SEWAGE SLUDGE

PRESERVE
RESOURCES
PROTECT THE
ENVIRONMENT
HEAT ENERGY

P-FERTILIZER

10-20 % plant-available phosphorus

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CARBON CYCLE

1. Sewage Sludge
2. Carbonization
3. Fertilizer

Process
Upcycling
Disposal
Pyreg...
THE RECYCLING OF SEWAGE SLUDGE IS FACING RISING DEMANDS. CAPACITY BOTTLENECKS, THE UPCOMING PHOSPHORUS RECYCLING OBLIGATION AND INCREASING ENVIRONMENTAL PROTECTION REQUIREMENTS ARE AMONG THE CHALLENGES YOU FACE. WE SUPPORT YOU.

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**UPCYCLING**
THE SLUDGE CARBONIZATE DOES NOT HAVE TO BE REPROCESSED AND CAN BE MARKETED DIRECTLY AS A PHOSPHORUS FERTILIZER

**CLIMATE POSITIVE PROCESS**
IMPROVE YOUR CO₂ FOOTPRINT AND REPUTATION

**DECENTRALISED SYSTEM**
REDUCTION OF TRANSPORT EFFORT AND COSTS

**USABLE WASTE HEAT**
USE AS AN ADDITIONAL ENERGY SOURCE FOR DRYING PROCESSES

**REDUCTION IN QUANTITY**
THE TOTAL QUANTITY OF SLUDGE IS REDUCED BY UP TO 90% THROUGH CARBONIZATION

**COMPLETE RECYCLING**
THERE ARE NO RESIDUES LEFT TO BE DISPOSED OF

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...closes the cycle
Sustainable for the environment

**ACTIVE ENVIRONMENTAL PROTECTION**
The carbonization process complies with current EU environmental standards.

**ACTIVE RESOURCE PROTECTION**
Phosphorus is recovered in plant-available form. Thanks to gentle carbonization at lower temperatures (500-700 °C) no after-treatment is necessary.

**REGENERATIVE HEATING**
Up to 150 kWth of surplus heat energy can be saved per system and used for drying the sludge, thus substituting fossile energy carriers.

**ACTIVE CLIMATE PROTECTION**
During carbonization in the Pyreg process, most of the carbon contained in sludge is stably bound and does not enter the atmosphere as CO₂. As a fertilizer substrate in the soil, carbon is removed from the cycle for centuries.

**PYREG SYSTEM: P500**

- **SIZE**
  - 45 m²
  - = 3 CAR GARAGE

- **CARBON STORAGE**
  - 440 t CO₂
  - = 34 HECTARE FOREST

- **WASTE HEAT**
  - 1,125,000 kWh
  - = 45 HOUSEHOLDS
FEWER TRANSPORT MEANS LOWER COSTS AND LOWER CO₂ EMISSIONS

SEWAGE SLUDGE
4% DS*

SEWAGE SLUDGE
DEWATERED WITH 25% DS*

SEWAGE SLUDGE
DRIED WITH 80% DS*

SEWAGE SLUDGE
AS PYREG® PHOSPHORUS FERTILIZER

* DS = dry substance

Additional CO₂ sequestration by using as fertilizer
Play It Safe
The phosphorus fertilizer, which is obtained by using the PYREG process, can be registered as an inorganic fertilizer for the first time in Sweden on September 27th, 2018 (PYREGPhos, KEMI no: 5164115262).

With the newly enacted EU regulation of March 29th, 2019, the phosphorus fertilizer is now available throughout the EU and finally also in Germany (EU Regulation 764/2008 on the free movement of goods & EU 2019/515 on the mutual recognition of goods).

Switzerland and Germany have already introduced a P-recycling obligation. Other countries will follow. PYREG offers you today a future-proof and environmentally friendly treatment of sewage sludge including phosphorus recycling.
The PYREG process is a continuous method and uses the principle of dried carbonization. For that purpose, the dried sewage sludge is guided through PYREG-reactors operated at a temperature of 500 - 700 °C. In the PYREG reactors the sludge is not burned, but carefully degassed and then carbonized, by admission of a tightly targeted air stream. This way the material is completely sanitized.

Due to the selected temperature level in the PYREG reactors the phosphorus in the final product grants a high plant availability (in contrast to ashes). Supplementary costly pulping of the phosphorus is not necessary.

The process gas, generated in the PYREG reactors, is cleaned from dust by an automated process gas filter and completely burned by the FLOX-burner (flameless oxidation) at temperature of 1,000 °C inside a separate combustion chamber. This way, thermal NOx is significantly avoided. The formation of problematic substances like oils or tar is suppressed as well, because the process gas is not cooled, but oxidized in the combustion chamber.

Inside a flue gas cleaning system, harmful acidic components are absorbed by means of alkaline flue gas scrubbers, whereas volatile components like mercury are retained by activated carbon filters.

The carbonization process is self-sustaining; after-completion of the activation phase no further external energy is required to run the process, as the energy of the sludge is sufficient for the continuance of the thermal treatment. It is even possible to benefit from the excess heat produced; an amount of 150 kWth may be used for sludge drying.
Receiver tank

Rotary wheel sluice

Exhaust gas heat exchanger

Wet scrubber

Activated carbon filter

Exhaust gas fan

Chimney

Conditioning

HEAT

INPUT

W

PYREG®-reactor

Process gas filter

FLOX®-burner

Slag pot

Combustion air

OUTPUT
PYREG systems

COMPACT AND DECENTRALIZED

PYREG plants are compact, container based and can easily be integrated into an existing infrastructure and material cycles. Our plants for sewage sludge recycling and for gentle phosphorus recovery have been proving their worth since 2015 and have been installed at 4 sewage treatment plants in Germany, USA and Sweden.

Please note: The adjacent system data are model values to give you an initial idea. Exact system data can only be determined together with you, after a detailed analysis of the location, available infrastructures, sludge and a material test. Please feel free to contact us for a discussion.

<table>
<thead>
<tr>
<th></th>
<th>P500</th>
<th>P1500*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>l 9,000 mm</td>
<td>l 12,000 mm</td>
</tr>
<tr>
<td></td>
<td>w 3,000 mm</td>
<td>w 3,000 mm</td>
</tr>
<tr>
<td></td>
<td>h 5,800 mm</td>
<td>h 5,800 mm</td>
</tr>
<tr>
<td><strong>Combustible rating</strong></td>
<td>500 kW</td>
<td>1,500 kW</td>
</tr>
<tr>
<td><strong>Annual throughput</strong></td>
<td>approx. 1,100 t per year</td>
<td>approx. 3,200 t per year</td>
</tr>
<tr>
<td>DS, dry substance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Yearly production</strong></td>
<td>approx. 610 t</td>
<td>approx. 1,760 t</td>
</tr>
<tr>
<td><strong>Excess thermal energy</strong></td>
<td>approx. 150 kWth</td>
<td>approx. 600 kWth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operation hours per year</strong></td>
<td>approx. 7,500 h/a</td>
<td>approx. 7,500 h/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power consumption</strong></td>
<td>approx. 12 kWel</td>
<td>approx. 25 kWel</td>
</tr>
<tr>
<td><strong>Additional technology module with flue gas cleaning system (flue gas scrubbers, activated carbon filters)</strong></td>
<td>l 6,000 mm</td>
<td>l 9,000 mm</td>
</tr>
<tr>
<td></td>
<td>w 3,000 mm</td>
<td>w 3,000 mm</td>
</tr>
<tr>
<td></td>
<td>h 2,800 mm</td>
<td>h 5,800 mm</td>
</tr>
</tbody>
</table>

Based on 25 % DS sewage sludge, (dried > 11 MJ/kg OS)

*in planning
Quality of your sludge

REQUIREMENTS FOR SAFE AND ECONOMICAL TREATMENT USING THE PYREG PROCESS

ANALYSIS

Obviously, every sludge is different. Only on the basis of an individual sludge analysis can we make an initial assessment and make statements as to whether your sewage sludge is suitable as a fertilizer substrate.

The focus is on

- Available annual quantity
- Heavy metal and pollutant contents
- Organic dry matter content
- Existing or necessary sewage sludge treatment technology such as dewatering or drying

BASIC CONDITIONS

- Pourable and free flowing
- Approx. 80% min. content of dry substance
- Min. calorific value 10 MJ/kg
- Total volume of min. 1,000 T (DS) per year
PYREG SYSTEMS IN OPERATION

**FURTHER PLANTS**

<table>
<thead>
<tr>
<th>Country</th>
<th>Plant Name</th>
<th>Type</th>
<th>Size</th>
<th>In Operation Since</th>
</tr>
</thead>
<tbody>
<tr>
<td>GER</td>
<td>Entsorgungsverband Saar (EVS)</td>
<td>P500</td>
<td></td>
<td>2016</td>
</tr>
<tr>
<td>SWE</td>
<td>Skanefro SE</td>
<td>P500</td>
<td></td>
<td>2019</td>
</tr>
<tr>
<td>GER</td>
<td>Abwasserverband Main-Taunus</td>
<td>P750</td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>CZE</td>
<td>City of Trutnov</td>
<td>P500</td>
<td></td>
<td>2020</td>
</tr>
</tbody>
</table>

**Key**

- **22** Biomass systems
- **6** Sewage sludge systems
- **3** Activated carbon systems
- **4** Laboratory systems
**WWTP LINZ-UNKEL, GERMANY**

**OPERATOR:** Zweckverband Abwasserbeseitigung Linz-Unkel  
**LOCATION:** Unkel (near Bonn), Germany  
**SEWAGE PLANT SIZE:** 30,000 p.e. (population equivalent)  
**PYREG SYSTEM OPERATION SINCE:** 2015: P500  
**SLUDGE TREATMENT:**  
- Sludge stabilization (2-stage compact digestion)  
- Dewatering and drying  
  (60 % reduction in quantity; required energy is completely covered by the thermal energy of the PYREG plant and micro gas turbine)  
- Carbonization of sludge with a P500 system  
  (approx. 90 % volume reduction; required process energy is completely self generated; additional excess thermal energy is used for the drying process)  

Europe-wide approval of sludge carbonizate as fertilizer

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**WWTP SILICON VALLEY CLEAN WATER, USA**

**OPERATOR:** Bioforcetech Corporation  
**LOCATION:** Redwood, California, USA  
**SEWAGE PLANT SIZE:** 200,000 p.e. (population equivalent)  
**PYREG SYSTEM IN OPERATION SINCE:** 2017: P500  
**SLUDGE TREATMENT:**  
- Drying of the sludge  
  (75 % volume reduction with 60 % lower energy consumption)  
- Carbonization of sludge with a P500 system  
  (approx. 90 % volume reduction; required process energy is completely self generated; additional excess thermal energy is used for the drying process)  

Sludge carbonizate is marketed directly to the agricultural sector as a natural soil improver.
The path to your PYREG system

**ANALYSIS**
We analyse your recycling problem: Is carbonization worthwhile for you? We will help you to find an answer to this question. We evaluate the quantity and quality of your sludge and give you a realistic assessment so that you can make a safe decision.

**LOCATION**
We analyse the structural conditions: Even at this early stage, we check the licensing conditions on site.

**PLANNING**
Draft planning and EIA screening: On the basis of a careful site analysis, we design the most suitable plant for your operation. On request, we can also configure any additional equipment you may need, such as drying, dewatering, power generation, etc., and plan the necessary infrastructure and technical interfaces with you.

**AUTHORITIES**
Coordination of a preliminary design with the competent authorities: We create the basis for the approval and construction of the plant. We coordinate the draft with the employees of the responsible offices.

**APPROVAL**
We accompany you through the approval process and prepare the necessary plant and process data for you.
The detailed planning of the plant begins. The individual modules are manufactured and the plant is going to be built.

We keep you fully informed about the individual production steps. As a plant manufacturer, we have been developing and manufacturing high-quality carbonization plants in tested quality and "Made in Germany" at our company facilities in Dörth for more than 10 years.

Acceptance and commissioning: We organise the official acceptance of the finished plant, commission the plant and support you during the running-in process.

We monitor the operation of your plant online. Around the clock.

We develop an individual maintenance plan for your plant and implement it on request with our on-site service and in-house service personnel.
OUR EXPERIENCE
As a company for mechanical engineering and environmental technology, we are active in the development and manufacturing of compact carbonization systems in proven quality for more than 10 years. Our PYREG systems are used worldwide.

ADDITIONAL SERVICES
To ensure that the PYREG technology fits optimally into your recycling cycles, we offer you a wide range of optional additional services. This includes, for example, a selection of different conveyor technology, storage technology and integration into the heat concept at the site.

ON-SITE SERVICE
Once your PYREG system is up and running, you also benefit from our comprehensive support. This includes remote monitoring and diagnosis as well as on-site service from our technicians.
Added value

PHOSPHORUS FERTILIZER

CARBONIZATION

SEWAGE SLUDGE

SAFE

DECENTRAL

COMPLETE

NATURE

CLIMATE
ONLY HIGH-QUALITY CARBON PRODUCTS AT ATTRACTIVE PRICES ARE IN LONG-TERM DEMAND ON THE MARKET.

*For large companies and municipalities
Thanks to permanent innovation and further technical development, PYREG meanwhile has turned out to be one of the most important pioneers in environmental technology. Particularly in the sector of phosphorous recycling from sewage sludge and the resulting production of valuable biochar, feeding char and activated carbon, we are one of the market leaders worldwide.

Winner of Success-Technology award, innovation award of Rhineland Palatinate, inventor award of Rhineland Palatinate ...  
Nominated for Diesel Medal, Start-Green-Award, Energy-Award, ...  
Technology supplier for winners of Bloomberg Philanthropies Majors Challenge (Stockholm), winner of Austrian Climate Protection Award (Gerald Dunst) ...

Proven method: More than 30 units are currently in service worldwide.  
Worldwide presence: D/A/CH-region, USA, China, Sweden, Belgium, Czech Republic, ...  
Clientele in several sectors: Municipal companies, manufacturers of compost and garden soil, agricultural enterprises, recycling companies, WWTPs, food and pharmaceutical industry as well as waste management companies make use of our systems.
2011 until today
Entry of further shareholders (State of Rhineland-Palatinate, German Startup Group, ELIQUO WATER GROUP/SKion, Abacus Alpha/KSB, Hevella Capital)

2010
Entry of PYREG Beteiligungsgesellschaft and establishment of PYREG GmbH in Dörth/Rhineland-Palatinate

2009
Spin-off of PYREG GmbH from the joint research project

2007 - 2010
Operation of a PYREG plant prototype at the wastewater treatment plant of the AVUS Ingelheim

1999 - 2009
Dipl.-Ing. Helmut Gerber and Prof. Dr.-Ing. Winfried Sehn develop the PYREG process at the University of Applied Sciences Bingen