Biorefinery project KoalAplan is extracting raw materials from wastewater

The Ministry of the Environment, Climate Protection and the Energy Sector is funding the KoalAplan project, which extends the functional scope of a wastewater treatment plant. The project, based in the Stuttgart district of Büsnau, aims at recovering raw materials from wastewater and is therefore making a positive contribution to climate neutrality, as the products obtained replace fossil raw materials and energy-intensive processes.

Scientists from the DVGW Research Centre at the Engler-Bunte Institute of the Karlsruhe Institute of Technology (KIT), the Fraunhofer Institute for Interfacial Engineering and Biotechnology, Hamburg University of Technology, the University of Stuttgart and the Clausthal University of Technology are working on a project to create new processes for wastewater treatment together with Umwelttechnik BW (UTBW), the state agency for environmental technology and resource efficiency in Baden-Württemberg. The KoalAplan project, also described as 'the Büsnau biorefinery' focuses on municipal wastewater as a source of ammonium nitrogen, hydrogen and bioplastics. The project has been launched to recover raw materials from municipal wastewater and to generate an impact towards climate neutrality.

Bypassing biological nitrogen removal for organic load recovery

In a conventional wastewater treatment plant, the nitrogen contained in the wastewater undergoes biological degradation. Microorganisms convert the nitrogen compounds into gaseous nitrogen, which escapes unused into the atmosphere. For the conversion process, the microorganisms require organic carbon, which is no longer available as a feedstock but is discharged as CO_2 and sewage sludge. "We are bypassing biological nitrogen removal in our project and would like to demonstrate that we can recover a large part of the organic load from wastewater," explains Professor Harald Horn, Head of Research at the Engler-Bunte-Institut.

Planned process produces fertiliser, biohydrogen and valuable chemicals

The planned process concept consists of chemical, physical and biological process steps. A core part of the entire process is the use of micro-screens to separate the particulate organic carbon from the wastewater stream already after primary sedimentation. In the main stream process, the ammonium nitrogen is subsequently removed using ion exchangers, producing a product that can be used as a fertiliser. In the side stream process, the actual biorefinery, the filtered solids and the primary sludge are first converted into organic acids by acid hydrolysis (dark fermentation), which also produces biohydrogen and CO_2. The hydrolysate is then filtered and converted to hydrogen (and again CO_2) through microbial electrolysis. Hydrogen has many applications in the chemical industry and is considered a future energy carrier. In a feasibility study, the gas flows from microbial electrolysis and dark fermentation are utilised in a biotechnological process for the production of valuable chemicals. In the process, the carbon dioxide contained is also fixed again.

The material streams, which contain carboxylic acids among other things, are converted into polyhydroxyalkanoates (PHA), a natural biopolymer, in a fermentation process. "From waste material streams, we produce the microbial biopolymer PHA, a starting material for biodegradable packaging materials and can thus replace persistent plastics from fossil sources," says Dr.-Ing. Susanne Zibek, group leader for bioprocess technology at Fraunhofer IGB.

Testing at wastewater treatment plant of the University of Stuttgart

The new process concept is currently being tested in Stuttgart-Büsnau, at the sewage treatment plant for research and education of the University of Stuttgart. Peter Maurer, Technical Operations Manager at the plant, explains: "We are testing innovative processes for wastewater treatment. We've often worked against the odds, but usually, our efforts have been rewarded with success."

Life cycle assessment shows contribution to environment and climate

The project is also investigating what other effects the innovations will have. "A detailed life cycle assessment will show whether the process enables us to make a positive contribution to the environment and climate," emphasizes Dr Andrea Hille-Reichel, Project Manager at the Karlsruhe Institute of Technology. With the help of a climate and energy balance, the process can be compared to conventional sewage plant operation.

"We are networking local players and looking to identify potential buyers for the products produced. We are convinced of the market potential and economic viability of the process," says Dr Anette Zimmermann, Head of Environmental Technology at Umwelttechnik BW.

The KoalAplan project intends to highlight the recycling potential in wastewater treatment. The projected recovery of the products hydrogen, bioplastics and nitrogen/phosphorus fertiliser can significantly reduce resource consumption. At the same time, energy-intensive processes will be replaced and emissions reduced.

Baden-Württemberg sustainable bioeconomy strategy

The project is considered an integral part of the Ministry's strategy to build a sustainable bioeconomy in the federal state of Baden-Württemberg. Based on this strategy the state government supports the change to a raw material-efficient and cycle-oriented economy using renewable and biological resources.

Funding and coordination

The project is funded by the Baden-Württemberg Ministry of the Environment, Climate Protection and the Energy Sector as part of the ERDF (European Research and Development Fund) programme "Bioeconomy – Biorefineries for the recovery of raw materials from waste and wastewater". ERDF is a structural fund that supports economic, territorial and social cohesion within the EU.

Project coordination and public relations are being managed by Umwelttechnik BW, the state agency for environmental technology and resource efficiency in Baden-Württemberg.

Fraunhofer IGB is involved in all five biorefinery projects funded by the Ministry of the Environment within the framework of the ERDF funding program "Bioeconomy Bio-Ab-Cycling". Three of the projects are coordinated in a lead role: InBiRa, SmartBioH2-BW and RoKKa.

Das Projekt wird durch das Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg im Rahmen des EFRE-Förderprogramms „Bioökonomie – Bioraffinerien zur Gewinnung von Rohstoffen aus Abfall und Abwasser – Bio-Ab-Cycling“ gefördert.

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