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Turning Wastewater into a Resource: Advancing Sustainable Water Management

With global water scarcity on the rise—impacting 38% of Europe's population in 2019 alone—a novel approach is emerging to transform wastewater into a valuable resource. Water-smart industrial symbioses (WSISs) offer an innovative solution, fostering collaboration between industries and the water sector to recover and reuse water, materials, and energy while reducing reliance on scarce freshwater resources.

A recent study conducted by Kompetenzzentrum Wasser Berlin (KWB) in Kalundborg, Denmark, explored the potential of WSISs by testing advanced methods to treat a mixture of industrial and municipal wastewater for industrial reuse. Researchers set up a pilot plant to evaluate membrane filtration techniques, aiming to produce high-quality water for industrial cooling systems. This research marks a significant step forward in tackling water scarcity through innovative solutions.

The Challenge of Complex Wastewater

The wastewater treated in Kalundborg presented unique challenges, as it combined municipal wastewater with pre-treated industrial and power plant effluents. This complex mixture pushed the limits of current water reclamation technologies. The study focused on the performance of three types of membranes—ultrafiltration (UF), ultra-tight UF, and nanofiltration (NF)—as pre-treatment steps for reverse osmosis to mitigate biofouling processes.

Results and Key Findings

The conventional UF membrane outperformed denser alternatives, achieving the highest water recovery rate of 87% with the least energy consumption. While ultra-tight UF and NF membranes were more effective at removing specific contaminants, they couldn't match the overall efficiency of the UF membrane. However, the study also revealed a persistent challenge: biofouling, the buildup of microorganisms on the membranes. Biocide dosing proved effective in mitigating biofouling, while UV treatment was found to be an environmentally friendly alternative.

Environmental Impacts and Sustainability

The study went beyond technical performance, conducting a life cycle assessment to evaluate environmental impacts. Researchers compared the water reclamation process to two alternatives: sourcing freshwater from a nearby lake and desalinating seawater. Key findings included:

- **Lake water sourcing** had the lowest carbon footprint but impacted local water availability.
- **Desalination** had the highest carbon footprint but preserved local freshwater resources.
- **Water reclamation** offered a balanced solution, with moderate energy use, carbon emissions, and water availability impacts.

One critical challenge identified was the treatment of brine, the concentrated waste stream generated by reverse osmosis. Treating brine significantly increased energy consumption and carbon emissions, underscoring the need to consider the entire water treatment cycle when evaluating sustainability.

Paving the Way for Circular Water Systems
The study demonstrates that even complex wastewater can be treated to produce high-quality water for industrial reuse, helping industries in water-stressed regions reduce their reliance on freshwater resources. However, the research also highlights the importance of tailoring solutions to local conditions, available water sources, and energy mixes.

“This research demonstrates that we have the tools to create circular water systems, where wastewater becomes a valuable resource rather than a waste product,” said Dr. Anne Kleyböcker, Project Manager at KWB. “As climate change, population growth, and industrial activity intensify water scarcity, these innovative approaches could be key to sustainable water management.”

About the Study
KWB’s study advances the understanding of water reclamation technologies and emphasizes the need for innovative, site-specific solutions to address water scarcity. By turning wastewater into a resource, industries and communities can move closer to a sustainable future, even in the face of growing global challenges.

[External link to study]

About KWB

Founded in 2001, the Berlin Centre of Competence for Water (KWB) integrates science, research, and consultancy to promote sustainable water management. We focus on applied research across the entire water cycle, collaborating with partners in academia, industry, and public administration to develop innovative solutions for future-ready cities.

KWB connects national and international stakeholders within the water sector through targeted networking, knowledge exchange, and public outreach, disseminating the latest trends in water research to both professionals and the wider community. With years of expertise, we also organise specialised conferences and workshops to foster dialogue within the water sector.

By linking innovative research with practical application, we support municipalities, policymakers, and infrastructure operators, driving forward creative water solutions for a sustainable future.

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