Federal Ministry
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RePhoR
REGIONAL PHOSPHORUS RECYCLING

Regional Phosphorus Recycling (RePhoR)

Phosphorus (P) is essential to all forms of life on this planet and an irreplaceable element. Phosphorus, or phosphate, which is its usable form, is used mainly in fertilizer to help farmers reap higher yields. Like virtually every country in the European Union (EU), Germany has no phosphate rock deposits of its own, making it reliant on imports from abroad. The problem, however, is that these finite phosphate rock deposits are limited to a few, often politically unstable regions of the world. What is more, this finite resource is increasingly contaminated by heavy metals such as cadmium and uranium. In fact, this is why phosphorus was put on the EU list of Critical Raw Materials (CRM) in as early as 2014, a move that was hoped would be an incentive for increased recycling of CRMs. Phosphorus recovery from waste streams such as wastewater and sewage sludge is becoming increasingly important in this context owing to the high phosphorus content. The German Sewage Sludge Ordinance in its amended version of October 2017 created the necessary regulatory framework for this.

Against this background, the Regional Phosphorus Recycling (RePhoR) funding measure of the Federal Ministry of Education and Research (BMBF), which began in 2018, seeks to develop innovative, cost-effective, and sustainable phosphorus recycling solutions that will help minimize phosphorus losses and reduce Germany's dependence on phosphorus imports. The RePhoR funding measure is part of the Research for Sustainability (FONA) Strategy of the BMBF.

Since mid-2020, the BMBF has been backing seven joint projects that explore different methods of recovering phosphorus from sewage, sewage sludge, or sewage sludge ash under real conditions in large-scale technical installations. These projects, which were selected following an initial concept phase and which will receive BMBF funding for up to five years, also look at holistic methods of using the recovered phosphorus to restore nutrient circularity in agriculture or as a raw material for industry.

Throughout project implementation, the RePhoR funding measure is accompanied by the networking and transfer project TransPhoR. This helps ensure that the outcomes of the individual joint research projects and the large-scale phosphorus recovery processes can be compared and transferred to practical applications. A further focus of TransPhoR is the examination of overarching technical issues. For example, the development and improvement of standardized test methods and product criteria for recovered phosphorus products, regulatory frameworks, as well as the evaluation of the economic efficiency and the life cycle assessment (LCA) of the processes developed.

With the guidance of a steering committee comprising coordinators of the joint projects, the accompanying project, as well as experts from businesses, associations, official bodies, and departments, the TransPhoR project will draw up recommendations for action to enable the findings of the research projects to be used in water management.

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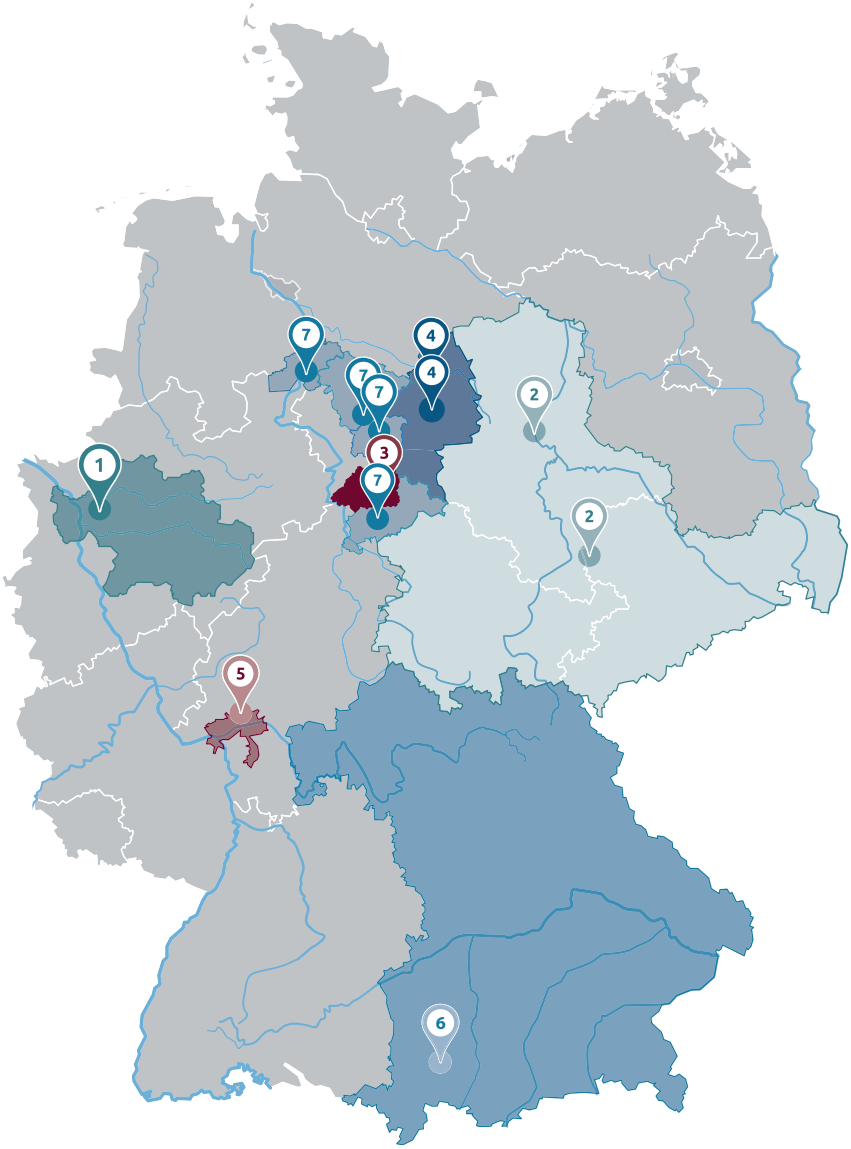
FONA
Research for sustainability

RePhoR Joint Research Projects



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Northeim

4 P-NET
Gifhorn, Braunschweig

5 RePhoRM
Frankfurt on the Main-Höchst

6 R-Rhenania
Altenstadt

7 SATTELITE
Hildesheim, Pattensen,
Landkreis Nienburg, Göttingen

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Federal Ministry
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RePhoR
REGIONAL PHOSPHORUS RECYCLING

AMPHORE – Regional Sewage Sludge and Sludge Management for Phosphorus Recycling for a Conurbation

Regional Phosphorus Recycling (RePhoR)

Rather than relying on third-country imports, Germany may be able to meet much of its demand for the vital element phosphorus by using phosphates recovered from wastewater. This approach has been rarely employed to date owing to the absence of fully developed technologies for a comprehensive recycling system. The research and implementation partners in the joint research project AMPHORE will be transforming a process for the recovery of phosphorus from sewage sludge ash into a large-scale integrated sewage sludge management system that encompasses everything from sewage sludge treatment to the reuse of the recovered phosphoric acid.

Recovery of Phosphorus – What Happens Next?

Phosphorus recycling can help compensate for fast depleting rock phosphate. The recycling potential in sewage sludge ash, a by-product produced during the combustion of sewage sludge, is particularly high. Owing to the new, tighter legal requirements for direct use of sewage sludge as fertilizer on agricultural land, however, often the only option is thermal conversion, with the phosphorus contained in the sludge going unused.

The AMPHORE project, whose lead partners come from the water sector and research institutes, focuses on the recovery and reuse of phosphorus from sewage sludge ash. The objective is to develop a joint regional concept for phosphorus recycling built on existing structures. The concept entails optimizing existing wastewater and sewage sludge treatment and recycling, including phosphorus recovery to create an integrated system which is cost-effective and technically and ecologically sound. With phosphorus making up no more than around five to nine percent of sewage sludge ash, a further aim is to find viable methods for reusing or disposing of the other by-products in the residual ash after phosphorus extraction.

Demonstration Plant at Bottrop Sewage Works

The AMPHORE project partners—five water associations from North Rhine-Westphalia—send the lion's share of their sewage sludge to sludge incineration plants. At the moment, the ash produced in the incineration process is disposed of or used in the construction industry. The project aims to change the focus, gearing the process away from disposal toward phosphorus recycling, bearing in mind the given organizational and regulatory frameworks.

In the Ruhr Metropolitan Region, wastewater from private homes as well as from industry and commercial enterprises flow into the municipal sewage works, resulting in sewage sludge with high levels of contaminants such as heavy metals or medical residues. The higher the contamination level, the more difficult it is to produce clean phosphoric acid and the more stringent the requirements for the disposal of residues. In the AMPHORE project, the concentration of residual substances in wastewater flows will be monitored and quantified and recycling chains developed on the basis of the composition of the respective sewage sludge ash.

Sewage sludge ash is disposed of without recovering the valuable resources it contains

A large-scale phosphorus recovery demonstration plant installed at Bottrop wastewater treatment plant will provide extensive operating data on the different qualities of sewage sludge ash. The demonstration plant employs PARFORCE technology, a wet-chemical process that uses acid to extract phosphorus from the ash. The process was adapted to the specifics of the demonstration plant.

Paving the Way for a Long-Term Recycling Concept

The key takeaways from the AMPHORE project are practical data on the process engineering, the optimization of operating conditions, expected costs, as well as the quality and quantity of the recovered materials and by-products. Potential users from various sectors in the region—fertilizer production or the chemical and metalwork industry, for example—have the opportunity to use samples of the recovered phosphoric acid in their processes on a trial basis. This provides tangible data that can be used to assess future market potential. The concept selected for the project region will then be scaled up to a long-term solution for regional sewage sludge management with phosphorus recovery that is compliant with the relevant regulatory requirements.

The wastewater treatment plant in Bottrop is the future location of the phosphorus recovery demonstration plant

Funding Measure
Regional Phosphorus Recycling (RePhoR)

Project Title
Regional Sewage Sludge and Sludge Management for Phosphorus Recycling for a Conurbation (AMPHORE)

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02WPR1543 A- K

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RePhoR
REGIONAL PHOSPHORUS RECYCLING

DreiSATS – Technology Demonstration of Combined Dust Firing and Acid Digestion with Subsequent Granulation Including Integrated Heavy Metal Removal as Part of a Regional Phosphorus Recycling Strategy

Regional Phosphorus Recycling (RePhoR)

When it comes to developing phosphorus recycling strategies both sustainability and economic viability are important. One approach that has proven to be very promising is the use of recovery and recycling processes that have the flexibility to be adapted to the specifics of a given region and that encompass the entire process chain from sewage sludge production to the sale of the final products. The partners involved in the DreiSATS joint research project are developing and testing an innovative concept based on decentralized sewage sludge incineration. The sewage sludge ash and the phosphorus contained in the ash are used in the production of marketable fertilizer products for agriculture.

Process Based on Decentralized Dust-Firing

The model region for the DreiSATS concept is the Central German Metropolitan Region, which encompasses parts of the states of Saxony-Anhalt, Thuringia, and Saxony. This region, which is known for the major industrial areas surrounding the cities of Halle, Leipzig and Chemnitz as well as for its rural areas, is one of Germany's most intensively cultivated areas. The majority of the sewage sludge that is produced here is currently still used as fertilizer on the fields or incinerated.

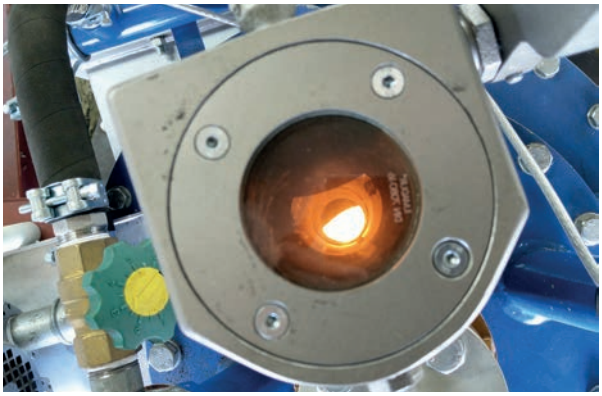
To make future phosphorus recovery possible, the DreiSATS project partners will be developing and testing an innovative process chain for the decentralized extraction of this important nutrient from sewage sludge. The phosphorus-based fertilizer products produced can then be used in the agricultural sector in the model region. This would make it possible to cover a large proportion of the phosphorus needs from regional sources and close the nutrient cycles while keeping transport costs to a minimum.

The new process is based on sewage sludge incineration in decentralized dust-fired systems featuring pre-drying and integrated heavy metal removal. This guarantees high productivity, irrespective of the properties of the sewage sludge. The aim is to develop the optimum solution from a technical perspective while ensuring maximum costeffectiveness.

Standardized, Commercially Viable Fertilizer Products

Unlike fluidized bed incineration, which is currently the most common thermal sewage sludge treatment method, dust-firing has already proven to be economically viable for much smaller plants. Moreover, the particle size of the ash produced using dust-firing has beneficial properties for the subsequent phosphorus recycling.

A further advantage of decentralized dust-firing is the combined drying and incineration process. This means that any heat produced can be used efficiently, transport volumes and related costs are reduced by up to 90 percent, and CO_2 emissions are far lower, too. The dust-fired incinerator includes an integrated hot gas filtration system to remove heavy metals.



A look inside the dust-fired sewage sludge incinerator

The DreiSATS concept will be implemented at pilot-plant scale in Magdeburg.

The standardized fertilizer products are produced using the Pontes Pabuli method, a wet chemical process that uses acid digestion to extract the phosphates—and enables heavy metal separation if needed—before treating the phosphates with additional nutrients to produce granular fertilizer. In terms of their properties and quality, these ready-to-use fertilizer products are equivalent to the mineral fertilizers used in agriculture today. The project partners will be testing the process at a pilot plant; the fertilizer will be tested in both pot experiments under standardized conditions and field tests.

Cost and Environmental Benefits

At the end of the DreiSATS project, the project partners are planning to build a model facility in the project region that models the finely tuned process chain comprising dust-fired sewage sludge incineration and the production of high-quality fertilizer from the sewage sludge ash using the Pontes Pabuli method. In future, a GIS software tool developed during the project will enable operators and users to plan cost-efficient raw materials and process logistics as well as the regional sale of the fertilizer product, ensuring efficient management of the phosphorus cycle.

The process chain chosen in the DreiSATS project boasts features technical and logistics benefits, lending it both cost and environmental advantages over other methods, thus making transfer to other regions very attractive.

A hot gas filtration unit removes heavy metals during the decentralized sewage sludge incineration process

Funding Measure
Regional Phosphorus Recycling (RePhoR)

Project Title
Technology Demonstration of Combined Dust Firing and Acid Digestion with Subsequent Granulation Including Integrated Heavy Metal Removal as Part of a Regional Phosphorus Recycling Strategy for the Central German Metropolitan Region of Saxony-Anhalt, Thuringia, and Saxony (DreiSATS)

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RePhoR
REGIONAL PHOSPHORUS RECYCLING

KlimaPhoNds–Climate-Neutral, Residue-Free Sewage Sludge Utilization and Phosphoric Acid Production in the South-East of Lower Saxony

Regional Phosphorus Recycling (RePhoR)

Sewage sludge is a valuable source of raw materials, especially phosphorus, but it also contains nitrogen, metals, and minerals. Energy—in the form of heat and electrical power—can also be harvested from sewage sludge. To foster a sustainable circular economy, our aim should be to extract and reuse all the valuable resources contained in sewage sludge. This very objective is the focus of the joint research project KlimaPhoNds, whose lead partners will be developing a climate-neutral, residue-free sewage sludge recycling process with recovery cycles for phosphorus, magnesium, and nitrogen. The sludge is also used as fuel in cement production so as not to lose the energy contained within it.

Local Recovery, Centralized Processing

The amended German Sewage Sludge Ordinance has created the regulatory framework for mandatory recovery of phosphorus in large-scale sewage treatment plants with more than 50,000 population equivalents. Such additional requirements often mean higher energy and resource consumption, a fact that conflicts with government climate goals. What is needed, therefore, is sustainable phosphorus recovery processes that keep costs to a minimum, have low resource consumption, and are climate-compatible at the same time.

The joint research project KlimaPhoNds centers on the development of a new concept that will meet these requirements. This concept will be tailored to the specific needs of wastewater treatment plants with biological phosphate removal. The project partners will be working on ways of increasing the efficiency of this process with a view to maximizing the phosphate yield from these plants. At the same time, they are aiming to reduce the consumption of iron-and aluminum-based flocculants.

The phosphate products recovered from the different wastewater treatment plants will then go to a central processing plant, ensuring effective phosphorus, magnesium, and nitrogen recycling. After phosphorus extraction, the remaining sewage sludge has a low phosphate content. This is then fully dried in an innovative waste heat recovery process that does not require an additional source of energy, making it virtually energy neutral. The resultant product is a high-quality fuel that also helps conserve resources.

Climate-Compatible Recycling Cycles

The project partners will be applying the final concept at Northeim wastewater treatment plant in southern Lower Saxony. This will be the first time a concept such as this involving multiple approaches and technologies has been implemented on an industrial scale. To yield as much phosphate as possible, the nutrient is removed from the thickened and dewatered sewage sludge in a two-stage process that uses far fewer chemicals and energy than in other recycling processes. The two separate process water flows, which have high levels of phosphates, are then treated in a precipitation step that produces magnesium ammonium phosphate (MAP). The MAP is stored in the wastewater treatment plant before being transported to the central processing plant where, in an innovative process known as PARFORCE (Phosphoric Acid Recovery From Organic Residues and Chemicals by Electrochemistry), it is heated, and acid added to produce the valuable substances phosphoric acid, ammoniac water, and magnesium chloride.

Parforce pilot plant produces high-quality phosphoric acid

The recovered phosphoric acid will be used in the chemical industry to produce fertilizer. The magnesium chloride, a by-product of the PARFORCE process, goes back to Northeim wastewater treatment plant where it is reused as a flocculant. The researchers will also be examining whether the ammoniac water is suitable for use in fertilizer production or flue gas denitrification.

After the two-stage phosphate removal process, the sludge, which has a low P content, is used in the cement industry. To dry the sludge, the KlimaPhoNds project uses a novel approach based on a fluidized bed steam dryer scaled up to commercial level. Here, the water is extracted from the sludge almost entirely under high pressure in a pure steam atmosphere. The majority of the heat needed for this process is recovered, making the drying process highly resource efficient, with no external source needed to produce the heat.

The co-incineration of dried, phosphate-free sewage sludge in the cement industry is a cost-efficient alternative to mono-incineration. The result is a cost-efficient fuel that can help lower CO2 emissions. The project partners will also be using the waste heat from the heat recovery process for various processes in the wastewater treatment plant, for instance to heat digesters and utility rooms or in sewage sludge treatment processes. It can also be used as district heating if needed.

Transferable Concepts

The KlimaPhoNds project partners aim to develop a model to demonstrate how climate-compatible or even climate-neutral the additional steps required for phosphorus recovery in wastewater treatment plants can be. The concept developed can be transferred to any wastewater treatment plants with partial biological phosphate removal in regions similar to that where the project was carried out. The same applies to the sewage sludge fuels produced almost without any auxiliary energy, since transport volumes are reduced to a minimum and the fuel can be used in cement works across the country.

Funding Measure
Regional Phosphorus Recycling (RePhoR)

Project Title
Climate-Neutral, Residue-Free Sewage Sludge Utilization and Phosphoric Acid Production in the South-East of Lower Saxony (KlimaPhoNds)

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RePhoR
REGIONAL PHOSPHORUS RECYCLING

P-Net – Development of a Network for Resource-Efficient Phosphorus Recycling and Management in the Harz and Heide Region

Regional Phosphorus Recycling (RePhoR)

In recent years, large-scale phosphorus recycling plants have relied primarily on processes that employ chemical precipitation and crystallization to produce phosphorus-based products such as magnesium ammonium phosphates (MAP), also known as struvite, a compound that is low in contaminants and has good plant availability. To date, however, these products have seldom been used in the agricultural sector, despite their many positive properties. Focusing on struvite, the P-Net joint research project will examine unanswered questions associated with the production and marketing of phosphorus-based products. The project aim is to establish a regional phosphorus recycling network.

New Requirements Pushing Innovation

For some years, the operators of wastewater treatment plants have been trying to extract the raw material phosphorus directly from wastewater or wet sewage sludge. This is done in dedicated phosphorus recovery systems that are integrated into the wastewater and sewage sludge treatment process at the wastewater treatment plant. These systems use chemical precipitation to produce phosphorus-based compounds such as magnesium ammonium phosphate or struvite. Struvite precipitation systems are relatively easy to integrate into existing treatment plants and make it possible to produce high-quality fertilizer that is low in contaminants. At a maximum of around 20 percent, however, the phosphorus recovery rates are relatively low. In addition, the different effluent quality in wastewater as well as the different treatment processes mean struvite-based fertilizers have different physical and chemical properties. This and other factors are the reasons why struvite-based fertilizers have not been successfully marketed to date.

This is where the P-Net project comes in. The eight partners aim to address the problems and unanswered questions relating to struvite. The project is intended to ensure the technology behind struvite recovery is geared up for the amended German Sewage Sludge Ordinance when it comes into effect. P-Net seeks to optimize existing struvite plants so that they meet the new legal requirements. The project partners will also be developing a regional phosphorus recycling network that will help better market struvite-based fertilizer that is currently being produced.

Regional Cluster for Phosphorus Recycling

The new regional phosphorus recycling network will be created in the Harz und Heide region, where a number of struvite recovery plants already exist, including those run by project partners in Braunschweig and Gifhorn. A struvite hub, which will be established in the village of Mieste near Wolfsburg/Saxony-Anhalt, will function as the region's production center for standardized, ready-to-use fertilizers that will be tested in cooperation with local farms before being launched on the market.

To ensure that the struvite plants can achieve the necessary recovery rates in future, the project partners will be adopting various other measures, including an additional process step to enhance biological phosphorus removal from excess sludge.

Map showing struvite plants in the region between Harz and Heide (blue) and the future struvite hub (red)

The process will be refined and further developed within the P-Net project and scaled up to industrial level. Other effluents besides sewage sludge will also be treated in the struvite plants—urine for example—and used to recover phosphorus. This could open up the possibility of tying in with other concepts that are geared towards wastewater recycling such as resource-oriented sanitation systems. The P-Net project thus offers a low-cost solution that is a viable alternative to more energy-intensive incineration processes, optimizing existing struvite recovery plants and making them viable for the future.

National and International Transferability

The concept developed as part of the P-Net project is not just a sustainable regional solution for phosphorus recovery, but can also be transferred to other locations in Germany and abroad where struvite plants already exist or are in the planning. The first recycling network developed in this project is just a starting point and will serve as a foundation for a continued exchange of experience in this area, fostering the creation of other struvite competence networks. Struvite plants are becoming increasingly popular especially in the European market, opening up huge export opportunities for German businesses.

Large-scale struvite recovery unit at a wastewater treatment plant in Braunschweig

Funding Measure
Regional Phosphorus Recycling (RePhoR)

Project Title
Development of a Network for Resource-Efficient Phosphorus Recycling and Management in the Harz and Heide Region (P-Net)

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O2WPR1542A-H

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RePhoR
REGIONAL PHOSPHORUS RECYCLING

RePhoRM – Regional Phosphorus Recycling in the Rhine-Main Area with Due Consideration to Industrial and Agricultural Nutrient Cycles

Regional Phosphorus Recycling (RePhoR)

Phosphorus is an essential component in the production of fertilizers and is thus also vital for agriculture. In future we will have to maximize our recovery and reuse of what the EU has classified as critical raw materials (CRMs). A suitable source of phosphorus, for example, is sewage sludge ash from the combustion of sewage sludge containing phosphates. Partners in the joint research project RePhoRM being implemented in the Rhine-Main Metropolitan Region plan to use an innovative new process to produce fertilizer from the sewage sludge ash, thus closing the nutrient cycle directly. The aim is for the project partners to cooperate within a recently established phosphorus recycling network.

Region-Specific Phosphorus Recycling

In large urban areas such as the Rhine-Main Metropolitan Region, we are seeing increasing numbers of sewage sludge mono-incineration plants being planned and implemented for the purposes of phosphorus recycling. A large proportion of the phosphorus content can be recovered from the resulting sewage sludge ash. In the Rhine-Main area, there are already four such plants either in operation or ready for commissioning, with a feasibility study underway for a fifth.

Against this backdrop, RePhoRM project partners are conducting research on suitable phosphorus recycling technologies that take the regional specifics into account. The aim is to set up a large-scale plant for extracting phosphorus from sewage sludge. The project partners are also developing the legal and organizational framework for shared use of the new technology.

Environmentally Friendly Production of High-Quality Fertilizers

In line with the resource conservation strategy of the German federal state of Hesse, a fertilizer produced from the recovered substances will be used in agriculture across the states of Rhineland-Palatinate and Hesse. To produce the new fertilizer, the project partners will be employing a novel approach known as PHOS4green technology. Here, phosphoric acid is used to treat the sewage sludge to improve the plant availability of the phosphorus in the ash as well as to bring the phosphate content of the later fertilizer product up to the level of commercial fertilizers. The next step is producing market ready granular fertilizer from this sewage sludge ash and acid mixture.

In large urban areas, however, sewage sludge ash contains elevated levels of heavy metals that can end up back in the environment by way of the fertilizer. To prevent this from happening, the RePhoRM project partners will add

Sewage sludge ash containing phosphorus

a processing step to the PHOS4green technology that is specifically aimed at reducing the heavy metal content in the sewage sludge ash used. It is important to note that the prior removal of heavy metals does not have an adverse impact on the subsequent granulation process. In other words, the granulation process is adapted to the new conditions without compromising the quality of the fertilizer produced. To evaluate quality, the effectiveness of the final fertilizer product will then be tested.

At the same time, at every stage of the project, the partners will keep a close eye on the impact of the fertilizer

production on the environment. An accompanying environmental accounting system will ensure that any negative environmental impact is identified at an early stage and minimized prior to large-scale implementation of the phosphorus recycling process at Höchst industrial park. The RePhoRM project partners will also be fleshing out suitable strategies for the disposal and reuse of the by-products of the adapted PHOS4green technology, in particular concentrated heavy metals.

Recycling Network to Serve as a Model

Phosphorus recycling involving several operators of sewage works and sewage sludge mono-incineration plants across the Rhine-Main Metropolitan Region will take the form of a cooperative, public-private partnership. With this in mind, the RePhoRM project partners will be creating a nationwide network that will also serve as a blueprint for other metropolitan regions across Germany. The aim is for the network to be in a position to guarantee stable prices for the recovery of phosphorus from around five percent of the sewage sludge or sludge ash produced in Germany every year.

Granular fertilizer from sewage sludge ash

Funding Measure
Regional Phosphorus Recycling (RePhoR)

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RePhoR
REGIONAL PHOSPHORUS RECYCLING

R-Rhenania – Modified Rhenania Phosphates from Sewage Sludge Ash for Bavaria

Regional Phosphorus Recycling (RePhoR)

With its high phosphorus content, sewage sludge from municipal sewage works is potentially extremely well suited for the production of fertilizers. However, sewage sludge also contains high levels of contaminants and requires incineration in order to remove them. The resulting sewage sludge ash, which is rich in phosphates, is not an effective fertilizer. The aim of the joint research project R-Rhenania is to construct and operate a demonstration plant, where, using a new thermochemical process, sewage sludge ash from incineration plants in Bavaria will be processed to produce a highly effective fertilizer with low levels of contaminants.

Thriving Crops, Happy Environment

In Bavaria, most of the sewage sludge from municipal wastewater treatment is incinerated. The large-scale incineration plants across Bavaria generate around 30 kilotons of sewage sludge ash every year. Some of this is disposed of and some is reused as fertilizer for agricultural land. The ash is rich in phosphorus, with concentrations ranging from 8 to 13 percent. Up till now, however, the potential for nutrient recovery has barely been exploited, as plants can only use the phosphates in the ash to a limited extent. What is more, although the ash does not contain any pathogens or contaminants such as hormones or antibiotics, it is sometimes contaminated by toxic heavy metals. In order to produce effective phosphate fertilizer with low levels of contaminants using sewage sludge ash, other treatments are needed.

The R-Rhenania project partners aim to tackle this challenge using a new thermochemical process for recovering phosphorus from sewage sludge ash. The AshDec process converts the phosphorus which has low plant availability into an easily usable phosphorus compound, at the same time reducing heavy metal content. This is the first time this process will be implemented on an industrial scale in a demonstration plant in Bavaria.

Demonstration Plant in Altenstadt, Bavaria

The construction of the AshDec demonstration plant will begin on the site of an existing sewage sludge ash incineration plant in the upper Bavarian municipality of Altenstadt in 2021. The planned capacity of the plant, which will commence operations in 2023, is an annual 30,000 metric tons of sewage sludge ash. The plant will process ash from various incineration plants in Bavaria, producing fertilizer that will be used in agriculture across the region. The R-Rhenania project covers the entire process chain from the evaluation and treatment of the raw materials to optimization of the AshDec process, and the analysis of fertilizer efficiency and environmental compatibility.

Over the past few years, AshDec technology has already been extensively optimized and tested in various pilot plants. The AshDec process involves recovering the phosphates from the sewage sludge ash in a rotary kiln heated to temperatures of 850 to 900 degrees Celsius. This produces the compound calcium sodium phosphate, which is characterized by high plant availability. The idea for the AshDec process builds on the Rhenania process, which was used up until the 1980s to produce Rhenania phosphate, a well-known fertilizer containing calcium sodium phosphate. In addition, the AshDec process reduces levels of toxic heavy metals such as arsenic, lead, cadmium, and mercury.

The project partners will be analyzing the fertilization efficiency of products from the AshDec process at the

The AshDec demonstration plant will be constructed on the site of the Emter GmbH sewage sludge incineration plant in Altenstadt

demonstration plant as well as those produced in comparable small-scale operations. This will be done in both pot experiments and field tests in organic farming.

Here, not only the phosphate is of interest, but also how other compounds such as silicates and the trace nutrients they contain affect plant availability and health. Lastly, the material from the demonstration plant will be processed to a marketable fertilizer, packed and sold in the region.

Given the low levels of heavy metal contamination in sludge ash from the Bavarian incineration plants, the researchers will be conducting small-scale experiments to test whether the AshDec process is also suitable for sewage sludge ash from other regions that has higher levels of heavy metal contamination. The cost effectiveness and environmental compatibility of the technology will be evaluated in a large-scale installation designed for this ash.

New and Existing Incineration Plants

In the coming years, up to 24 new sewage sludge incineration plants will be built in Germany. The future operators of these plants would be well advised to factor in the phosphorus recovery that will become mandatory in future sooner rather than later, and to integrate it into the original plant design and construction phase. At the same time, existing sewage sludge incineration plants will have to be retrofitted to meet this obligation. This illustrates the considerable economic potential of the AshDec process. The high quality of the ash-based fertilizer the process generates in terms of plant availability and heavy metal content also makes for excellent sales potential.

The image shows granular ash-based fertilizer

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Regional Phosphorus Recycling (RePhoR)

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Modified Rhenania Phosphates from Sewage Sludge Ash for Bavaria (R-Rhenania)

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RePhoR
REGIONAL PHOSPHORUS RECYCLING

SATELLITE – Process Technologies in the Primary and Satellite Operations of an Inter-Municipal Recycling Center for Optimized Regional Nutrient Recycling

Regional Phosphorus Recycling (RePhoR)

Up till now, 60 percent of the sewage sludge produced by the municipalities in the northern German federal states of Lower Saxony, Mecklenburg-Western Pomerania, Schleswig-Holstein, and Saxony Anhalt, as well as Thuringia and Saxony, has been used for agricultural purposes. The phosphorus contained in the sludge is thus returned to the nutrient cycle. However, as a result of amendments to the German Sewage Sludge and Fertilizer Ordinance, this will, for the most part, no longer be possible in the future. Using the region of southern Lower Saxony as a pilot, the joint research project SATELLITE therefore plans to implement a regional nutrient recycling concept for major agricultural regions. The aim of the project is to guarantee efficient, resource-efficient, sustainable sewage sludge management in compliance with the new legal requirements. The basis for this is extensive cooperation between the municipalities in the planning and management of their sewage works.

Creating Synergies through Cooperation

In the agricultural region of southern Lower Saxony, between Nienburg and Göttingen, there is a large number of municipally operated small and medium-sized sewage works located in the vicinity of larger plants serving the regional centers. Through a recently established inter-municipal network, the municipalities will consolidate their sewage sludge management systems and implement a sustainable regional concept for the recycling of nutrients, including both phosphorus and nitrogen. A key component of the project is the operation of a shared municipal mono-incineration plant that will function as a central recycling center.

The SATELLITE project explores different possible nutrient recycling concepts. The focus of the investigations conducted by the partners is on the relevant process steps upstream and downstream of the actual incineration and recovery process at the sewage works supplying the sludge. The inter-municipal network will allow the measures at the individual sewage works to be properly coordinated, enabling effective planning and implementation and creating technological and operational synergies for the entire system. The aim is for the central recycling center to provide optimal quality sewage sludge in terms of its fuel value and phosphorus content, while ensuring the lowest possible environmental impact. At the same time, it will be ensured that the regional sludge supply centers also benefit from the concept.

To achieve this, the project partners will be developing processes that are tailored to each sewage plant, a regional recycling concept for the valuable resources obtained, and a customized logistics concept to support the individual plants with their sewage management. With individual sewage works being able to accept and recycle not only sewage sludge but also other regionally available agricultural fertilizers such as liquid manure, slurry, or waste materials from food production, additional energy and nutrient potential, for instance in nitrogen recovery, can be tapped into locally.

Alongside the sewage works in the regional centers, other smaller plants in the surrounding area, which are not legally obligated to recover and recycle phosphorus, can deliver their sewage sludge to the recycling centers as well, thus allowing them to manage their waste flexibly throughout the year.

The future location of the new municipal recycling center for the region of southern Lower Saxony (adjacent to the Hildesheim sewage works)

Options for Different Sizes

SATELLITE is conducting investigations at four different research sites that are representative of typical setups at the different plants in the network. These include the Göttingen and Hildesheim wastewater treatment plants which are two large regional centers. The inter-municipal recycling center will be built adjacent to the Hildesheim sewage works. Here, sewage sludge will be dried, incinerated, and the ash stored for later phosphorus recovery. Options for smaller treatment plants will be investigated in Pattensen and the district of Nienburg which serves as the SATELLITE pilot region.

For sewage sludge treatment at the wastewater works, SATELLITE is testing various processes, including nitrogen recovery to maximize nutrient recycling. Besides sewage sludge, slurry and other locally available substrates are being used as sources of nitrogen. In addition, project researchers are testing processes that enable local sewage works to recover phosphorus from sewage sludge onsite, for instance in the form of calcium or magnesium ammonium phosphate (MAP) which can then be sold directly as fertilizer or undergo additional treatment to produce phosphoric acid.

To ensure cost-effective nutrient recycling in the region, SATELLITE will be developing a nutrient management system in coordination with the local agricultural sector. A pilot plant will be used to test the production of commercially viable fertilizer products made from recovered substances, i.e. phosphoric acid, calcium, and magnesium ammonium phosphate, as well as different concentrations of ammonia solutions.

Recommendations for Action

In the SATELLITE project, data on the processes tested as well as operational data and data on plant design is used to develop model-based modules that can be used to plan individual plant components and processes. These modules are used in scenario modelling to ensure that the recommendations for action made to individual plants within the municipal waste management network as well as their investment decisions are strategically coordinated. This will enable even small and medium-sized municipalities to conduct more efficient and sustainable nutrient recovery in future.

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Regional Phosphorus Recycling (RePhoR)

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Process Technologies in the Primary and Satellite Operations of an Inter-Municipal Recycling Center for Optimized Regional Nutrient Recycling (SATELLITE)

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