of phosphorus and phosphorus compounds are the apatites. 95% of the phosphorus on earth is bound in apatites. Of these, fluorapatites and phosphorites interbedded with calcium carbonate are the most important in economic terms. In addition there are more than 200 known phosphoric minerals such as wavellite, vivianite and turquoise, which contain > 1% by weight phosphorus. Elementary phosphorus is obtained by thermal treatment (1400 - 1500°C) of a mixture of phosphorus concentrate with coke and quartz. 8 Mg of phosphorus (with 31% by weight P₂O₅), 2.8 Mg of quartz gravel (> 95% by weight SiO₂), 1.25 Mg coke and energy (1300 kW/Mg P) produce approximately 1 Mg of phosphorus.
- (2) Apart from their application in mineral fertilisers, phosphorus and phosphorus compounds have many uses in various sectors of industry. For example, phosphorus is used in feedstuffs (dicalcium phosphate), corrosion prevention (phosphatisation) and flame retardants. In addition, organophosphate compounds function as softeners in plastic and paint products. Pentasodium triphosphate is one of the chemicals used for water softening in detergents and cleaning products. Sulphurous compounds of phosphorus are used among other things in the manufacture of pesticides. Phosphates such as sodium phosphate (E 339), potassium phosphate (E 340), calcium phosphate (E 341), magnesium phosphate (E 343), salts of the orthophosphoric acid diphosphate (E 450), triphosphate (E 451), polyphosphate (E 452) and phosphoric acid (E 338) are all used in food additives such as preservatives, acidifiers, acidity regulators, emulsifiers, stabilisers, emulsifying salts and antioxidants. Phosphorus is also frequently used to maintain water-binding capacity in meat production.
- (3) As Germany does not possess any phosphorus deposits of its own, around 118,000 Mg of unmilled phosphates had to be imported in 2010. Around 83% of this came from Israel, with the remaining 17% from Syria, Algeria and Egypt (source: Federal Institute for Geosciences and Natural Resources, BGR). Approximately

² No distinction is made in this report between the terms phosphate and phosphorus.

50% of this raw phosphorus was processed into fertilisers by a single company. Germany also imports and exports a large number of industrially produced phosphates and phosphorus compounds, including calcium phosphates, phosphoric acid and fertiliser.

Table 2.1: Annual phosphorus use in Germany by sector (Federal Environment Agency estimate based on information from the different sectors and associations, with some variation in reference periods. July 2011)

Sector/ area of use	P used as	Approx. amount used per year [Mg]	Approx. P content [Mg]
Fertiliser	P ₂ O ₅	235,160	102,530
Animal feed	PO ₄	115,000	37,490
Detergents and cleaning products used in private households	Na ₅ P ₃ O ₁₀ Phosphonates H ₃ PO ₄	31,800 3,900 700	8,050 880 220
Detergents and cleaning products used in industry and institutions (I&I)	Na ₅ P ₃ O ₁₀ Phosphonates H ₃ PO ₄	3,180 780 180	810 180 60
Food industry	P ₂ O ₅	23,000	10,030
Flame retardants			4,000
Drinking water supply			4,300
Corrosion prevention			No information
Pharmaceutical products			No information
Plant protection products, insecticides, etc			No information
Total			168,550

Table 2.1 shows the total amount of phosphorus used in Germany for the various industrial sectors, while Figure 2.1 illustrates its percentage distribution.

Summarized this means that a total of approximately 170,000 Mg of phosphorus is used in Germany each year. However, no estimates are available for the proportion of this used in corrosion prevention (paints, enamel, coatings, cooling circuits), pharmaceutical products and products such as pesticides and insecticides.

Furthermore, it must be assumed that the figures are incomplete to an extent, given that phosphorus is used in many different forms and compounds for which figures cannot be provided in every case. With regard to feedstuffs, it should also be noted that some additional phosphorus comes from calcium phosphates of animal origin and therefore not from raw mineral phosphorus.

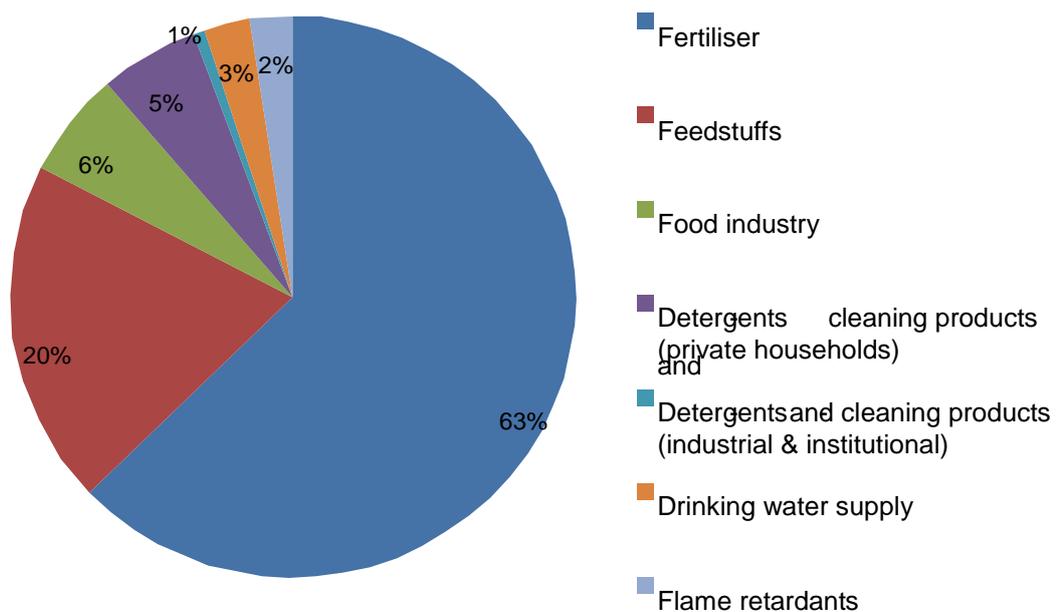


Figure 2.1: Estimated percentage distribution of amounts of phosphorus used in Germany (Federal Environment Agency estimate based on information from the different sectors and associations, July 2011)

3 Evaluation of options

3.1 Recovery precept for phosphorus from relevant material flows

- (1) The priority status of phosphorus recovery from waste can be deduced from the provisions contained in Article 6 of the Closed Cycle and Waste Management Act (*Kreislaufwirtschaftsgesetz, KrWG*) regarding the waste hierarchy (recycling prior other forms of recovery prior disposal) and in Article 8 regarding the order of priority and quality of recovery. Special statutory provisions are possible for organic waste and sewage sludge in accordance with Article 11 (2) No. 3 of the Act. The condition for applying Articles 6 and 11 is that the waste falls within the terms of the regulation to which the Act applies.
- (2) As approximately 60% of the phosphorus needed is used as fertiliser, it should generally be in plant-available form. In the case of other applications (chemical industry or for specific source materials) it may be more useful to recover the phosphorus in a different form. It needs to be made clear for each source material and application in what form the phosphorus is needed and, in the case of a recovery precept, how it is to be recovered.
- (3) The source materials listed below occur in significant quantities. The working group has looked at a recovery precept for these. However, it should be remembered that materials of organic origin always contain valuable organic materials and other plant nutrients as well, albeit in varying degrees. This report does not provide an evaluation of the benefit of the organic material or other constituents of the various phosphoric materials.

3.1.1 Sewage sludge

- (1) In accordance with the Fertiliser Act, sewage sludge can be used either as a source material for the production of fertilisers or used directly as fertiliser under the provisions of the Sewage Sludge Ordinance (*Klärschlammverordnung, AbfKlärV*). Sewage sludge spreading on agricultural land is the subject of controversial debate among the *German Federal States* and between them and the federal government. There is no uniform position on this.

- (2) Fertilisers produced directly from sewage sludge (without phosphorus recovery) contain all the phosphorus from the sludge. The production process can be carried out at the sewage treatment plant itself. In this case it must be ensured that the resulting fertiliser complies the provisions of the Fertiliser Act undiluted and enriched with additives, in particular regarding harmful substances, minor components and complexing agents , . In addition to the requirements of the Sewage Sludge Ordinance, the statutory fertiliser provisions should be extended to include other harmful substances, especially organic pollutants, where necessary. A phosphorus recovery precept is not needed for sewage sludge used in this way.
- (3) Mandatory checks and proof of the destination of the sewage sludge continue to be required in order to be able to identify the person for example, which is responsible for unlawful soil contamination. Corresponding provisions on this should be added to the Fertiliser Act if necessary.
- (4) If sewage sludge is recycled directly, prior treatment technologies used during sludge dewatering and phosphorus elimination from the sewage have an influence on the plant availability of the phosphorus contained in the sewage sludge. Chemical-physical and biological processes are used to eliminate phosphorus from sewage. Chemical-physical elimination is carried out through precipitation or flocculation by adding metal salts to the sewage. Adding metal salts restricts the availability to plants of the phosphorus in the sewage sludge. Biological elimination causes higher uptake of phosphorus by the micro-organisms in the activated sludge. The fewer metal salts used during the treatment process, the greater the fertiliser effect may be.
- (5) Where sewage sludge is not used directly as fertiliser, the following alternatives exist. In these cases the working group considers a recovery precept necessary to ensure sufficient phosphorus recovery:
- Liquid sludge: in some processes it is possible to separate the phosphorus from the liquid sludge during purification. At present the recovery quota stands at 45% to 50%. More recent research give reasons to expect that this quota can be raised as high as 70%.
 - Sewage sludge ash: Sewage sludge should be dried and incinerated in a mono-incineration plant if phosphorus use is not permitted because of legal restriction

either in form of processed sewage sludge or by separation from liquid sludge and there is also no intention of generating energy, . Procedures exist which can recover up to 90% of the phosphorus from the ash. The ash itself can also be used as fertiliser after processing.

- Other forms of sewage sludge use: Digested sewage sludge also has other properties besides phosphorus which can be used elsewhere, such as the energy content and other mineral components. Both together make it an important additive, e.g. in cement factory. In such cases a phosphorus recovery precept is necessary prior to further use.

3.1.2 Livestock manure

- (1) According to the definition in the Fertiliser Act, livestock manure is fertiliser that occurs as animal excrement when raising animals for food production or in the course of other livestock farming in agriculture (solid and liquid manure, slurry). Also herbal material as part of horticultural or agricultural production or mixtures of the two can be livestock manure. Digestates and composts produced after anaerobic or aerobic treatment of the above mentioned materials are also counted as livestock manure.
- (2) These materials have a high phosphorus content. Livestock manure is usually applied directly to agricultural land as fertiliser. At present a recovery precept is not necessary, since the phosphorus is used entirely for fertiliser use.
- (3) A regional restriction on liquid manure-spreading and redistribution in areas which are undersupplied with phosphorus is a possibility. However, there is a need for research in respect of the technology necessary for this (e.g. separation technologies) in order to improve transportability.
- (4) A recovery precept is also not necessary if livestock manures are used for biogas generation. However, it may be expedient for those digestates that are not directly applied as fertiliser.

3.1.3 Digestates

- (1) Digestates arise during anaerobic digestion of organic materials. In most cases the purpose of the process is to generate biogas. Depending on the anaerobic digestion plant's licence, livestock manure, energy crops grown for the purpose (e.g. maize and sunflowers), animal waste or by-products, organic waste or mixtures of varying composition are used. The digestates are generally used as fertiliser. They contain all the phosphorus from the original materials used, since this is not converted into biogas.
- (2) A recovery precept is not necessary for these digestates, as long as they are actually used as fertiliser in accordance with the Fertiliser Act. In this regard it is necessary to ensure that the requisite quality management takes place in the treatment plants and that analyses are conducted. There could be a supplementary requirement that the phosphorus must be processed into a form readily available to plants.
- (3) A phosphorus recovery precept may be expedient for digestates if their disposal as waste becomes necessary because contamination is found.

3.1.4 Composts

- (1) Composts are produced through the aerobic treatment of organic waste. Prepared composts are usually subject to quality controls. A phosphorus recovery precept is not necessary for compost, mulch or shredded materials.
- (2) So that source materials from food and feedstuffs production undergo phosphorus recovery, requirements should be set to ensure segregated collection and delivery to suitable treatment plants. If ligneous green waste (such as tree and shrub prunings) is recycled to generate energy, consideration should be given to using the ash as fertiliser or for phosphorus recovery.

3.1.5 Residues from the organic treatment of domestic refuse

- (1) The residues occur during the mechanical-biological treatment of domestic refuse and other municipal waste. The organic component of this waste, which is extracted for anaerobic and/or aerobic treatment in mechanical-biological waste

treatment (MBT) plants, is fundamentally unsuitable for processing into fertilisers because of its heterogeneous composition and unknown pollutant content. The residues are usually consigned to landfills or incinerated. A phosphorus recovery precept might possibly be expedient in this case. However, it should first be established what proportion of phosphorus is contained in these residues and whether environmentally sound and economically viable processes for phosphorus extraction exist or could be developed.

- (2) Research conducted by the German Federal Environment Agency has shown that there is no data available on the phosphorus content of MBT residues. The intended expansion of segregated collection of bio-waste based on the new Closed Cycle and Waste Management Act will result in a further decline in the phosphorus potential of MBT residues.

3.1.6 Animal by-products

- (1) In the case of animal by-products the phosphorus content is dependent on the quantity of bone and varies between 0.1% and 6.1%. However, the phosphorus is bound in the bone substance and therefore has only poor availability to plants. Animal by-products in Categories 2 and 3 are already used as organic fertiliser and soil improver. In this case it is mainly the nitrogen that is the key potential fertiliser.
- (2) Recovery precepts are a possibility in view of the past use as organic fertiliser and soil improver. Mono-incineration is preferable if thermal treatment takes place, so that the phosphorus can be recovered from the ash. The same remarks apply to the finished products as for sewage sludge.
- (3) A recovery precept is likewise conceivable for meat-and-bone meals from Category 1 material which, for example, is disposed of or used for energy recovery without using the phosphorus.

3.1.7 Former sewage sludge dumps

- (1) Until 2005 it was permissible to deposit untreated sewage sludge in landfills, primary at mono-landfill sites. It is possible that in the past sewage sludge exhibited a higher phosphorus content than it does today, as provisions on phosphorus limits

such as those for detergents did not exist. In the mid 1980s a limit was placed on the phosphorus content of discharge from sewage treatment plants. This is why a large number of phosphorus precipitation installations were built. As a result the phosphorus content of sewage sludge may have risen further, at least for a while. Over the years this has led to the accumulation of a recoverable stock of phosphorus.

- (2) It is conceivable that in the medium term the decommissioning of these landfill sites may contribute to the phosphorus supply. This would require further studies. If decommissioning were to occur, a recovery precept may be helpful. It may be especially necessary if the site is decommissioned on account of external pressures.

3.1.8 Waste water

- (1) The current Waste Water Ordinance (*Abwasserordnung*) stipulates a phosphorus content of 2 mg/l P_{tot} in the discharge from sewage treatment plants with a capacity of 10,000 PE (population equivalents) to 100,000 PE and a phosphorus content of 1 mg/l P_{tot} for sewage treatment plants larger than 100,000 PE. This regulation makes a considerable contribution to the reduction of eutrophication in water bodies. For sewage treatment plants with capacities below 10,000 PE no standard regulation applies in relation to the phosphorus concentration in the discharge. However, the phosphorus remaining in the treated water cannot be recovered for use.
- (2) Ways of developing opportunities for direct phosphorus recovery from waste water include the further limiting of phosphorus monitoring values via the Waste Water Ordinance, the Urban Waste Water Treatment Directive (91/271/EEC) and a recovery precept for phosphorus as part of waste water treatment. However, the expenditure required to limit phosphorus can result in a considerable burden on the cost-benefit ratio at treatment plants. For this reason, provisions of this kind require additional investigation.
- (3) A significant part of the phosphorus present in sewage can be recovered through appropriate processes at the treatment plant within the context of waste water treatment. However, the proportion of phosphorus needed to build biomass in

biological waste water treatment is not available for direct phosphorus recovery from sewage.

- (4) Practical experiences show that phosphorus recovery measures at treatment plants can have a positive effect on the stability of the plants' operation and so are likely to generate additional economic benefits.
- (5) The working group recommends that, before new treatment plants are built or renovations undertaken, a phosphorus recovery plan should be devised and the feasibility of implementation tested.

3.1.9 Other waste

- (1) There are many production processes in the chemical industry in which phosphorus is used, e.g. for flame retardants, softeners, matches, fertilisers, desiccants, phosphoric acid and smoke munitions. The waste and sewage arising from these processes can be a source of phosphorus. In some production plants the phosphorus is recovered within the production process. Another source is the ash from incinerating biomass, whereby this may be contaminated with heavy metals.
- (2) There are also reports of phosphorus precipitations at eutrophic lakes to inhibit algal bloom, where the precipitated phosphorus compounds are deposited unused on the lake bottom.
- (3) It is assumed that the total amounts are comparatively small. No recommendations on recovery precepts can be made without precise knowledge of the recyclable amounts, sources, phosphorus content and recovery processes. The working group is in favour of surveying the quantities and carrying out studies about the efficiency of recycling the waste referred to above.

3.1.10 Supporting regulations

Besides a recovery precept, supporting regulations are necessary in order to use the phosphorus of the sewage sludge in a plant available form:

- (1) A ban on co-incineration of sewage sludge without prior phosphorus recovery: if phosphorus is not already recovered in the treatment plant or through other

processes, phosphorus recovery from the incineration ash from mono-incineration plants offers the best potential for recovery, as things stand at present. Large quantities of phosphorus should be obtained if the incineration of sewage sludge in mono-incineration plants is significantly expanded and if a ban is imposed on co-incineration in waste incineration plants and power stations as well as on other forms of energy and material recovery (for example in cement works) without prior phosphorus recovery. In the long term, co-incineration of phosphorus-bearing sewage sludge in brown or hard coal-fired power plants or in cement works should in general be replaced by mono-incineration.

One stipulation for mono-incineration plants should be that they are operated on the basis of energy self-sufficiency as far as possible. At the very least it should be possible to dry the sewage sludge with the heat of the incineration. In addition the possibility of incinerating sewage sludge together with other phosphoric materials such as animal by-products in mono-incineration plants should be investigated.

It has been found that, given the current level of emissions limits, enriched mercury in sewage sludge that is co-incinerated in power plants without a special sink for mercury generates higher emission mass flows than during mono-incineration. The German Federal Ministry for the Environment (BMU) plans to lower the mercury emissions limits significantly in both large combustion plants and waste incineration plants and is aiming to have a standard emission level for all plants. Meanwhile the joint working group on water issues (LAWA) has set up a working group entitled 'Airborne immissions as the cause of mercury pollution in biota' in connection with the large-scale mercury pollution in surface waters. The first task for this working group, which is made up of representatives of LAWA, BLAK Abwasser, (the joint government and *Länder* working group on waste - water) LAGA, and the joint working groups on soil (LABO) and LAI (joint working group of air quality) is to jointly establish clarity regarding the paths by which mercury enters the environment.

(2) Storage of ash from mono-incineration of sewage sludge:

As yet there are no high-quality, economic large-scale processes available for direct phosphorus recovery from sewage sludge ash. For this reason, the option of storing this ash so that the phosphorus in it can be recovered at a later date is

under discussion. Given the state of current knowledge and the marketing situation, long-term storage facilities will have to be set up in many cases.

The substantive requirements for the storage and for ash destined for storage are essentially provided by the Landfill Ordinance (*Deponieverordnung*). The method of storage must ensure that the stored ash does not deteriorate so that it is no longer usable for later recovery. In view of this the working group favours further research into the valuable substances and mechanical properties of the ash as well as changes brought about by storage.

- (3) Phosphoric substances obtained from waste should be placed on the market as a product if the requirements for end-of-waste status in accordance with the Closed Cycle and Waste Management Act are met. This means that specific requirements must be developed and if necessary statutory provisions amended. With end-of-waste status the manufacturer accepts complete product liability, and so is just as responsible and legally liable for possible consequential damages as the manufacturer of an organic fertiliser. A product of this type is also subject to REACH provisions.

3.1.11 Summary of Section

- (1) The decision to introduce a phosphorus recovery precept from relevant material flows depends on various factors, such as the availability to plants and the technical and economic viability. The purpose of a recovery precept should be to obtain the greatest possible quantity for recycling. The introduction of a recovery precept also certainly requires the setting of a general recovery quota or several quotas specific to material flows and processes. In this regard quotas that are adapted flexibly to the available technology can be helpful. One advantage is that, with suitable processes, the phosphorus recovered often exhibits a lower pollutant content than primary phosphate stocks. Table 3.1 shows the material flows for which the working group approves of a recovery precept.

Table 3.1: Recovery precept for relevant material flows (Estimated phosphorus quantities from the PhoBe cooperative project, 2011)

Material flow	Estimated phosphorus quantities [Mg/a]	Current recovery	Recovery precept is expedient
Municipal sewage (inflow)	54,000	No	Yes
Municipal sewage sludge	50,000	Partial	Yes
Industrial sewage (inflow)	15,000	No	Possibly
Livestock manure	(240,000)Yes	Possibly
Digestates	125,000	Partial	Possibly
Composts	No information	Yes	No
Residues from biological treatment of domestic refuse	No information	No	Possibly
Animal by-products (Categories 1-3, excl. animal fats)	20,000	Partial	Yes
Former sewage sludge dumps	No information	No	Research needed

3.2 Recovery quotas based on state of the art technology

- (1) Should a recovery precept be set for phosphorus, there is the inevitable question of what minimum quota should be set for recovery. This should not only take into account the technology available but also be determined in such a way that it promotes technical development towards the most efficient measures possible.

3.2.1 Parameters for a recovery quota

- (1) A recovery quota is only expedient if the key figures needed can reliably be identified. The framework conditions for a recovery quota require precise examination. Thus for sewage sludge that is not used directly as fertiliser or for manufacturing fertiliser, a decision must be made whether the quota refers to the remaining sewage sludge in Germany as a whole or to individual recovery processes.
- (2) Provisions for phosphorus recovery make little sense if this phosphorus is not in a plant-available form and thus the nutrients cannot be used by plants when applied as fertiliser. Should a recovery quota be set, it should therefore refer to bioavailable phosphorus and possibly also to other industrially recyclable phosphorus compounds.
- (3) Because of the current state of development of phosphorus recovery processes from the relevant source materials, it will not be possible now or in the coming years to develop and set binding recovery quotas for individual materials based on the technology available. Recovery quotas presuppose a level of technology which is not yet available for many relevant cases.

The recovery quota should relate to a specific mass flow with known composition or origin and to clearly defined facilities of origin. For example, in the case of sewage sludge, ambitious quotas could be set for large treatment facilities of a certain capacity. There could be a lower quota for small facilities, not least to avoid transporting larger amounts to central incineration plants and to promote locally appropriate, simpler technologies.

- (4) Despite the remaining open questions mentioned above, the working group is basically in favour of recovery quotas for waste containing phosphorus, if there are suitable recovery processes available on the market. This is especially

important considering the need to recover as much phosphorus as possible. Such processes should be supported.

- (5) When the recovery quota is set, requirements upon suitable reference figures and key parameters should be established, so that the quotas can be determined reliably.
- (6) Recovery quotas are in general expedient in order to implement recovery precepts. However, recovery quotas presuppose a state of the art level of technology not yet available for many relevant cases of applications.

3.2.2 Consideration of source materials

- (1) The various source materials have different compositions and often contain a variety of phosphorus compounds. For this reason, it makes sense to set recovery quotas depending on the source material. On the basis of current knowledge, the various options for phosphorus recovery from sewage sludge give rise to the following potential percentages, depending on the source material:

Table 3.2: Recovery options for sewage sludge (modified table based on Montag et al., 2010)

Source material	Recovery potential (% of phosphorus in inflow load)	Current (2011) recovery possible (% of inflow load)
Discharge from sewage treatment plants	Max. 55%	50%
Sludge water	Max. 50%	45%
Dewatered (digested) sludge	~ 90%	60%
Sewage sludge ash	~ 90%	80%

According to this overview, processes of phosphorus recovery from sewage sludge ash can achieve higher potential recovery amounts than the other processes listed. The quota for this can be set higher than for recovery from digested sludge or discharge from sewage treatment plants. However, new research results point to a higher recovery quota of up to 70% for processes of phosphorus recovery from digested sludge. The processes for sewage sludge ash

still need to be optimised with respect to nutrient availability, whereas the phosphorus compounds in digested sludge may well be far more readily available to plants. Transparent documentation, using the recommended monitoring platform, would be helpful in order to track developments.

- (2) A quota should also be set if a recovery precept is set for digestates, livestock manure or other wastes which do not make the phosphorus immediately available as fertiliser or for the manufacturing of fertilisers. However, at present there is still no data available on the state of the art technology required for such processes, from which quotas could be calculated. Moreover, different processes are likely to be used for the many different types of waste, for which varied quotas would then be appropriate.
- (3) In the medium term technical developments may permit higher recovery quotas for phosphorus from sewage sludge and other materials, both in relation to individual processes or certain materials and in terms of the total quantity of the available waste. In order to take this into account from the outset, it may be helpful to establish a variable quota with stipulated rates of increase.

3.3 Admixture quotas for phosphorus from secondary sources

- (1) Admixture quotas for materials produced in an environmentally sound manner can ensure that stipulated amounts of these materials are used. Admixing quotas are technology neutral. They ensure that there is a demand for the relevant materials and that the most efficient producers are most successful in a market thus created. However, admixture quotas presuppose that an effective fertiliser is produced as a result of the admixing process. At present the introduction of an admixture quota is not recommended because of the specific fertiliser properties which this requires. However, there are other instruments which, like admixture quotas, are suitable for enabling market launch.
- (2) Other potential instruments for enabling market launch are:
 - Compulsory or voluntary commitment by producers
The producers of phosphoric fertilisers commit voluntarily or are obliged to use phosphorus from secondary sources in, for example, 10% of the phosphoric fertilisers they put onto the market.

- Fund solution (levy solution)
Firms marketing phosphoric fertilisers for the end-user must pay a certain amount per Mg of fertiliser into a fund. Companies producing phosphorus from secondary sources receive a subsidy from the fund in order to be able to sell their product at a competitive price.
- Purchasing solution
Obligation for distributors of phosphoric fertilisers to purchase phosphorus from secondary sources. The quantity purchased is calculated on the basis of the quantity of fertiliser distributed.

(3) Regardless of which market launch strategy is used for phosphorus from secondary sources, it must be borne in mind that, at a rough estimate, around 120,000 Mg of phosphorus is applied annually in Germany in mineral fertilisers. Of these fertilisers only about 5% are not subject to the EU Fertiliser Directive. This means that the marketing instruments discussed above can be implemented successfully only at EU level, rather than nationally.

3.4 Support for establishing and further developing suitable phosphorus recovery processes

- (1) Many research projects aimed at developing phosphorus recovery processes have already been carried out, with funding from the German government and the German Federal States. The studies have been carried out at laboratory and pilot plant scale and reflect the current state of knowledge. The information obtained so far is of a modular nature.
- (2) At present, large-scale use of phosphorus recovery processes is technically and economically possible for only a few select fractions under certain conditions. For the majority of waste and by-products produced in Germany which contain relevant amounts of phosphorus further developmental work is needed in order to solve the technical problems that still exist and to improve the economic viability of phosphorus recovery processes. A number of publications make the assumption that the processes can be operated economically from somewhere between 2020 and 2030. It is therefore necessary to continue to support the establishment and further development of suitable phosphorus recovery processes.

- (3) Looking at only sub-segments of phosphorus use (agriculture) and phosphorus recovery (sewage and sewage sludge) is inadequate for a comprehensive phosphorus management strategy. Further possibilities for reducing phosphorus use (detergent and cleaning products) and for recovering it (relevant industrial process water streams and production waste, as well as meat-and-bone meal from Category 1 material) must also be considered.
- (4) Operational experiences of phosphorus recovery processes that are suitable for incorporation into the normal running of certain sewage treatment plants have already proven promising in practice. It should generally be possible, from the point of view of both economic viability and available support, to integrate phosphorus recovery processes when major renovations are carried out or new treatment plants are built as long as treatment outside the plant is neither more profitable nor more promising.
- (5) Furthermore, due to gaps in the data, there continues to be a major need for research regarding the overall analysis of material flows, the identification of resource efficiency potential (covering the entire value chain) as well as research on the large-scale implementation and optimisation of the processes known to date.
- (6) Funding measures are considered essential to ensure the swift introduction of phosphorus recovery processes and sufficient market penetration. In this regard the working group believes it to be necessary to develop a support strategy that includes establishing a suitable assessment framework containing specific assessment criteria for projects eligible for support. It is also important in this regard to establish processes for testing the effectiveness of fertiliser in field trials.
- (7) In addition, the working group is in favour of establishing a 'Phosphorus Information and Monitoring Platform' that can be used as an overarching instrument for pooling information and findings as well as for coordinating projects aimed at using phosphorus as a sustainable resource. The option of expanding the platform into an EU-wide network should be kept open.

3.5 Evaluation of the technical feasibility and economic viability of suitable recovery processes, in particular when incorporated into the running operation of sewage treatment plants

- (1) The technical approaches that currently appear most promising are on the one hand phosphorus recovery through precipitation or adsorption from sludge water or digested sludge (e.g. MAP [magnesium ammonium phosphate] precipitation) directly at the sewage treatment plant. And on the other hand the manufacturing of phosphoric fertilisers from sewage sludge ash after thermal recovery in mono-incineration plants. The technical feasibility of these two recovery variants has been demonstrated with MAP on an industrial scale and with sewage sludge ash in pilot plants.
- (2) MAP products are already manufactured on an industrial scale and in some cases can be obtained relatively cheaply. The most successful process on the market to date can evidently be operated in an economically viable way.
- (3) Since no recovery process based on sewage sludge ash has yet been implemented on an industrial scale, it is not possible to provide any reliable details about economic viability here. Products from plants currently at the planning stage are to be sold at market prices. Owing to the high technical effort this process is expected to become economically viable only in around ten years' time, with the anticipated increase in the market price of raw phosphorus. The comparatively high potential for recovery (up to 90% of the treatment plants' inflow) should be noted.
- (4) The per capita costs for setting up phosphorus recovery are estimated at 0.5 to 3.5 euros per inhabitant per year, depending on the process. However, these figures can only be compared to a limited extent. Among other things, findings regarding fertilising effects and proceeds from the sale of recycled products are not taken into account and the available data cannot be compared owing to a wide variation in framework conditions and the absence of standardisation.

3.6 Evaluation of secondary products as fertiliser

3.6.1 Requirements for fertiliser

- (1) When licensing types of fertiliser, besides the impact on the yield (phosphorus content) and the solubility of phosphorus (immediate availability/slow-release effect), the following points should be taken into account: contaminant limit values, hygiene provisions and the technical processing needed (precipitants,

granulation, abrasion, surface, hardness, particle size, suitable containers etc.). In addition, to assess the fertiliser effect of phosphorus as against other plant nutrients, the influence of other factors such as type of soil, pH value of the soil and the phosphorus content of the soil solution must also be considered.

- (2) The legal basis for the distribution of phosphorus fertilisers that are not designated EU fertilisers is the Fertiliser Ordinance (*Düngemittelverordnung*, DüMV). Specifically, it regulates
 - the classification of phosphoric ash, substances or source materials (including from sewage treatment) into specific types of fertiliser,
 - the requirements with respect to suitable source materials and
 - the requirements with respect to phosphorus solubility.
- (3) 'End-of-waste status' can be established in accordance with Article 5 of the Closed Cycle and Waste Management Act (KrWG). Specifically, this involves looking into the intended use, the existence of a market, the fulfilment of technical requirements, legal provisions and norms, and the prevention of harmful impacts for each fertiliser based on secondary phosphorus. For example, magnesium ammonium phosphates (MAPs) fulfil the status of product as source materials for fertilisers. In the case of fertilisers manufactured from sewage sludge ash waste status ceases when they meet the requirements of Article 5 KrWG and the Fertiliser Ordinance.

3.6.2 Research into fertiliser effect and impact on the environment

- (1) There are only a few research projects of the effectiveness and harmlessness of phosphoric substances in Germany. A series of trials have studied the immediate and long-term fertiliser effect according to soil composition (soil type, pH value, phosphorus concentration in soil solution). The nutrient and pollutant contents (heavy metals, organic pollutants) of secondary phosphorus products have been compared with those of commercial fertilisers (raw phosphate, triple superphosphate). The results show that the materials based on secondary phosphorus available to date are in principle an equivalent alternative to standard commercial mineral fertilisers. In the course of recovering these substances, an

increase in phosphorus concentration occurred and the pollutant content verifiably dropped in relation to specific substrates and processes.

(2) Secondary phosphorus products from sewage sludge, sewage sludge ash and animal by-products can be divided into the following two categories:

- thermally produced materials and
- wet chemically produced materials.

The plant availability of the phosphorus content is process-dependent. According to available research and with regard to phosphorus absorption, calcium acetate lactate phosphorus content and phosphorus concentration in soil solution the plant availability can be evaluated in an initial approximation as follows (in order of decreasing plant availability):

Triple superphosphate = MAP > sewage sludge ash > processed animal proteins/meat-and-bone meals > raw phosphate

With regard to their solubility and availability to plants the MAP products that were tested behaved like triple superphosphate and were recommended unreservedly for their fertiliser effect. However, all the materials examined showed good slow-release fertiliser effect (sustained fertiliser effect for the next crop).

(3) Owing to a variation in trial conditions it is not possible to make a precise comparison of the studies conducted to date and of their findings regarding plant availability. For this reason, the working group considers it essential to undertake further, more comprehensive studies to establish the fertiliser effect and plant availability of all currently available secondary phosphorus products on the basis of comparable framework conditions. This research should include field trials and should investigate the impacts of pollution of the environmental media (soil, groundwater, surface waters).

(4) When looking at pollutant content (heavy metals), the cadmium content of the reference fertiliser triple superphosphate far exceeds that of the secondary source materials examined (MAP, ash, animal by-products). Overall, the products recovered thermally show a smaller reduction in heavy metals than the materials recycled using a wet chemical process (with the exception of aluminium phosphate produced using a wet chemical process). In isolated cases nickel in sewage sludge ash exceeded the set limit from the Fertiliser Ordinance .

- (5) In the case of secondary fertilisers manufactured from sewage sludge using wet chemical processes, contamination with organic pollutants is sometimes above the specified limit, but significantly below the average concentration in sewage sludge. Organic pollutants do not accumulate in the secondary phosphorus product.
- (6) With regard to hygiene provisions, germs (salmonella, viruses etc.) can in general survive the process chain in the case of wet chemical procedures. Further research into this is recommended.
- (7) Almost all measurements taken so far of the pollutant content of recycled phosphorus products can be judged as insignificant. The data available to date is not yet adequate for making valid pronouncements on fertiliser effect, impact on environmental media or consumer protection as compared with commercial phosphate fertilisers. Therefore the working group is in favour of further studies being conducted, especially field trials. The products must be manufactured to a consistently high quality and exhibit a good immediate effect (high water solubility) to be an equivalent substitute for mineral fertiliser; in this respect the manufacturing processes are still to be improved. In addition, procedures for eliminating pollutants must be developed further and possible process-related accumulations of pollutants investigated.

3.7 Dilution ban for matrices with a phosphorus content above 5% (mono-incineration, retrievable storage in a separate facility, inclusion of phosphorus in the Ordinance on Underground Waste Stowage)

- (1) According to figures from the German Federal Environment Agency 53.2% of the sewage sludge in Germany (around 1 million Mg dry matter) has recently undergone combined incineration in coal-fired power stations, waste incineration plants or cement works or has been thermally treated in the approximately twenty sewage sludge mono-incineration plants across Germany. Owing to the relatively small amounts of sewage sludge, the phosphorus concentration in the ash from the combined incineration plants is too low to justify the cost of recovery. The phosphorus, which is useful mainly for purposes of fertilisation, is lost through combined incineration unless it is recovered in advance.

- (2) Ash from mono-incineration is generally recycled for use in backfilling mines, asphalt plants, landscaping and at landfill sites (substitute building materials). In this way the priority of recovery over disposal is formally taken into account. Some of the ash is consigned to landfill together with other residual waste. As yet recovery with the aim of obtaining phosphate fertiliser from the phosphorus in the ash to substitute mineral fertiliser is only happening to a limited extent. Various pilot plants have already been tested successfully but not yet implemented on a large scale. There are plans to construct several demonstration plants in the next few years. If the phosphate content of sewage sludge is estimated at an average of 5% (corresponding to 2.2% phosphorus), then currently a total of approximately 50,000 Mg of phosphates is lost annually to potential processing into fertiliser through thermal treatment of sewage sludge, assuming the ash is not stored at mono-disposal sites. In the light of this, a limit of 5% phosphorus for a dilution ban seems too high. Instead the working group favours a limit of 2% phosphorus. The inclusion of the phosphorus parameter in the Ordinance on Underground Waste Stowage is recommended.
- (3) There is a lack of large-scale practical experience in Germany and in neighbouring countries, not only in terms of processing ash from mono-incineration into fertiliser but also of storing the ash in separate cells (mono-cells) at landfill sites or at special storage depots and of handling ash of this sort.
- (4) The management plans for thermal treatment of sewage sludge – whether by combined or separate incineration – currently practised at various sites without the inclusion of either upstream or downstream measures for phosphorus extraction are difficult to reconcile with the new statutory waste provisions at European and national level (intensification of material recovery or recycling in the context of the waste hierarchy, provided that consigning to landfill is not better for the environment). In future, management plans for sewage sludge that is not recycled in agriculture need to be based on these new waste provisions. Analogous standards should be applied in the case of phosphoric animal by-products, even if these materials are not subject to the statutory waste provisions. With regard to boosting recycling and material recovery, Article 11 of the new Closed Cycle and Waste Management Act contains extensive enabling provisions for implementing statutory waste priorities, including those for organic waste.

3.8 Greater use of phosphorus from all categories of animal meal³, provided the animal meal is not being used in other ways

(1) In 2010 approximately 3 million Mg of animal by-products including dead animals were processed in Germany's processing plants. Regulation (EC) No 1069/2009 classifies animal by-products into three categories according to the potential risk to humans and animals. For this purpose the Regulation contains instructions for processing and disposal in relation to each category.

In accordance with the Regulation, Category 1 material must be disposed of by incineration as waste or by other reliable procedures, in so far it cannot be used as fuel or for the manufacture of derived products. Safe treatment and a safe end use must be guaranteed, particularly for derived products. Category 2 material may be used for purposes other than feedstuffs manufacture (e.g. biogas generation, composting, fertiliser) after appropriate treatment. Category 3 material (by-products of healthy animals that have been slaughtered for human consumption) can be used in the manufacture of feedstuffs after appropriate treatment.

(2) The total animal by-products arising in 2010 are divided into material in Categories 1 and 2, including dead animals from livestock farming (1.25m Mg), and Category 3 material, including edible fats (1.72m Mg).

(3) The Category 3 animal by-products are used to produce approximately 222,000 Mg (dry matter) of pet food. This amount is not available for phosphorus recovery. Animal fats are disregarded owing to their limited phosphorus potential of about 0.1% (F. Knappe, S. Krause, G. Dehoust).

³ The term 'animal meal' is no longer used in the laws on animal by-products. In accordance with the terminology of Regulation (EU) No 142/2011 a distinction is made between 'processed animal protein' (exclusively from Category 3 material) and 'meat-and-bone meal' from Category 1 and Category 2 material.

Table 3.3: Use of proteins from Categories 1-3 produced in 2010 (figures from Servicegesellschaft Tierische Nebenprodukte mbH - STN)

Products	Feedstuffs [Mg]	Fertiliser [Mg]	Thermal recovery [Mg]
Meat-and-bone meal (proteins Cat. 1)) ²			250,500
Meat-and-bone meal (proteins Cat. 2)		44,000	193
Proteins Cat. 3 and edible fats) ³	222,500	175,600	

)² Preconditions for the recovery and extraction of phosphorus must be identified.

)³ The possibility of recovering phosphorus from the mass in the category used as feedstuffs should be examined.

(4) Around 44,000 Mg (dry matter) of Category 2 material and around 176,000 Mg (dry matter) of Category 3 material is used as fertiliser. Use of the phosphorus should be ensured here by means of appropriate treatment. The potential for phosphorus recovery is estimated at around 12,000 Mg per year. Animal fats in Category 1, amounting to around 137,000 Mg dry matter, are not taken into account owing to their limited phosphorus potential (around 0.1%).

Table 3.4: Phosphorus potential in relation to the quantity arising in 2010 (phosphorus load according to Montag/Pinnekamp and S. Kratz and E. Schnug)

Product	Mass [Mg]	P load [%]	P potential [Mg]
Meat-and-bone meal (Cat. 1)	Approx. 250,000	3.1	7,750
Meat-and-bone meal (Cat. 2)	Approx. 44,000	3.1	1,364
Proteins (Cat. 3)	Approx. 176,000	6.1	10,736
Total			19,850

(5) The greatest unused potential (approx. 250,000 Mg dry matter) is represented by Category 1 meat-and-bone meal, which is currently used to generate energy in plants such as cement works or is otherwise disposed of by incineration. The amount of phosphorus is estimated at approximately 7,800 Mg per year. This

potential could be tapped by mono-incineration, for example, which takes into account the hygiene requirements of Regulation (EC) No 1069/2009. The use of ash from animal by-products in Category 1 is not yet covered specifically in the current version of the Regulation. The use of Category 1 ash as fertiliser is excluded according to Article 32, sentence 1 (a) of Regulation (EC) No 1069/2009 in combination with Article 36 paragraph 1. In view of the prior treatment of the ash by incineration and the phosphorus potential available, an amendment to the relevant provisions should be sought.

- (6) There is little phosphorus available to plants from animal by-products and ash obtained from them, since it is water-insoluble. Further processing is necessary in order to improve the plant availability and solubility of phosphorus from animal by-products and the resulting ash.
- (7) The incineration of animal by-products of all categories has the fundamental advantage that the unintentional spread of pharmaceutical residues (e.g. antibiotics) can be prevented.
- (8) Phosphorus recovery from the ash of animal by-products is technically possible and has already been tested successfully at pilot plants. In order that thermal recovery from animal by-products is economically viable, the possibility of public funding should be investigated.

3.9 Observation and evaluation of developments in phosphorus recovery in other countries

- (1) In recent years the development of phosphorus recovery processes has gained massive momentum on an international scale. Projects and initiatives of this sort are now being carried out in numerous countries.

Netherlands:

The Netherlands have been practising phosphorus recovery for more than ten years. Phosphorus is recovered successfully from low-iron sewage sludge and animal by-products, and the resulting material is used not as fertiliser but as a secondary source material for various industrial applications. There are currently attempts to establish uses for iron-rich sewage sludge ash as well, for example in

the fertiliser manufacture. In the Netherlands a Dutch Nutrient Platform has already been set up, where representatives of sewage companies, NGOs, the phosphorus and fertiliser industry and engineering firms advise on policy aspects and research issues. The platform also functions as a contact point for politicians.

Poland:

Phosphorus recovery is new to Poland, but mono-filling of sewage sludge ash (9,000 Mg/a) is just starting up in Gdansk, and a plan to use ash to produce fertiliser is being considered in collaboration with a fertiliser manufacturer.

Scandinavia/Sweden:

In Scandinavia support has been provided for the development of phosphorus recovery processes for many years. As far back as twenty years ago Sweden defined phosphorus recycling as a political goal and is seeking to recover at least 60% of the phosphorus contained in sewage for recycling in agriculture by 2015.

Switzerland:

In Switzerland a bill is being drafted requiring phosphorus to be recovered from the waste water stream as well as from animal by-products with the aim of turning Switzerland from an importer to an exporter of phosphorus. The requirement is scheduled to come into effect during 2012 and is to set a recovery quota of between 50% and 100%. A transition period will be granted until 2015. A total ban on conventional spreading of sewage sludge as fertiliser has been in effect in Switzerland since 2008. As far as the authors are aware, no processes have been established so far for large-scale use.

USA/Canada:

The USA and Canada operate a number of phosphorus recovery plants that have been successfully producing fertiliser on a large scale using the MAP process for several years. The process can be used for phosphorus recovery directly at the sewage treatment plant.

Japan:

Japan already recycles phosphorus particularly intensively. Plants that recover phosphorus from sewage sludge ash and waste water are in operation. There is also a Phosphorus Recycling Promotion Council of Japan, which brings together industry, science and politics.

3.10 Working Group's proposals

The LAGA ad-hoc working group makes the following recommendations:

- (1) The combined incineration of sewage sludge, animal by-products and other waste with a high phosphorus content should cease after expiry of a transition period, unless the phosphorus can be recovered beforehand. One possible approach to this would be to introduce a regulation allowing combined incineration from a date yet to be specified provided the phosphorus content in the waste for incineration does not exceed a permitted maximum amount (suggested 3...5% dry matter, reducing to 1% dry matter).
- (2) As yet no high-quality, economically viable large-scale processes are available for direct phosphorus recovery from sewage sludge ash. For this reason storage of ash is being considered, so that the phosphorus in sewage sludge ash can be recovered at a later date. Based on current knowledge and the marketing situation, long-term storage facilities will have to be set up in many cases.
- (3) In the context of the requirements for phosphorus recovery a dilution ban for matrices with a phosphorus content above 2% should be introduced. Particulars should be determined in a detailed assessment.
- (4) When the Sewage Sludge Ordinance comes to be amended, as announced, consideration should be given to whether to include requirements for processes aimed at recovering phosphorus by technical means from sewage sludge not used for agriculture purposes (wet chemical processes, mono-incineration, combined incineration).
- (5) Practical marketing strategies to promote the recovery of phosphorus from secondary sources, such as a fund solution or a purchasing solution, should be investigated.

- (6) Further support measures along with research and development projects are considered necessary to ensure the swift introduction of phosphorus recovery processes and sufficient market penetration. A support strategy should be developed, as part of which a suitable framework should be established to assess which projects should receive support.
- (7) Further, more comprehensive studies are needed to establish the fertiliser effect and plant availability of all currently available secondary phosphorus products, based on comparable framework conditions.
- (8) A 'Phosphorus Information and Monitoring Platform' should be set up, which can be used as an overarching instrument for pooling information and results as well as for coordinating projects on using phosphorus as a sustainable resource.