Interreg Austria – Czechia
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From Waste to Resource
Recycling Sewage Sludge Ash into Phosphate-rich Plant Fertilizer

How the phosphorus contained in sewage sludge can be used to improve the closing of the phosphorus cycle.

Motivation

Phosphorus is an essential fertilizer in the agricultural production but is limited, regionally concentrated, and mined under harmful conditions. It has been on the EU's critical raw materials list since 2014 due to its importance and high import dependency. Around 90 % of phosphorus in wastewater is retained in sewage sludge – nearly 7,000 tons yearly in Austria and 8,000 tons in the Czech Republic.

Sewage sludge use differs in the Czech Republic, agriculture remains dominant, whereas Austria incinerates most sludge, with Vienna using mono-incineration. By 2033, Austria will mandate, beside onsite solutions, the incineration for larger wastewater treatment plants, requiring 80 % phosphorus recovery from the ash. The Czech Republic plans stricter laws limiting agricultural use, pushing for alternative sludge disposal, with thermal utilization as the primary option.

Recovery of phosphorous from sewage sludge ash is challenging due to the co-pollution with heavy metals. In addition, the use of industrial acids for leaching and consequent precipitation renders it an economically and environmentally challenging process. In PHOS4PLANT, alternative ways for incinerating sewage sludge, leaching, and precipitating phosphorous are explored that could represent an environmentally friendly alternative to obtain high quality fertilizer based on biological processes.

The current state of research in Work Package 2

Enrichment of acidophilic bacteria from sewage sludge

To obtain microorganisms present in sewage sludge that are suitable for bioleaching, a sample of activated sludge was taken from a wastewater treatment plant in Lower Austria. The organisms contained in the activated sludge were enriched for the bioleaching of phosphorus from the sewage sludge ash.

A literature research was conducted, to select a culture medium in which common micro-organisms for biological leaching are cultivated. By choosing this medium, it was possible to keep the main nutrient composition constant and only change the components of the substrates that are necessary to enrich microorganisms with different properties for sulfur oxidizers, iron oxidizers, mixed sulfur- and iron-oxidizers, and heterotrophic microorganisms.

Further advantages of the selected culture medium for the enrichment were the optimized use of nutrients, as necessary nutrients are often added in excess to culture media. Furthermore, the culture medium provided suitable conditions for acidophilic enrichment cultures. Microorganisms were selectively enriched by repeatedly transferring them to fresh culture medium in three cultivation rounds.

Figure 1: Sampling spot for the enrichment of bioleaching microorganisms

In the first cultivation phase, the organisms were cultivated for a duration of three weeks. This provided the microorganisms with sufficient time to adapt to the deviating conditions that are necessary in the bioleaching cultivation medium and the applied temperature, which differs from their natural environment in the activated sludge.

The successfully enriched mixed cultures from sewage sludge were then kept at BOKU as living cultures for further use in the subsequent biological leaching tests. Furthermore, the prepared samples were sent to MU for molecular biological analysis and identification. There, the enrichment cultures were subsequently characterized. As an example, the results of the 16s rRNA analysis of the sulfur-oxidizing enrichment experiments following three rounds of enrichment with a minimum of 14 days, demonstrated that the family of *Eubacteriaceae* (Class *Clostridia*) was present with a share of 24.4 %. These bacteria, together with the other five most present microorganisms in sulfur-oxidizers enrichment, can be described as typical protagonists in the sewage sludge from wastewater treatment plants. Besides the typical wastewater treatment organisms, the bacterium *Desulfovibrio desulfuricans* was found with an abundance of 2.3%. According to literature, the organism possesses a dominant sulfur metabolism.

As *D. desulfuricans* is not capable of sulfur oxidation, at least one more microorganism is required for the metabolization of sulfur to achieve the pH-reduction necessary for an acidic phosphorus leaching. In this regard, *Alicyclobacillus disulfidooxidans* with an abundance of 0.6% in the microbial community could provide the necessary pathway option to fully metabolize the elemental sulfur.

The enrichment of acidophilic bacteria from sewage sludge in the form of activated sludge utilizes the capability of microorganisms already present in the sewage sludge for the phosphorus leaching of sewage sludge ash.

Dissemination activities

K1-MET participated in the 9th World Conference of the International Society for Microbial Electrochemistry and Technology (ISMET), which took place in Leipzig, Germany from 16 to 19 September 2025. This international conference brings together the global community working on microbial electrochemical technologies, providing a platform for sharing innovations and research advances. Marianne Haberbauer presented the project in the form of a poster titled “Bioelectrochemical Precipitation of Struvite from Synthetic Leachate Using Electroactive Microorganisms in a Two-Chamber System”.

Furthermore, on 8 May 2025, Ms Haberbauer participated in the International Life Science Meeting 2025 at IMC Krems. Titled “Bioelectrochemical systems for recycling processes”, her presentation provided an opportunity to present the objectives of PHOS4PLANT.

Masaryk University presented the PHOS4PLANT project during “Scientists’ Night” on 26 September 2025 at the University Campus in Brno.

Brno University of Technology leads the preparations of the 1st project workshop: Phosphorus and Beyond: Circular Approaches in Waste Management, which will be held on 26 November 2025 in Brno.

BOKU University participated in the 20th International symposium on waste management, resource recovery and sustainable landfilling (Sardinia Symposium 2025), presenting the latest advances carried out for the project. A paper on the presentation was published in the Proceedings of the conference.

Involved partners

K1-MET GmbH has proven expertise in the further development of processes for the treatment of residues and recycling materials with the aim of recovering valuable materials and closing material cycles. The tasks of K1-MET are, therefore, the recovery of phosphorus from sewage sludge ashes by non-contact bioleaching or with acids and the subsequent production of the phosphate-rich plant fertilizer. This is combined with the removal of impurities, such as metals, from the sewage sludge ashes. K1-MET is the lead partner in this project.

Masaryk University (MU) is the second-largest university in the Czech Republic. The Department of Biochemistry, the Department of Chemistry, and the Department of Geological Sciences are involved in the project. The team has many years of experience in the field of acidophilic microorganisms, molecular mechanisms of plant-microorganism interactions, structure-function analysis of microbial communities, mineral analysis, and trace element analysis.

A team from the Department of Thermal Processes and Gas Cleaning which is a part of the Institute of Process Engineering of Brno University of Technology (BUT) is involved in the project. This team has extensive experience in the field of thermal processes and emission treatment. They are responsible for the production of sewage sludge ash in the project. The institute possesses a drum dryer and a rotary kiln necessary for pilot-scale experiments. In addition, analytical infrastructure is available to measure fuel and waste properties and to analyze flue gas emissions.

The Institute of Waste Management and Circularity (ABF-BOKU) is focused on the safe disposal and recycling of waste in order to reduce the amount of waste and to save resources in primary production. Its tasks in the project are the pre-treatment of the highly alkaline ashes, which hinder the biological leaching of the material, the bioleaching of sewage sludge ashes, and the identification of acidophilic bacteria from sewage sludge. In addition, the entire process chain will be evaluated using LCA.

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