CEPHAWA

PHA-cellulose composites with simultaneous water recovery to increase cellulose-processing circularity

Water4All
Water security for the planet

Coordinated by Early Career Researcher

Abstract

CEPHAWA develops a circular approach for cellulose-rich industrial wastewaters, with a particular focus on the pulp and paper sector. These streams are often costly to treat, yet they contain substantial amounts of cellulose and dissolved organic carbon that remain underused and represent a significant environmental challenge. Rather than viewing them as a disposal problem, CEPHAWA treats them as a resource for recovering both materials and water.

The project combines microbial process engineering, materials science, and water technology to convert cellulose-derived carbon into polyhydroxyalkanoates (PHAs), a family of biodegradable biopolymers.
In a first step, cellulose-rich streams are partially converted into carboxylates (C2-C8), which serve as substrates for PHA production. CEPHAWA explores two complementary biological routes for this step: aerobic heterotrophic microorganisms and purple non-sulfur bacteria. These routes offer different opportunities for carbon utilization, process robustness, and product formation, thereby broadening the design space for wastewater-based biopolymer production.
A second key innovation is the dual valorization of the cellulose fraction.

CEPHAWA uses them as a resource for carboxylates and as a structural component for the formation of PHA-cellulose composites. This opens a broader material design space, because the final properties depend on both the polymer and the fiber fraction. Cellulose fibers contribute structure, stiffness, and reinforcement, while PHAs provide the matrix and processability.

In addition, short-chain-length PHAs and medium-chain-length PHAs exhibit distinct material characteristics, ranging from stronger, more rigid to more flexible, more ductile behavior. By combining these dimensions, CEPHAWA aims to create in situ composites with tunable properties for various applications.

Beyond material production, CEPHAWA also addresses water circularity. By linking biopolymer synthesis with on-site water reuse, the project aims to reduce freshwater demand, lower wastewater loads, and decrease the overall environmental footprint of cellulose-processing industries. Techno-economic analysis, water-reuse scenarios, and application-oriented materials screening will identify the most promising implementation routes.

The project is closely linked to practice through industrial partners, which helps ensure that material development, application testing, and valorization routes remain relevant to real-world implementation. In this way, CEPHAWA bridges the gap between lab-scale innovation and industrial uptake, providing the evidence needed to support decision-making and policy discussions on circular water and materials strategies.

By bringing together expertise in microbial biotechnology, wastewater engineering, polymer science, and system assessment, CEPHAWA aims to deliver a practical platform for turning cellulose-rich wastewaters into valueadded biomaterials while supporting more circular water use in European industry.

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Project partners

- DELFT UNIVERSITY OF TECHNOLOGY - THE NETHERLANDS
- EBERHARD KARLS UNIVERSITAET TUEBINGEN - GERMANY

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