WATER 2026 IN INDUSTRY

an IWA conference

Conference Venue
Delft University of
Technology and Haskoning

Date: Sat 27 June – Fri 3 July 2026

IWA
the international water association

Contents

Welcome Message

Dear Participants

It is our great pleasure to welcome you to the Water In Industry 2026, WIN2026, held in Delft, The Netherlands. We are delighted to host you in this historic city for an inspiring and productive conference. The central theme of the conference is "Balancing water demand to enhance availability and quality – From Science to Implementation". This theme reflects both the urgency and the opportunity that define today's challenges in industrial water management: translating scientific advances into practical scalable solutions that improve water availability and quality across industrial sectors.

WIN2026 marks the third edition of the biennial series of IWA's Specialist Group "Treatment of Industrial Waters". The Specialist Group brings together a diverse community committed to sustainable industrial water management. Its activities bridge water supply, process effluent treatment, residual stream management, water reuse, and resource and energy recovery. The Group promotes solutions from process to site scale, recognizing that sustainable water management requires both technological innovation and system-level thinking.

A key focus of the Specialist Group is promoting the circular use of water, materials and energy in industry through water reuse, resource recovery and energy recovery, and the use of alternative water sources. By addressing both technical and economic challenges the Group seeks to support sustainable industrial production and reduce resource consumption and minimize impacts on natural water bodies. This mission is becoming increasingly important as water scarcity and water quality challenges increase due to population growth, rising industrial demand, and climate change.

WIN2026 is the third edition of this series and builds on the success of WIN2024 in Nanjing, China. In line with the mission of the Specialist Group, WIN2026 aims to bring together practitioners, consultants, researchers, and policy makers to exchange knowledge and discuss emerging solutions, technologies, and approaches in industrial

water management. The conference provides a platform for bridging disciplines and fostering collaboration between science and practice.

The scientific programme of WIN2026 reflects this ambition. The overall themes include: industrial effluent treatment and reuse; resource and energy recovery; biological treatment processes; membrane-based separation and recovery technologies; advanced oxidation processes; materials for industrial water treatment; industrial water-saving strategies; electrochemical treatment and valorization techniques; industrial symbiosis; digitalization and smart control systems; industrial water pollutants; and life cycle assessment of industrial water systems. Together, these topics highlight the diversity of approaches needed to support more sustainable and circular industrial water use.

The conference programme is designed to encourage both depth and interaction. It includes two short courses, seven workshops, six keynotes, and approximately 21 plenary and parallel technical sessions, featuring several oral presentations. In addition, the programme includes 11 company presentations and several posters, providing ample opportunity for exchange between academia and industry. Special activities include a Young Water Professionals panel, as well as five technical site visits, offering participants the opportunity to experience applied water innovation in practice.

We gratefully acknowledge the generous support of our sponsors: Haskoning, Lenntech, Evides and Delfland . Their contributions are essential in enabling this conference and in fostering the exchange of knowledge across industry, academia, and policy domains.

Beyond the scientific programme, we warmly encourage you to take some time to explore Delft. Delft is an ancient city where history, industry, and art meet. Known for its role in early Dutch industrialization, it was home to industrialist Jacques van Marken, who founded the yeast and spirits industry that evolved into DSM. Visitors can explore its rich history, Royal Delft pottery, the Johannes Vermeer Center, and scenic canals, highlighting Delft as a hub of history and innovation.

We sincerely hope that your participation in WIN2026 will be both inspiring and rewarding, and that the conference will generate new collaborations, ideas, and solutions for the future of industrial water management.

With best regards,

Henri Spanjers (TU Delft)
Sanne Smith (TU Delft)
Sanjeeb Mohapatra (TU Delft)
Conference Chairs

Invited Speakers

Welcome Speech by Kala Vairavamoorthy

Executive Director, International Water Association

Kala Vairavamoorthy is an internationally recognised water resource management expert, with particular expertise in urban water issues. He combines a strong engineering background with practical international experience. He has published extensively and has a strong international profile working closely with the World Bank, UN-Habitat, UNESCO, GWP, SIWI and the EU. This includes leading several urban water management projects for the World Bank, African Development Bank, Asian Development Bank and DFID.

Prior to joining the International Water Association, he was the Deputy Director General for Research at the International Water Management Institute. Kala was also the Founding Dean of the Patel College of Global Sustainability and a tenured Professor in the Department of Civil and Environmental Engineering, at the University of South Florida (USA). Prior to that he was a full professor and Chair of Water Engineering at the University of Birmingham (UK), and Professor and Head of Core of Sustainable Urban Water Infrastructure Systems at UNESCO-IHE (Netherlands). He is currently Professor (adjunct) at the Indian Institute of Technology, Madras (IITM). Kala has a PhD and MSc in Environmental Engineering from Imperial College, University of London, UK and a BSc (Hons) from King's College, London.

Opening Speech by Dr Geoff Townsend

Industry Fellow, Ecolab

Geoff engages in the strategic direction of Ecolab's water and energy related innovation with a particular emphasis on the water-energy-productivity nexus. He has 34 years direct experience in industrial water management including sales, project management, auditing, research & development and technical training. He has been involved in the design, optimisation and troubleshooting of many key utility processes across a variety of industries including manufacturing, power production and the petrochemical sector.

Geoff is also actively involved in Ecolab's sustainable development initiatives, especially in water stewardship and decarbonization. He initiated and continues to support the industrial affiliation and applied research activities at KAUST, KSA. Since 2017, Geoff has led Water Europe's Cluster Theme 'Water Smart Industry' and he now chairs their Water-Smart Industries Community of Practice. He also engages with NGOs to lessen industrial

impacts on vulnerable river basins (e.g. Lake Taihu, China). He represented the Netherlands in the development of ISO14046 "Water footprint – Principles, requirements and guidelines". Dr Townsend has a BSc (Hons) in Ecology (UEA) and a PhD in Environmental Chemistry from the University of Cambridge.

Keynote by Christophe Lasseur

European Space Agency (ESA), Head of MELiSSA program

Christophe Lasseur, born and now retired in Normandy, was for 35 years staff of the European Space Agency, where he successively was: research fellow, Life Support engineer, head of MELiSSA project, Coordinator of life support development, Certified Astronaut instructor and for 12 years Head of the International Life support working group aiming to coordinate NASA, ESA, JAXA, RSA, CSA life support activities. He owns a PhD in bioengineering from Compiegne university, and received a doctor honoris Causa from Antwerpen university. He is the first non-American since 1944 to have received the Jeffries award from the American Institute of Aeronautics and Aerospace.

Keynote by Guido Janssen

CEO, Nyrstar

Guido joined Nyrstar in 2001, was Head of Leaching and Roasting and held several management positions. He was General Manager for Nyrstar Netherlands in the period 2014-2016 and switched to General Manager for Nyrstar Belgium in the period 2016-2019. In 2018 he became Nyrstar's Vice President for European Operations. In early 2024, he was appointed Global CEO of the Nyrstar Group and is responsible for the company's global operations in Europe and Australia.

Before joining Nyrstar Guido worked as Technology Manager for an innovative wastewater treatment company doing projects all over the world. Guido holds a master's degree in Chemical Engineering.

Keynote by Iris Janssen

Water Process Technologist, HaskoningDHV

Iris is a Water Process Technologist at HaskoningDHV, specializing in industrial water treatment challenges. She is also part of the Water Compliance team, where she works

with Dutch water regulations and supports clients in navigating the complexities of their water permits. Her work is driven by the question of what is technically achievable while minimizing the environmental impact of industrial discharges on receiving water bodies.

She holds both a BSc and MSc in Process Biotechnology from Wageningen University and has been working for Haskoning for over two years.

Keynote by Kees van der Voort Maarschalk

Science Director · Royal Avebe

Kees Maarschalk has joined Royal Avebe in 2017 and is currently Science Director. He focuses on scientific and technological developments with special emphasis on innovation, sustainability and value creation from starch potatoes. He is active in projects around water use, extraction of ingredients from potatoes and starch conversions. Before Kees joined Avebe he had roles in R&D in different food and pharmaceutical companies. He also was a teacher at the University of Groningen.

Dinner Talk by Rick Hogeboom

Executive Director Water Footprint Network / Associate Professor University of Twente

Rick Hogeboom, PhD, leads the Water Footprint Network, a non-profit knowledge center that seeks to use the water footprint concept to promote science-based water stewardship practices in public and private policy worldwide. He is also Associate Professor in Multidisciplinary Water Management at the University of Twente, the Netherlands, where he studies how natural and socio-economic processes affect water resources, and vice versa. In this dual capacity, Rick works with various actors, from multilaterals and multinationals to local communities and civil society, to move the needle on water.

Young Water Professional Panel Members

Ruizhe Pei

Postdoctoral researcher, University of Vienna

Ruizhe Pei is a postdoctoral researcher at the University of Vienna. He earned his PhD from TU Delft in collaboration with Wetsus. Trained as an environmental engineer, his work combines microbial ecology and environmental biotechnology to advance sustainable wastewater treatment and resource recovery. Beyond the lab, he serves as the founding Chair of the IWA YWP Switzerland Chapter and represents YWP on the management committee of the IWA Resource Recovery Cluster. He is also actively engaged in science communication and outreach, with particular enthusiasm for engaging younger generations.

Hanneke Spijkerboer

Corporate sustainability water specialist, Aviko

My name is Hanneke Spijkerboer, and I work as a corporate sustainability water specialist at Aviko, where I am working on the future of industrial water use by connecting technology and strategy. With my physical-chemical background in molecular life sciences and the broad development I have undergone during the Nationaal Water Traineeship, I enjoy working at the intersection of operational processes, policy, and technological innovation. In my role I work on water reuse, water treatment, and water reduction, and I am committed to solutions that both strengthen the industry and contribute to a future-proof water sector. As a Young Water Professional, I strongly believe in collaboration and circular thinking as drivers of real change.

Eva IJzermans

Water strategy consultant for Industry, Haskoning

Eva IJzermans is a water strategy consultant for Industry at Haskoning, specializing in water strategy, water stewardship, and circular water systems. She works at the interface of industry, policy, and science, supporting organizations across the globe in addressing water scarcity, quality challenges, and regulatory pressures.

Eva has experience translating complex methodologies into practical strategies for industrial clients, in several sectors. Her work focuses on developing actionable water roadmaps, identifying sustainable water solutions, and embedding water into broader business strategy and value chains. With a strong interest in bridging ambition and implementation, Eva is passionate about empowering organizations and young professionals to accelerate the transition towards more resilient and sustainable industrial water management.

Pooja Halvawala

R&D engineer · Lenntech Water Treatment Solutions

Pooja Halvawala is a Research and Development Engineer at Lenntech, specializing in applied research for industrial process-water challenges. With five years of hands-on experience and a foundation in water treatment technologies, her work focusses on advanced water treatment technologies – especially pressure driven and electrochemical processes – to turn complex industry needs to practical solutions. Passionate about circularity, reuse, and recycling, Pooja contributes to efficient water treatment strategies across diverse industrial sectors, with a strong focus on water and salt recovery, brine minimization, and the recovery of valuable chemicals. She focuses on turning research findings into practical improvements for industrial water treatment. Outside of work, Pooja enjoys strength training at the gym, exploring nutrition, and dancing.

Courses

Electrochemical and Hybrid Technologies for Wastewater Treatment and Resource Recovery

Sanjeeb Mohapatra (TU Delft), Jules van Lier (TU Delft), David Vermaas (TU Delft), Ivan Buijnsters (TU Delft), Jouke Dykstra (WUR), Tuur van den Eijnde (Nijhuis), Jasper Schakel (CIWI).

Life Cycle Assessment as a Decision-Support Tool for Industrial Water and Wastewater Projects Using openLCA.

Nooshin Barzegar Marvasti (University of Birmingham), and Aashlesha Chekkala (BITS Pilani-Goa)

Workshops

1. Enabling Water Circularity and Management: Feasibility, Finance and Practice

   Arpita Amarnani (Centre for Excellence in Sustainable Development, Goa Institute of Management, India)

2. Educating the Next Generation of Industrial Water Professionals — developing a dedicated industrial water curriculum

   Bram Ooms (Water Opleidingen), and Cazimir ten Brink (Shell)

3. Building the bridges — Comprehensive Water Stewardship Plan for Industrial Resilience in Water-Stressed Basins.

   Basja Jantowski (Haskoning, Global Water Strategy for Industry Lead), Lourens Meijer (Unilever, Global Water Stewardship Lead), Gerrit Westhoff (Royal FrieslandCampina, Global SHE & Sustainability Director) and Arthur Gleijm (Rebel Group, Director)

4. Humber UK Case Study of the implications of no water available for Industry: How can we ensure growth in the sector whilst protecting the environment and ensuring enough water for people?

   Liz Cairns, Jenny Marshall-Reed, and Matt Woollin (Environment Agency, United Kingdom)

5. Data-Driven Water Stewardship: Certification as a Structured Pathway to Water Positivity.

   Shabnam Bassi, Akash Deep, and Moumita Ghosh (GRIHA Council, India)

6. Water Efficiency in the Industry: Practical Pathways to Circular Industrial Water Use

   Johann Poinapen-KWR, Julian Munoz-KWR, Ivaylo Hitsov-University Ghent

7. Building the Business Case for Circular Industrial Water Management Investments at Site Level.

   Cejna Anna Quist-Jensen, Thomas Track, Ken Stockil Colm Gaskin, Aisling O'Connor, Christoph Höfer, Andres Lucht (Denmark, Germany, Ireland, Austria

Company Case Presentations

C1. *Potable Water from Industrial Effluent in the Food Industry - Operational experience with Closing the Waterloop* – Wilbert Menkveld, Nijhuis

C2. *Waterbank Agriport: A Large-Scale Rainwater Storage and Reuse System for industry and horticulture – Releasing pressure on the drinking water supply.* – Toon Boonekamp, Sweco, representing ECW

C3. *Industrial Brine Treatment by Crystallization-Optimized Membrane Distillation: From Concept to Application Cases* – Norbert Kuipers, Wageningen University

C4. *Demineralization Unit Performance Troubleshooting* – Utku K Karani, OQBI

C5. *Water Management at Linde Gas: Globally addressing water stress to ensure plant reliability* – David Miklos, Linde GmbH

C6. *Reducing Industrial Water Intake Through Utility–Industry Collaboration.* – Nienke Peek, Vitens

C7. *Every threat to the status quo is an opportunity in disguise: Water reduction as a business case at BASF.* – Mark Lazonder, BASF

C8. *From Linear to Circular: The development and application of a Water Efficiency Framework at Dow production locations* – Johann Poinapen, KWR Water Research Institute

C9. *Reuse of Garmerwolde municipal effluent for industrial processes.* – Hannah van der Wal, WLN

C10. *Salt Removal / Reducing Industrial Water Intake* – Rosan van Wyngaard, Proxa Water South Africa

C11. *From complex wastewater streams to tailored solutions: Two industrial cases*-Suzanne Reinartz, Inopsys

Technical Site Visits

1. Veolia Water Tech – Biothane
2. Holland Hydrogen 1 – clean water for a clean fuel
3. Tata Steel IJmuiden
4. Lenntech – Lab-, pilot- and full-scale membrane- and resin-based water treatment systems

Local Organising Committee

Henri Spanjers
Chair

Sanne Smith
Co-chair

Sanjeeb Mohapatra
Co-chair

Jan Appelman

Mark van Loosdrecht

Andre Mepschen

Jules van Lier

Johan van Mourik

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Nanjing Tech University, China · Chair IWA-SG TIW

Sven-Uwe Geißen
Technical University Berlin, Germany · Co-chair IWA-SG TIW

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- **Mina Mahdian**, University of Toronto
- **Mui Choo Jong**, Tsinghua Shenzhen International Graduate School
- **Mustafa Taher**, Faculty of Science and Technology (REALTEK), Norwegian University of Life Science
- **Nothando Mungwe**, Rand Water
- **Olivier Lefebvre**, National University of Singapore
- **Paul Schausberger**, UNIHA Wassertechnologie GmbH
- **Qilin Wang**, University of Technology Sydney
- **Rajesh Dash**, Indian Institute of Technology Bhubaneswar, India

- **Reyes Sierra-Alva**, University of Arizona
- **Rukundo Keneth**, National Water and Sewerage Corporation

- **Sankar Chakma**, Indian Institute of Science Education and Research Bhopal
- **Siti Norzam Nadizmi**, PETRONAS
- **Sovik Das**, Indian Institute of Technology Delhi
- **Suanny Mosquera**, Escuela Superior Politecnica Del Litoral (Espol)
- **Sven Uwe Geissen**, Technische Universitaet Berlin
- **Thomas Track**, DECHEMA
- **Tjandra Setiadi**, Institut Teknologi Bandung
- **Val S. Frenkel**, TYLin INternational
- **Vinay Kum Tyagi**, National Institute of Hydrology
- **Woei Jye Lau**, Universiti Teknologi Malaysia
- **Wolfgang Uhl**, H2U aqua.plan.Ing-GmbH
- **Xuan-Thanh Bui**, Ho Chi Minh City University of Technology (HCMUT), Vietnam National University Ho Chi Minh
- **Yongjun Zhang**, Nanjing Tech University

Program

Sunday 28th June 2026 (13:00-22:00)

Location: Haskoning—former Mining Faculty on the TU Delft Campus, Mijnbouwstraat 120

13:00–	Registration
13:30–15:00	**Workshops (parallel)** ● *Enabling Water Circularity and Management: Feasibility, Finance and Practice*. Mehak Puri and Arpita Amarnani (Centre for Excellence in Sustainable Development, Goa Institute of Management, India) **Room: Nickel** ● *Educating the Next Generation of Industrial Water Professionals — developing a dedicated industrial water curriculum*. Bram Ooms (Water Opleidingen), and Cazimir ten Brink (Shell) **Room: Auditorium**
15:00–15:30	**Coffee Break**
15:30–19:00	**Courses (parallel)** ● *Electrochemical and Hybrid Technologies for Wastewater Treatment and Resource Recovery* - Sanjeeb Mohapatra, Jules van Lier, David Vermaas, Ivan Buijnsters (TU Delft), Jouke Dykstra (WUR), Tuur van den Eijnde (Nijhuis), Jasper Schakel (CIWI). **Room: Auditorium** ● *Life Cycle Assessment as a Decision-Support Tool for Industrial Water and Wastewater Projects Using openLCA*. - Nooshin Barzegar Marvasti (University of Birmingham), and Aashlesha Chekkala (BITS Pilani-Goa) **Room: Nickel**
19:00–22:00	Welcome Reception **Room: Atrium West**
19:30–19:45	Welcome speech Kala Vairavamoorthy, Executive Director, International Water Association
19:45–22:00	Drinks and Food (Networking)

Monday 29th June 2026 (08:00-17:30)

Location: Delft University of Technology (TU Delft) – Aula, Mekelweg 5, 2628 CC Delft

Chairpersons: Yongjun Zhang (Nanjing Tech University) & Henri Spanjers (TU Delft) **Room:** Auditorium	
08:00	**Registration**
09:00–09:30	**Welcome and Opening Session (plenary)**
09:30–10:00	**Opening speech (plenary)** Geoff Townsend, Water Europe Chair of the Water-Smart Industries Community of Practice. Water stress across Europe: challenges for the industry
10:00–10:45	**Keynote 1 (plenary)** Keynote: Christophe Lasseur, European Space Agency, head of MELiSSA program — Mission to Mars, the ultimate example of a circular economy?
10:45–11:15	Break
11:15–12:00	**Keynote 2 (plenary)** Guido Janssen, CEO Nyrstar and Iris Janssen, Haskoning DHV. Water challenges in industry at different corners of the world: challenges and solutions
12:00–12:30	Group Photo

Lunch (Workshop parallel): 12:30 - 14:00

- Building the bridges — Comprehensive Water Stewardship Plan for Industrial Resilience in Water-Stressed Basins. Basja Jantowski (Haskoning, Global Water Strategy for Industry Lead), Lourens Meijer (Unilever, Global Water Stewardship Lead), Gerrit Westhoff (Royal FrieslandCampina, Global SHE & Sustainability Director) and Arthur Gleijm (Rebel Group, Director)

  Room: Commissiekamer 3

- Humber UK Case Study of the implications of no water available for Industry: How can we ensure growth in the sector whilst protecting the environment and ensuring enough water for people? Liz Cairns, Jenny Marshall-Reed, and Matt Woollin (Environment Agency, United Kingdom)

  Room: Frans van Hasselt

- Data-Driven Water Stewardship: Certification as a Structured Pathway to Water Positivity. Shabnam Bassi, Akash Deep, and Moumita Ghosh (GRIHA Council, India)

  Room: Collegezaal D

Sessions 1 & 2 (Monday 29th June 2026, 14:00-15:30)

Industrial Effluent: Treatment **Chairpersons:** Ingrid Pinel (Lenntech) & Ran Shang (Veolia) **Room:** Fans van Hasselt		Resource and Energy Recovery **Chairpersons:** Jan Appelman (Haskoning) & Sanjeeb Mohapatra (TU Delft) **Room:** Commissiekamer 3	
14:00-14:20	ID 115 – *BODAC®; A sustainable biological regenerable activated carbon filter for biofouling control and micropollutant removal* – Wilbert Menkveld, Nijhuis	14:00-14:20	ID 134 – *Boosting Biogas Production with a Non-Conventional AnSBR Treating Protein- and Lipid-Rich Wastewater: Pilot Evaluation – Julian* Munoz Sierra, KWR Water Research Institute
14:20-14:40	ID 69 – *Chemical-Free Scaling Control as RO Pretreatment: Performance Gains Across Fresh, Brackish and Seawater Desalination* – Chris Rose, Sidon Water Ltd.	14:20-14:40	ID 174 – *Recovering Ammonia and Organic Acids from Residual Streams via Bipolar Membrane Electrodialysis* – Gladys Mutahi, TU Delft
14:40-15:00	ID 50 – *Learnings from the pilot testing of innovative technologies for the removal of marine plastic litter* – Harsha Mysore, BlueXPRT	14:40-15:00	ID 39 – *Extraction of silica aerogel by acid-base reaction from coal gasification slag for lead adsorption* – Bingyang Xun, Anhui University of Science and Technology
15:00-15:20	ID 36 – *Leather Industry Wastewaters: Performance of Polymer-Based Hybrid Materials in Coagulation-Flocculation and Sludge Reduction* – Begüm Uzluk, Boğaziçi University	15:00-15:20	ID 171 – *Electrochemical Ammonia Recovery from Anaerobic Digestion Reject Water* – Iosif Kaniadakis, TU Delft
15:20-15:25 (Pitch 1)	ID 169 – *Alkalized TripolyPhosphate Cross-linked Chitosan Beads Synthesized from Mushroom Waste (agaricus bisporus brunnescens) Were Developed as a Sustainable Biosorbent for the Batch Removal of Toxic Heavy Metals Cr (VI), Cu (ii), and Pb (ii)* – Tesfalem Belay Tesfalem Belay, Bahir Dar Institute of Technology	15:20-15:25 (Pitch 3)	ID 158 – *Assessing the feasibility of reclaiming process water from industrial wastewater effluent by using Closed-Circuit Reverse Osmosis and evaluating options for treating the resulting brine* – Tamarindo Metekohij, Evides Industriewater
15:25-15:30 (Pitch 2)	ID 73 – *Determination of C0-C2 Alkylphenols in Stripped Water using UPLC-Q/Orbitrap HRMS* – Yu-long Liu, CNPC Research Institute of Safety and Environment Technology	15:25-15:30 (Pitch 4)	ID 31 – *Enhancing the Regeneration Efficiency of Ion Exchange Resins with Ammonium Bicarbonate via CO_2 and Air Pressurisation* – Kamran Jalali, Univeristy of New South Wales

15:30-16:00 Coffee Break (Poster Presentation)

Sessions 3 & 4 (Monday 29th June 2026, 16:00-17:25)

Industrial Effluent: Biological Treatment **Chairpersons:** Julian Munoz Sierra (KWR) & Yeyuan Xiao (Shantou University) **Room:** Fans van Hasselt		Resource and Energy Recovery (Cont.) **Chairpersons:** Matthias de Cazes (Yara International) & Jules van Lier (TU Delft) **Room:** Commissiekamer 3	
16:00-16:20	ID 34 – *Anaerobic Treatment of Waste(water) from the Chemical Industry* – Meenakshi Prasad, Covestro Deutschland AG	16:00-16:20	ID 30 – *From nitrogen-rich process condensates to fertilizer* – Arjen Kok, Evides Industriewater
16:20-16:40	ID 92 – *Full-Scale Application of Anaerobic Sequential Batch Reactor for Efficient Treatment of High-Fat Ice Cream Wastewater* – Ran Shang, Veolia Water Tech	16:20-16:40	ID 72 – *Ammonium removal and recovery from industrial digestates* – Tjark Holst, Lenntech B.V.
16:40-17:00	ID 132 – *Phosphorus Control at Wastewater Treatment Works by Enhanced Adsorption with Water Works Sludge* – Fika Nikendary, PT Pertamina Energy Terminal, University of Leeds	16:40-17:00	ID 117 – *Towards Chemical-Free Nitrogen Recovery: Advancing Resource-Recovery Oriented Wastewater Treatment* – Ian Tomassen, Nijhuis
17:00-17:20	ID 166 – *Compost or Digest? A Life Cycle and Net Present Value Comparison for Managing MBBR Sludge at a Mexican University Campus – Mexitli Sandoval-Reyes,* Instituto Tecnológico y de Estudios Superiores de Monterrey	17:00-17:20	C1. *Potable Water from Industrial Effluent in the Food Industry - Operational experience with Closing the Waterloop* – Wilbert Menkveld, Nijhuis
17:20-17:25 (Pitch 5)	ID 7 – *Phytomigration of Residual Heavy Metals from Technogenically Contaminated Treated Waters (Bolnisi, Georgia)* – Konstantine Khachapuridze, Technical University of Georgia	17:20-17:25 (Pitch 6)	ID 157 – *Human-in-the-loop reinforcement learning for safe economic operation of membrane bioreactor processes in wastewater treatment*– Thu Minh Hoang, Nanyang Technological University

Tuesday 30th June 2026 (09:00-18:30)

Location: Delft University of Technology (TU Delft) – Aula, Mekelweg 5, 2628 CC Delft

Session 5 (Tuesday 30th June 2026, 09:00-10:30)

Industrial Effluent: Reuse **Chairpersons:** Thomas Track (Dechema e.V.) & Roy van Lier (Yara Sluiskil) **Room:** Auditorium	
09:00-09:30	**Keynote:** Kees van der Voort Maarschalk, Science Director at Royal Avebe. Dealing with water scarcity, it is not necessarily water re-use: An industry perspective
09:30-09:50	ID 45 – *Evaluation of advanced treatment trains for agri-food wastewater reuse across different food sectors* – Isabella Muñoz, University of Vic - Central University of Catalonia
09:50-10:10	ID 96 – *Industrial Wastewater Reclamation in Cosmetics Industry* – Rosario Gomes, Lenntech BV
10:10-10:30	ID 37 – *Optimizing Water Sourcing Strategies for Large-Scale Hydrogen Production: Balancing Cost, Reliability, and Environmental Impact* – Elizabeth Carlisle, Wageningen University & Research

10:30-11:00 Coffee Break (Poster Presentation)

Sessions 6 & 7 (Tuesday 30th June 2026, 11:00-12:30)

Industrial Effluent: Reuse (Cont.) **Chairpersons:** Begüm Tanis (TU Delft) & Isabella Muñoz (University of Vic - Central University of Catalonia) **Room:** Frans van Hasselt		Company Case Presentations **Chairpersons:** Moumita Ghosh (GRIHA Council) & Yongjun Zhang (Nanjing Tech University) **Room:** Commissiekamer 3	
11:00-11:20	ID 86 – *From wastewater to process water: a novel reutilization system of stripped water* – Zixian Wang, CNPC Research Institute of Safety and Environment Technology	11:00-11:15	C2. *Waterbank Agriport: A Large-Scale Rainwater Storage and Reuse System for industry and horticulture – Releasing pressure on the drinking water supply.* – Toon Boonekamp, Sweco, representing ECW
11:20-11:40	ID 106 – *Integrated MBR-RO process for water recycling at a multi-user manufacturing site in Ho Chi Minh City at demonstration-scale* – Norman Schweimanns, Technische Universität Berlin	11:15-11:30	C3. *Industrial Brine Treatment by Crystallization-Optimized Membrane Distillation: From Concept to Application Cases* – Norbert Kuipers, Wageningen University
11:40-12:00	ID 93 – *Treatment and Reuse of Piggery Effluent: Integrating Solar & Recycled Combustion Gases in a Bubble Column Evaporator* – Adrian Garrido Sanchis, University of New South Wales (UNSW)	11:30-11:45	C4. *Demineralization Unit Performance Troubleshooting* – Utku K Karani, OQBI
		11:45-12:00	C5. *Water Management at Linde Gas: Globally addressing water stress to ensure plant reliability* – David Miklos, Linde GmbH
12:00-12:20	ID 123 – *Water reclamation for industrial use potential for Maputo* – Noor Jehan Gulamussen, duardo Mondlane University	12:00-12:15	C6. *Reducing Industrial Water Intake Through Utility–Industry Collaboration.* – Nienke Peek, Vitens
		12:15-12:30	C7. *Every threat to the status quo is an opportunity in disguise: Water reduction as a business case at BASF.* – Mark Lazonder, BASF

Lunch (Workshop parallel): 12:30 - 14:00

- Water Efficiency in the Industry: Practical Pathways to Circular Industrial Water Use (Johann Poinapen-KWR, Julian Munoz-KWR, Ivaylo Hitsov-University Ghent) **Room:** Commissiekamer 3
- Building the Business Case for Circular Industrial Water Management Investments at Site Level. (Cejna Anna Quist-Jensen, Thomas Track, Ken Stockil Colm Gaskin, Aisling O'Connor, Christoph Höfer, Andres Lucht (Denmark, Germany, Ireland, Austria) **Room:** Frans van Hasselt

Sessions 8 & 9 (Tuesday 30th June 2026, 14:00-15:30)

Advanced Oxidation-based Treatment Techniques **Chairpersons:** Izba Ali (Air Liquide) & Anlin Xu (Nanjing Tech University); **Room:** Commissiekamer 3		Membrane-based Resource Recovery **Chairpersons:** Stylianos Flambouris (Lenntech) & Niels van Linden (Lenntech); **Room:** Frans van Hasselt	
14:00-14:20	ID 40 – *AnMBRs Coupled with Advanced Oxidation for Removal of Antibiotics and Membrane Fouling Control* – Yeyuan Xiao, Shantou University	14:00-14:20	ID 18 – *High-Performance Nanofiltration Membranes for Lithium Extraction from Water via Positively Charged Silica Nanoparticle Modification* – Amir Aghaei, University of Alberta, National Research Council Canada (NRC)
14:20-14:40	ID 47 – *Catalytic ozonation with high-entropy oxides for water treatment* – Anlin Xu, Nanjing Tech University	14:20-14:40	ID 59 – *Water and resource recovery from industrial effluents using oscillatory flow-enhanced membrane distillation (OMD)* – Christoph Hofer, AEE INTEC
14:40-15:00	ID 83: *A Life Cycle Analysis of Bismuth Vanadate During Solar Photocatalysis* – Sanjeeb Mohapatra, TU Delft	14:40-15:00	ID 80 – *Development and characterization of ultrafiltration membranes made with residual polymers: Phase inversion method application* – Paola Andrea Alvizuri Tintaya, Universidad Católica Boliviana San Pablo
15:00-15:20	*ID 98 – 1,4-Dioxane treatment in industrial wastewater using ozone-based advanced oxidation* – Charlotte Bopp, Veolia Water Tech	15:00-15:20	ID 46: *Efficiency of Ultrafiltration and Nanofiltration in Removing Pharmaceuticals from Water* – Andrea Bernardes, Federal University of Rio Grande do Sul
15:20-15:25 (Pitch 7)	ID 161: *Ultra Short Chain (USC) PFAS Removal from Process Water at Chemours Netherlands*–Henk Walpot, Chemours	15:20-15:25 (Pitch 8)	ID 108: *Optimized Energy for Water Production (Desalination) and Transmission in Hilly Terrains with Moderate Solar Flux* – Selvakumar Rajendran, IWA

15:30-16:00 Coffee Break (**Poster Presentation**)

Sessions 10 & 11 (Tuesday 30th June 2026, 16:00-17:30)

Materials for Industrial Water Treatment **Chairpersons:** Rebecca Dhawle (Nijhuis Saur Industries) & Merle de Kreuk (TU Delft) **Room:** Commissiekamer 3		Membrane-based Resource Recovery (Cont.) **Chairpersons:** Norbert Kuipers (Wageningen University & Research) & Mohammad Karimi (Amirkabir University of Technology) **Room:** Frans van Hasselt	
16:00-16:20	ID 127 – *Biochar-regulated MnO_2 for catalytic ozonation of benzotriazole: performance, mechanism and practical application* – Siyan Fan, Technische Universität Berlin	16:00-16:20	ID 99 – *Recovery of valuable salt under supersaturated conditions with Nanofiltration: From lab bench to full-scale*– Stylianos Flambouris, Lenntech BV
16:20-16:40	ID 112 - *Bridged Polysilsesquioxane-Magnetite Adsorbents with Tunable Amino/Thiol Interfaces for Multicontaminant Water Treatment* - Inna Melnyk, Institute of Geotechnics SAS	16:20-16:40	ID 129 – *Recovery of Hyper Saline Wastewater using Hybrid Forward Osmosis – Membrane Distillation (FO-MD)* – Veerabhadraiah Gudideni, Aramco
16:40-17:00	ID 168 – *Efficient Removal of Emerging Contaminants from Water using Sustainable Bio-Aerogel Materials for Circular Economy* – Soumi Dutta, IISC Bangalore	16:40-17:00	ID 61 – *Advanced water recovery from groundwater NF concentrate* – Ingrid Pinel, Lenntech
17:00-17:20	ID 170 – Start-up and operation of a sulfidogenic reactor seeded with methanogenic sludge using the COD/SO_4^{2-} ratio and free H_2S as control parameters – Xingzhou Lyu, TU Delft	17:00-17:20	ID 126 – *BiOI–ZnO Heterojunctions Integrated PES Ultrafiltration Membranes for Photocatalytic Degradation and Separation of Contaminants of Emerging Concern* – Akshay Kulkarni, Leibniz Institute of Polymer Research
17:20-17:25 (Pitch 9)	ID 24: *Transforming microplastic waste from water to syngas* – Mohammed B. Al Rayaan, Aramco	17:20-17:25 (Pitch 11)	ID 52: *Development of a Membrane-Based Treatment Train for Water and Solute Recovery in a Bio-Based Industrial Stream* – Sara Salvador Cob, VITO
17:25-17:30 (Pitch 10)	ID 124: *Source-Dependent Functionalization of Silica with Pectin for Heavy Metal Removal from Industrial Wastewater* – Viktoriia Kyshkarova, Institute of Geotechnics of the Slovak Academy of Sciences	17:25-17:30 (Pitch 12)	ID 56: *Membrane Distillation for Reverse Osmosis Brine Management*- Marco Rodrigues, Feevale University

17:45–18:30 Open meeting of the IWA Specialist Group "Treatment of Industrial Waters" **Room:** Frans van Hasselt

Wednesday 1st July 2026 (09:00-17:30)

Location: Delft University of Technology (TU Delft) – Aula, Mekelweg 5, 2628 CC Delft

Sessions 12 (Wednesday 1st July 2026, 09:00-10:30)

<table>
<tr><td colspan="2">Industrial Water-Saving Strategies

Chairpersons: Goksen Capar (Ankara University) & Sara Salvador Cob (VITO)

Room: Frans van Hasselt</td><td colspan="2">Industrial Water Forum by Isle Group

Chairpersons: To be confirmed

Room: Commissiekamer 3</td></tr>
<tr><td>09:00-09:20</td><td>ID 103 – *Water and Wastewater Streams and Reuse Opportunities in TOPCon Solar Cell Production – Jascha Reich*, Technische Universität Berlin"</td><td>09:00-09:05</td><td>**Welcome and Opening Remarks** Ioanna Livaniou, Managing Director – Europe, Isle Group</td></tr>
<tr><td>09:20-09:40</td><td>ID 120 – *Recent advances in Industrial Water Reuse: Technological outcomes of pulp and paper end-of-pipe wastewater reuse and brine management* – Sem Schrijer, Nijhuis Saur Industries</td><td rowspan="2">09:05-09:50</td><td rowspan="2">**Reduce, Reuse, Recycle, Reclaim —** Closing the Industrial Water Loop **Speakers:**
- Heleen Nieuwenhuis, Director of Marketing, Total Water Management, Nalco Water-Ecolab
- Dimitra Papagiannaki, Process Engineer, Evides Industriewater
- Martin Pelle, Global WWTP Global Technology, Tate & Lyle (TBC)
- Paul Jacob, Senior Water Innovation Manager, Danone
Moderator: Sara Shehi, Technology Consultant, Isle Group</td></tr>
<tr><td>09:40-09:55</td><td>C8. *From Linear to Circular: The development and application of a Water Efficiency Framework at Dow production locations* – Johann Poinapen, KWR Water Research Institute</td></tr>
<tr><td>09:55-10:10</td><td>C9. *Reuse of Garmerwolde municipal effluent for industrial processes.* – Hannah van der Wal, WLN</td><td rowspan="3">09:50-10:30</td><td rowspan="3">**Optimising Industrial Water Systems —** Efficiency opportunities in cooling towers, boilers and site water circuits

Speakers
- Aurélie Grelot, Global Water Treatment Lead, Cargill
- Paul Jacob, Senior Water Innovation Manager, Danone
- Tommaso Marengo, Environment Manager, Ferrero
Moderator: Magela Odriozola, Principal Consultant, Isle Group</td></tr>
<tr><td>10:10-10:25</td><td>C10. *Salt Removal / Reducing Industrial Water Intake* – Rosan van Wyngaard, Proxa Water South Africa</td></tr>
<tr><td>10-25-10:30 (Pitch 13)</td><td>ID 118: *Achieving Water Positivity Through Metered Water consumptions and CSR-Led Replenishment Across Multi-Sector Sites in India* – Moumita Ghosh, GRIHA Council</td></tr>
</table>

10:30-11:00 Coffee Break (Poster Presentations)

Sessions 13 (Wednesday 1st July 2026, 11:00-12:30)

<table>
<tr><td colspan="2">Electrochemical Treatment Techniques

Chairpersons: Andréa Moura Bernardes (Federal University of Rio Grande do Sul) & Sovik Das (IIT Delhi)

Room: Frans van Hasselt</td><td colspan="2">Industrial Water Forum by Isle Group (Cont.)

Room: Commissiekamer 3</td></tr>
<tr><td>11:00-11:20</td><td>ID 43 – *Integrated Adsorption–Electrochemical Oxidation for Enhanced Pharmaceutical Wastewater Treatment* – Orlando Garcia-Rodriguez, NUS Environmental Research Institute, National University of Singapore</td><td rowspan="2">11:00-11:35</td><td rowspan="2">**From Pilot to Practice —** Industry Case Studies in Water Innovation

Case Study Presenters

- *From Regulatory Challenge to Business Case: Wastewater Solutions in Specialty Chemicals,* Jozef Kochan, Clariant
- *Recycling wastewater in Spanish refinery – from feasibility to reality*, Anne Saramito, Senior Group Leader RD&E Industrial Water EU, Ecolab
- Georg Stockinger, Senior Water Treatment & Integration Technologist, Shell

Moderator: Ioanna Livaniou, Managing Director – Europe, Isle Group</td></tr>
<tr><td>11:20-11:40</td><td>ID 57 – *Towards Safe Discharge: Electrochemical Degradation of Antibiotics in Concentrated Aquaculture Effluents* – Salatiel da Silva, NESA, PPG-IPH, Federal University of Rio Grande do Sul</td></tr>
<tr><td>11:40-12:00</td><td>ID 104 – *PFAS occurrence and removal in semiconductor wastewater using electrochemical oxidation* – Tom Ducrocq, ICRA</td><td rowspan="2">11:35-12:20</td><td rowspan="2">**Making Technology Work in the Real World —** Water Conditioning and Wastewater Treatment at Scale

Speakers

- Jozef Kochan, Manager Environmental Technologies, Clariant
- Georg Stockinger, Senior Water Treatment & Integration Technologist, Shell
- Iván Blanco, Senior Researcher Water Solutions, ArcelorMittal Global R&D Spain

Moderator: Eva Martínez, Associate Director, Isle Group</td></tr>
<tr><td>12:00-12:20</td><td>ID 49 – *Bridging the gap from lab to implementation – a decade of applied research in electrochemical oxidation of real industrial wastewater* – Olivier Lefebvre, National University of Singapore</td></tr>
<tr><td>12:20-12:25
(Pitch 14)</td><td>ID 35: *Maximizing Petrochemical Wastewater Reuse Through Hybrid Membrane and Electro-Oxidation Technologies* - Marco Antônio Rodrigues, Feevale University</td><td>12:20-12:30</td><td>Wrap-Up & Conclusions

- Key takeaways and Closing remarks</td></tr>
</table>

12:30–14:00 Lunch Break

Sessions 14 and 15 (Wednesday 1st July 2026, 14:00-15:30)

Water policies and industrial symbiosis **Chairpersons:** Hans Cappon (HZ University of Applied Sciences) & Eva IJzermans (Haskoning) **Room:** Commissiekamer 3		Electrochemical-based Valorization **Chairpersons:** Olivier Lefebre (NUS) & Mexitli Sandoval-Reyes, Instituto Tecnológico y de Estudios Superiores de Monterrey **Room:** Frans van Hasselt	
14:00-14:20	ID 23 – *A novel framework for water reclamation in the petrochemical industry* – Tamara Elizabeth Leon Oviedo, Cetaqua, Water Technology Center	14:00-14:20	ID 10 – *Coupling Granular Ferric Hydroxide and 3D Cathode for Enhanced Electrochemical Water Softening and Antiscalant Recovery* – Jiayu Luo, Southern University of Science and Technology
14:20-14:40	ID 33 – *A Strategic Framework For Membrane-Based Water Recovery in the Textile Industry* – Mohammad Karimi, Amirkabir University and Technology	14:20-14:40	ID 85 – *Selective Nitrate Recovery from Chloride-Rich Wastewater via Ion Exchange and Bipolar Membrane Electrodialysis* – Mojtaba Torkaman, Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
14:40-15:00	ID 138 – *Water Efficiency Framework developed as part of the project AQUASPICE* – Johann Poinapen, KWR Water Research Institute	14:40-15:00	ID 109 – *SmartBrine: Feasibility of SWRO brine valorization in northeastern Brazil* – Marcos Bruno Colombo, NHL Stenden University of Applied Sc.
15:00-15:20	ID 114 – *Water Efficiency Evaluation in a Rapidly Expanding Organized Industrial Zone in Türkiye* – Goksen Capar, Ankara University	15:00-15:20	ID 172– *(Bio)Electrochemical Solutions for Environmental Sustainability: Water Remediation, Biohydrogen Production and Resource Recovery* – Sovik Das, IIT Delhi
15:20-15:25 (Pitch 15)	ID 74: *Enabling Circular Water Transitions: Integrating AI-driven Governance, Feasibility, and Stakeholder Adoption* – Mehak Puri, Goa Institute of Management	15:20-15:25 (Pitch 17)	ID 81: *Electrocoagulation Treatment of Mature Landfill Leachate: Performance Evaluation and Energy Reduction via Pulsed Current* – Inga Urniežaitė, Kaunas University of Technology
15:25-15:30 (Pitch 16)	ID 68: *Analysis, Comparison and Review of Water Policies for Governance and Management in Sub-Saharan Africa* – Joseph Igbinedion, ELTE Eötvös Loránd University	15:25-15:30 (Pitch 18)	ID 28: *Electrochemical Recovery of Alkalis from Ultrapure Water Resin Regeneration Wastewater Using Selective Ion-Exchange Membranes* – Sin-Yi Huang, Industrial Technology Research Institute

15:30-16:00 Coffee Break (Poster Presentations)

Young Water Professionals (Plenary) (Wednesday 1st July 2026): 16:00-17:30

Chairpersons: Begüm Tanis & Sanne Smith **Room:** Auditorium	
16:00–16:15	Introduction by the director of the local water authority
16:15–17:30	Panel discussion with young water professionals: Water for industry, industry for the future Ruizhe Pei – University of Vienna Hanneke Spijkerboer – Aviko Pooja Halvawala – Lenntech Water Treatment Solutions Eva IJzermans - Haskoning
17:30-	Drinks & pub quiz **Room:** Frans van Hasselt

18:00–19:30 **Management Committee meeting of the IWA Specialist Group "Treatment of Industrial Waters"** (by invitation only)

Room: Commissiekamer 4

Thursday 2nd July 2026 (09:00-17:30)

Location: Delft University of Technology (TU Delft) – Aula, Mekelweg 5, 2628 CC Delft

Sessions 16 & 17 (Thursday 2nd July 2026, 09:00-10:30)

Digitalization and Smart Control **Chairpersons:** Paul Schausberger (UNIHA Wassertechnologie GmbH) & Henri Spanjers (TU Delft) **Room:** Commissiekamer 3		Industrial Water Pollutants: PFAS **Chairpersons:** Tom Ducroqc (ICRA) & Sanne Smith (TU Delft) **Room:** Frans van Hasselt	
09:00-09:20	ID 32 – *Data-driven reinforcement learning for multi-stream wastewater pH control in pulp and paper industry* – Muhammad Momotazul Islam, Fraunhofer Institute for Ceramic Technologies and Systems IKTS	09:00-09:20	ID 22 – *Integrated Nanofiltration and Regenerable Ion Exchange for PFAS Removal in the Industrial Laundry Sector supporting water reuse* – Dores Cirne, VITO NV
09:20-09:40	ID 131: *Automated non-destructive, in-situ monitoring of (bio) fouling layers - Embodying Optical Coherence Tomography on a portal robot* – Arthur Leon, Chair of Process Engineering in Hydro Systems, Inst, Technische Universität Dresden	09:20-09:40	ID 42 – *Integrating Foam Fractionation into the Activated Sludge Process for PFAS Removal from Landfill Leachate* – Joséphine van Ruiten, TU Delft
09:40-10:00	ID 75 – *The All-in-one AI and ML N_2O solution for low-carbon wastewater treatment* – Dhavissen Narayen, Cobalt Water Global	09:40-10:00	ID 107: *Electrochemical Oxidation of PFAS using Boron-doped Graphene-coated Ti/RuO2 Anode* – Niketha Narayana Rao, IIT Madras
10:00-10:20	ID 94 – *Model predictive control for optimum condensate reuse* – Iarima Mendonça, HZ University of Applied Sciences	10:00-10:20	ID 116 – *Enhancing PFAS Removal Through Vacuum Airlift Foam Fractionation: Lab-Scale Optimization for Industrial Deployment* – Rebecca Dhawle, Nijhuis Industries
10:20-10:25 (Pitch 19)	ID 64: *Sustainable operation of semi-batch reverse osmosis for industrial effluent treatment using artificial intelligence* – Jungbin Kim, Wenzhou-Kean University	10:20-10:25 (Pitch 21)	ID 135: *Optimizing Foam Fractionation as a Key Concentration Technology for PFAS Removal* - Julian Muñoz Sierra, KWR Water Research Institute
10:25-10:30 (Pitch 20)	ID 156: *Data-enabled predictive control for membrane-based wastewater treatment processes – Xunyuan Yin,* Nanyang Technological University	10:25-10:30 (Pitch 22)	ID 164: *Sustainable Adsorptive Removal of PFAS Using Waste-Derived Activated Carbons: Role of Surface Chemistry and Pore Structure* – Intae Shim, University of Science & Technology

10:30-11:00 Coffee Break (Poster Presentation)

Sessions 18 & 19 (Thursday 2nd July 2026, 11:00-12:35)

Digitalization and Smart Control (Cont.) **Chairpersons:** Iarima Mendonça (HZ University of Applied Sciences) & Mehak Puri (Goa Institute of Management) **Room:** Commissiekamer 3		Industrial Water Pollutants **Chairpersons:** Dores Cirne (VITO) & Charlotte Bop (Veolia) **Room:** Frans van Hasselt	
11:00-11:20	ID 26 – *Process Simulation for the Selection of Complex Industrial Water Treatment Processes* – Paul Schausberger, UNIHA Wassertechnologie GmbH	11:00-11:20	ID 38 – *Removal of Trace Organic Pollutants from Industrial Effluents with A Pilot-scale Biofilter Enhanced by Manganese Oxidizing Bacteria* – Yunhai Zhang, Nanjing Tech University
11:20-11:40	ID 153 – *Economic real-time operation of membrane bioreactors in wastewater treatment via constrained economic model predictive control with Koopman modeling and meta learning* – Adrian Wing-Keung Law, National University of Singapore	11:20-11:40	ID 111 – *Reactor-Scale and Local Transport Phenomena in Fungal Trickle-Bed Bioremediation* – Tazio Siegmann, ULB
11:40-12:00	ID 173 – *Water Footprint Assessment and Setting Water Efficiency Strategies in the Refractory Industry* – Goksen Capar, Ankara University	11:40-12:00	ID 110 – *Integrated Wastewater Remediation and Antibiotic Detection Using Silica Hybrid Adsorbents* – Olga Semeshko, Slovak Academy of Sciences
12:00-12:20	ID 88 - *Hybrid Transformer-driven autonomous soft-sensing system for N_2O emissions in a full-scale wastewater treatment plant: Sensor fault reconstruction, quantification, and self-recalibration* - SeonJu Kim, Kangwon National University	12:00-12:20	ID 121 – *Industrial Fluorinated Liquid Crystal Monomers in E-Waste-Impacted Rivers and their Environmental Interactions* – Rui Yang, Tsinghua Shenzhen International Graduate School

12:20–14:00 Lunch Break

Session 20 & 21 (Thursday 2nd July 2026, 14:00-15:20)

Industrial Effluent: Treatment (Cont.) **Chairpersons:** Sven Uwe Geissen (Technical University Berlin) & David Moed (Evides Industriewater) **Room:** Frans van Hasselt		Life-Cycle Assessment **Chairpersons:** Rosan van Wyngaard (Proxa Water South Africa) & Mar Palmeros Parada (TU Delft) **Room:** Commissiekamer 3	
14:00-14:20	ID 21 - *Natural wetlands for water treatment in Yara* – Matthias de Cazes, Yara International	14:00-14:20	ID 8 – *Exploring Tail Gas as an Alternative Water Source in Carbon Black Manufacturing through Process Simulation and LCA* – Aashlesha Chekkala, BITS Pilani Goa
14:20-14:40	C11. *From complex wastewater streams to tailored solutions: Two industrial cases*-Suzanne Reinartz, Inopsys	14:20-14:40	ID 54 – *Life-cycle assessment of two effluent reclamation plants for hydrogen production in Denmark* – Sylvie Braekevelt, Ramboll
14:40-15:00	ID 95 – *Reducing N2O Emissions in Wastewater Treatment with Pure Oxygen Aeration: A Full-Scale Study* – Izba Ali, Air Liquide	14:40-15:00	ID 55 – *Closing nutrient loops from municipal wastewater and industrial process water in the Netherlands: Life Cycle Assessment of recovered fertilizers* – Ruben van den Berg, KWR
15:00-15:20	ID 71 - *Effect of superhydrophobic lamellar plates on particle settling velocity under abrasive sedimentation conditions* - Barraza Belen, Universidad Técnica Federico Santa María	15:00-15:20	ID 128 – *Beyond carbon and conventional LCA of wastewater treatment projects: Integrating PMTs and MPs into a cradle-to-grave life cycle assessment of a nature-based tertiary treatment* – Nooshin Barzegar Marvasti, University of Birmingham

15:20-16:00 Coffee Break

Closing Session (Plenary) (Thursday 2nd July 2026): 16:00-17:30

Room: Auditorium

16:00–16:30	Awards: Best poster, Best oral presentation
16:30–17:00	Announcement of WIN2028
17:00-17:30	Concluding Remarks
19:00-23:00	Conference Dinner Dinner Talk: **Rick Hogeboom** **Location:** Haskoning

Friday (3rd July 2026)

09:00 – 17:00	Site visits (depending on site) **Pick-up and drop-off point:** Aula • Veolia Water Tech – Biothane • Holland Hydrogen 1 – clean water for a clean fuel • Tata Steel IJmuiden • Lenntech – Lab-, pilot- and full-scale membrane- and resin-based water treatment systems

Pitches

Ph 1. ID 169: *Alkalized TripolyPhosphate Cross-linked Chitosan Beads Synthesized from Mushroom Waste (agaricus bisporus brunnescens) Were Developed as a Sustainable Biosorbent for the Batch Removal of Toxic Heavy Metals Cr (VI), Cu (ii), and Pb (ii)* – Tesfalem Belay Tesfalem Belay, Bahir Dar Institute of Technology

Ph 2. ID 73: *Determination of C0-C2 Alkylphenols in Stripped Water using UPLC-Q/Orbitrap HRMS* – Yu-long Liu, CNPC Research Institute of Safety and Environment Technology

Ph 3. ID 158: *Assessing the feasibility of reclaiming process water from industrial wastewater effluent by using Closed-Circuit Reverse Osmosis and evaluating options for treating the resulting brine* – Tamarindo Metekohij, Evides Industriewater

Ph 4. ID 31: *Enhancing the Regeneration Efficiency of Ion Exchange Resins with Ammonium Bicarbonate via CO_2 and Air Pressurisation* – Kamran Jalali, Univeristy of New South Wales

Ph 5. ID 7: *Phytomigration of Residual Heavy Metals from Technogenically Contaminated Treated Waters (Bolnisi, Georgia)* – Konstantine Khachapuridze, Technical University of Georgia

Ph 6. ID 157 – *Human-in-the-loop reinforcement learning for safe economic operation of membrane bioreactor processes in wastewater treatment*– Thu Minh Hoang, Nanyang Technological University

Ph 7. ID 161*: Ultra Short Chain (USC) PFAS Removal from Process Water at Chemours Netherlands*–Henk Walpot, Chemours

Ph 8. ID 108: *Optimized Energy for Water Production (Desalination) and Transmission in Hilly Terrains with Moderate Solar Flux* – Selvakumar Rajendran, IWA

Ph 9. ID 24: *Transforming microplastic waste from water to syngas* – Mohammed B. Al Rayaan, Aramco

Ph 10. ID 124: *Source-Dependent Functionalization of Silica with Pectin for Heavy Metal Removal from Industrial Wastewater* – Viktoriia Kyshkarova, Institute of Geotechnics of the Slovak Academy of Sciences

Ph 11. ID 52: *Development of a Membrane-Based Treatment Train for Water and Solute Recovery in a Bio-Based Industrial Stream* – Sara Salvador Cob, VITO

Ph 12. ID 56: *Membrane Distillation for Reverse Osmosis Brine Management*- Marco Rodrigues, Feevale University

Ph 13. ID 118: *Achieving Water Positivity Through Metered Water consumptions and CSR-Led Replenishment Across Multi-Sector Sites in India* – Moumita Ghosh, GRIHA Council

Ph 14. ID 35: *Maximizing Petrochemical Wastewater Reuse Through Hybrid Membrane and Electro-Oxidation Technologies* - Marco Antônio Rodrigues, Feevale University

Ph 15. ID 74: *Enabling Circular Water Transitions: Integrating AI-driven Governance, Feasibility, and Stakeholder Adoption* – Mehak Puri, Goa Institute of Management

Ph 16. ID 68: *Analysis, Comparison and Review of Water Policies for Governance and Management in Sub-Saharan Africa* – Joseph Igbinedion, ELTE Eötvös Loránd University

Ph 17. ID 81: *Electrocoagulation Treatment of Mature Landfill Leachate: Performance Evaluation and Energy Reduction via Pulsed Current* – Inga Urniežaitė, Kaunas University of Technology

Ph 18. ID 28: *Electrochemical Recovery of Alkalis from Ultrapure Water Resin Regeneration Wastewater Using Selective Ion-Exchange Membranes* – Sin-Yi Huang, Industrial Technology Research Institute

Ph 19. ID 64: *Sustainable operation of semi-batch reverse osmosis for industrial effluent treatment using artificial intelligence* – Jungbin Kim, Wenzhou-Kean University

Ph 20. ID 156: *Data-enabled predictive control for membrane-based wastewater treatment processes – Xunyuan Yin,* Nanyang Technological University

Ph 21. ID 135: *Optimizing Foam Fractionation as a Key Concentration Technology for PFAS Removal* - Julian Muñoz Sierra, KWR Water Research Institute

Ph 22. ID 164: *Sustainable Adsorptive Removal of PFAS Using Waste-Derived Activated Carbons: Role of Surface Chemistry and Pore Structure* – Intae Shim, University of Science & Technology

Poster Sessions

Industrial Effluent – Treatment

1. **ID 56:** *Membrane Distillation for Reverse Osmosis Brine Management* – Marco Rodrigues, Feevale University
2. **ID 62**: *Industrial Wastewater characteristics in Addis Ababa and treatment challenges* – Girum Tegegnework Wolde, Mekuria Enviro Friendly Consultancy
3. **ID 64**: *Sustainable operation of semi-batch reverse osmosis for industrial effluent treatment using artificial intelligence* – Jungbin Kim, Wenzhou-Kean University
4. **ID 124**: *Source-Dependent Functionalization of Silica with Pectin for Heavy Metal Removal from Industrial Wastewater* – Viktoriia Kyshkarova, Institute of Geotechnics of the Slovak Academy of Sciences
5. **ID 145**: *Performance of CO2 Degasification in a Lab-scale Stripper with Activated Carbon Bed* – Miseon Kim, University of Science and Technology
6. **ID 151**: *Amino- and Imidazole-Functionalized Silica Adsorbents for Cr(VI) Removal from Industrial Wastewater* – Nataliia Chechitko, Institute of Geotechnics of the Slovak Academy of Sciences, Technical University of Košice (TUKE)
7. **ID 165**: *Microalgal Phycoremediation of Pulp and Paper Wastewater: From Strain Screening to Pilot*-Scale Validation – Ricky Rajamanickam, Linnaeus University
8. **ID 169**: *Alkalized TripolyPhosphate Cross-linked Chitosan Beads Synthesized from Mushroom Waste (agaricus bisporus brunnescens) Were Developed as a Sustainable Biosorbent for the Batch Removal of Toxic Heavy Metals Cr (VI), Cu (ii), and Pb (ii)* – Tesfalem Belay Tesfalem Belay, Bahir Dar Institute of Technology

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Reuse, Resource, and Energy Recovery

9. **ID 35:** *Maximizing Petrochemical Wastewater Reuse Through Hybrid Membrane and Electro-Oxidation Technologies* – Marco Antônio Rodrigues, Feevale University
10. **ID 146**: *Toward Sustainable CO_2 Mineralization: Reaction Pathways and Applications* – Doheun Kwak, University of Science and Technology
11. **ID 130**: *A Multi-Criteria Review and Geospatial Analyses for Air Conditioner (AC) Condensate Water Reuse* – Samuel Nketia Boateng, Univeristy of Cape Coast
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Phytomigration of Residual Heavy Metals from Technogenically Contaminated Treated Waters (Bolnisi, Georgia)

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Abstract

The extraction of mineral resources in the mining industry, such as quarry development, processing of non-ferrous metals, and the formation of waste dumps, presents significant environmental challenges. These processes generate acid mine drainage contaminated with heavy metals, which have substantial adverse effects on the environment.

For this study, we selected industrial wastewater generated by the mining and processing operations of the "RMG Group" in Bolnisi district, Georgia. The research aimed to identify a modern method to remove residual heavy metals (Cu, Zn, Cd) from chemically treated wastewater through phytomigration. The chosen method for this purpose was phytoremediation.

Keywords

Phytomigration, wastewater, Heavy metals, plants, Typha latifolia L.

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Exploring Tail Gas as an Alternative Water Source in Carbon Black Manufacturing through Process Simulation and LCA

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Abstract

Water use in carbon black manufacturing is dependent on natural water sources. A tail gas stream is generated in the process, at 250–350 °C, with 30–50% water vapor and presents an opportunity for water recovery and reuse. To utilize this potential, two water recovery schemes—WRS-ORC and WRS-QHP, were developed in ASPEN Plus®, involving gas cooling through an Organic Rankine Cycle (ORC) and direct water cooling, respectively, followed by condensation and condensate treatment. Both the process schemes offered a water recovery potential of 30–70%. Further a Life Cycle Assessment (LCA) was conducted using the ReCiPe 2016 method to evaluate environmental feasibility of the schemes. The the water footprint was assessed using Water Scarcity Index (WSI) impact and reported that the WRS-QHP achieved a WSI of –21.15 m^3. This indicated better water management in the WRS-QHP compared to WRS-ORC. In both the process schemes, the human carcinogenic impact category, showed significant variability based on an uncertainty analysis using Monte Carlo simulation. The combustion gas and aromatic hydrocarbon emissions were found to be the primary contributors. The present study aims to highlight the use of tail gas streams as an alternative water source in the carbon black manufacturing process, thereby improving the resource efficiency.

Keywords

Tail gas, Water and energy recovery, Process scheme, Life Cycle Assessment

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Coupling Granular Ferric Hydroxide and 3D Cathode for Enhanced Electrochemical Water Softening and Antiscalant Recovery

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Abstract

Industrial cooling water accounts for 80% of industrial water use. However, cyclic evaporation concentrates Ca^{2+}/Mg^{2+}, forming scales that reduce heat exchange efficiency and shorten equipment lifespan. Phosphonate antiscalants (e.g., NTMP) inhibit scaling but severely suppress electrochemical softening (EMP). Here, we propose three progressive innovations. First, to address EMP's inherent inefficiency from 2D cathodes, 3D Ni foam cathodes (vs. 2D plates) boosted Ca^{2+} removal by 26% at 20 A/m², cut energy use by 50%, and maintained >50% efficiency over 104 days. The precipitation does not affect the Ca^{2+} removal efficiency, as H_2 bubbles prevent precipitate blockage. Since 3D cathodes did not resolve NTMP inhibition, we next integrated granular ferric hydroxide (GFH, 0.5-2.0 mm), which adsorbed nearly all 100 μM NTMP via Ca^{2+}-GFH-NTMP complexes; post-adsorption EMP achieved 83% Ca^{2+} removal and 80% alkalinity removal (11.1 kWh/kg $CaCO_3$, vs. 2.7% without adsorption), with desorbed NTMP retaining 100% antiscalant capacity. Additionally, we consider the important role of anode material in electrochemical softening. BDD performed best in Ca^{2+} removal (73%) due to its higher NTMP conversion efficiency, and the addition of 8 mM Cl^- narrowed the anode differences. The system maintained greater than 50% Ca^{2+} removal and complete NTMP conversion over 28 days.

Keywords

Industrial cooling water, Electrochemical softening, 3D cathode, Antiscalant, Anodic oxidation

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High-Performance Nanofiltration Membranes for Lithium Extraction from Water via Positively Charged Silica Nanoparticle Modification

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Abstract

The rising demand for lithium, largely driven by the widespread use of lithium-ion batteries, has made efficient lithium extraction from salt-lake brines increasingly critical. A key aspect of this process is the effective separation of Li^+ and Mg^{2+}, for which advanced nanofiltration (NF) membranes have proven highly promising. In this study, we report the fabrication of polyamide (PA) thin-film nanocomposite (TFN) membranes exhibiting exceptionally high Li^+/Mg^{2+} selectivity. This was achieved by incorporating functionalized silica nanoparticles (F-SiO_2NPs) into the PA selective layer and applying them onto the membrane surface. The silica nanoparticles were functionalized with a combination of superhydrophilic ligands, including primary amine and quaternary ammonium groups, imparting a strongly positive surface charge. In a 2000-ppm salt solution (Li^+/Mg^{2+} = 1:20), the modified TFN membrane demonstrated a markedly enhanced Li^+/Mg^{2+} selectivity of 37.95, compared to only 5.05 for the unmodified TFC membrane. It exhibited a Li^+ rejection of -63.2% and Mg^{2+} rejection of 95.7%, indicating preferential permeation of Li^+ and strong Mg^{2+} exclusion. The membrane also showed an outstanding water flux of 56.0 $L.m^{-2}.h^{-1}$ at 70 psi. This approach offers a novel and effective strategy for enhancing TFN membranes, providing valuable insights for lithium extraction from salt-lake brines.

Keywords

nanofiltration, thin-film nanocomposite membranes, silica nanoparticles, lithium recovery, Li+/Mg2+ separation

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Natural wetlands for water treatment in Yara

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Abstract

Yara has implemented natural water treatment systems at several production sites to reduce nitrogen and phosphorus emissions.

The site of Yara Montoir in France operates a phyto-purification unit to treat contaminated site run-off. This natural system relies on combined biological activity of bacteria and plants without the addition of any chemicals. It was decided to expand it to ensure the required abatement of nitrogen and phosphorus from spillage/run-off and achieve compliance all-year round also in the new site configuration. It has proven possible to reduce total nitrogen and phosphorus concentrations by 70 and 40% respectively with the initial configuration. Even better performances are expected over time with the enlarged system.

At Yara Rio Grande in Brazil, dust, raw material and product can end up on the floor. Some spillage can make its way into the site's drainage system. During heavy rains stormwater is collected in the mostly open canal network all around the site. The volume of effluent generated can lead to flooding as this water cannot be processed and reused fast enough. It is not allowed to discharge it and this situation impairs production. The site has recently built and seeded a wetland system in an existing water storage basin. It is not yet fully commissioned but previous pilot tests demonstrated around 90% of nitrogen and phosphorus abatement.

Natural wetland systems represent an environmentally attractive and cost-effective treatment solution while offering opportunities for potential reuse of treated water.

Keywords

Water treatment, Constructed wetland, Emissions, Nitrogen, Phosphorus

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Integrated Nanofiltration and Regenerable Ion Exchange for Per- and Polyfluoroalkyl Substances (PFAS) Removal in the Industrial Laundry Sector supporting water reuse

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Abstract

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants in industrial wastewater. Conventional treatment technologies - adsorptive media (GAC, IX) and membrane systems (NF, RO) - face limitations related to efficiency, waste generation, and regulatory constraints on thermal destruction. This work investigates the combination of nanofiltration (NF) and regenerable ion exchange (IX) to address these issues. NF selectively concentrates PFAS while allowing monovalent ions, notably chloride, to pass, improving IX performance. Trials were conducted in the Flemish laundry sector, where PFAS emissions arise from textile coatings and reapplication processes. Lab-scale screening of four NF membranes identified dNF40 as preferred for combined PFAS retention (97%, with partial retention of ultra-short PFAS) and chloride passage (minimal retention). The IX selected for the pilot, based on the tests, was Sorbix HC5. The combined NF–IX system shows potential to reduce PFAS from the wastewater. The findings will help close knowledge gaps on PFAS treatability in industrial wastewater and provide a transferable model for other sectors.

Keywords

Per- and poly-fluoroalkyl substances (PFASs) removal, Nanofiltration, Regenerable ion exchange, onsite water reuse, industrial laundry

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A novel framework for water reclamation in the petrochemical industry.

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Abstract

This study addresses water scarcity and high energy costs in European industrial wastewater treatment, focusing on the petrochemical sector. It develops a customized membrane-based Zero Liquid Discharge (ZLD) system at a Spanish refinery's wastewater plant, aiming to recover over 90% of water, 80% of energy, and 40-60% of key solutes such as NaOH, HCl, and NH_3. Using simulations and experimental tests with novel and commercial membranes, the treatment train integrates pressure-driven membranes, electrodialysis, membrane contactors, sorption, and chemical precipitation processes. Early results show 92-93% water recovery with effective contaminant removal (99.9%), producing water suitable for reuse in cooling and boilers. The promising nanofiltration performance supports scaling beyond laboratory trials. This approach sets a practical benchmark for sustainable water reuse in the water-intensive industry.

Keywords

circular economy; wastewater; resource recovery; zero liquid discharge

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Transforming microplastic waste from water to syngas

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Abstract

Microplastics, a rising environmental contaminant of water. Due to their microscopic size, these plastic particles easily disperse across the biosphere through oceanic currents, posing serious ecological risks. In this study, we investigate the physicochemical characteristics of microplastic waste collected from sea and assesses its potential for conversion into gaseous products via pyrolysis. Based on our preliminary results, the gate-to-gate process from collecting of microplastic until syngas production (Average yield = 34.79%), highlighting the feasibility of microplastic transformation.

Keywords

Syngas, water, Microplastic, ecosystem, Pyrolysis

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Process Simulation for the Selection of Complex Industrial Water Treatment Processes

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Abstract

A greenfield industrial project in a remote location needs process water supply for indirect and direct cooling. A technoeconomic study is performed to compare potential treatment solutions in terms of investment cost, byproduction and electric and chemical consumption. Four different treatment schemes are developed and compared, using a novel process simulation tool. The schemes vary from basic treatment to maximum recovery with zero liquid discharge (ZLD). The paper presents the used tool as well as the outcome of the study.

Keywords

process simulation, mass and energy balance, electrolyte equilibria, MLD, ZLD

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Electrochemical Recovery of Alkalis from Ultrapure Water Resin Regeneration Wastewater Using Selective Ion-Exchange Membranes

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Abstract

Ion-exchange (IX) resin regeneration in ultrapure water (UPW) systems produces acid and alkali wastewater with inherently high conductivity due to accumulated inorganic ions. This high-conductivity wastewater limits downstream RO and polishing performance by increasing osmotic pressure and energy demand, while also challenging compliance with environmental discharge regulations.

This study evaluates anion-selective electrodialysis (AsED) as a method to recover reusable NaOH from IX regeneration wastewater and reduce overall chemical consumption. In a 100 CMD RO-IX-RO UPW system, the regeneration waste stream exhibited 98 mS/cm conductivity and contained approximately 15,000 mg-CO_3^{2-}/L, 1,500 mg-SO_4^{2-}/L, and 400 mg-Cl^-/L. Using monovalent-selective membranes, the recovered NaOH reached 97% purity, with divalent-ion leakage reduced nearly threefold compared with conventional membranes. The process required approximately 1.5 kWh/kg to produce 5 wt% NaOH. Pilot operation achieved 23% NaOH recovery, reduced H_2SO_4 consumption by 38%, and lowered effluent conductivity.

Overall, AsED enables resource recovery from high-conductivity regeneration waste streams, reducing external chemical purchases and supporting circular chemical use, operational cost savings, and Net Zero objectives.

Keywords

electrodialysis, waste alkali valorization, caustic recovery, monovalent-selective membrane, chemical consumption reduction

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From nitrogen-rich process condensates to fertilizer

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Abstract

The increasing world population and the subsequent industrialization of agriculture have led to a growing demand for nutrients, primarily in the form of fertilizers. The production process of fertilizers generates process condensates, some of which contain relatively high levels of nitrogen yet low concentrations of (other) impurities. Targeted, decentralized treatment of such condensates offers an opportunity to integrate multiple resource (water, nitrogen species) recovery and move towards circular industrial processes. This presentation showcases a full-scale application of an ammonium nitrate and water recovery concept. This presentation covers the proof of concept (lab research), design and performance evaluation for a full-scale industrial installation focusing on nitrogen recovery. The installation, which is in operation since June 2024, treats a condensate stream of a Dutch ammonium nitrate (NH_4NO_3) fertilizer production factory. In this set-up, the nitrogen present in the condensate is removed by ion exchange resins. More specifically, ammonium (NH_4^+) and nitrate (NO_3^-) ions are retained by a Strong Acid Cation (SAC) resin and a Weak Base Anion (WBA) resin, respectively. Resins' regeneration is of high importance, because with the right chemicals, it is possible to concentrate nitrogen in the regenerant stream without contaminating it with other components. The regenerant is then re-used as feedstock for the NH_4NO_3 fertilizer production process, resulting in a nitrogen recovery of 18 kg N/d. In parallel, the purified water is being reused as process water within the same factory. In this way, nitrogen and water recovery rates of 99+% are achieved.

Keywords

nitrogen, recovery, ion exchange, full-scale, circularity

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Enhancing the Regeneration Efficiency of Ion Exchange Resins with Ammonium Bicarbonate via CO_2 and Air Pressurisation

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Abstract

In recent decades, researchers have improved the regeneration of ion exchange resin (IER) after their exchange cycle, starting with chemical regeneration with salts like sodium chloride (NaCl) or acids and bases like HCl and NaOH, to thermal energy, carbon dioxide, or Bioregeneration. Chemical regeneration with salt is still known as the best solution for industries due to its simplicity and lower cost, even if many of these recent innovations performed well. Finding better technologies with higher efficiency and less environmentally hazardous is the main focus of researchers in the IER process, and in this regard, using ammonium bicarbonate (AB) with a new method of application and process could be an alternative to using common salts. In this research, a new approach of using AB was investigated on the regeneration of IER after exhaustion with NaCl.

Keywords

Seawater, Desalination, Ion Exchange Resin, Regeneration, Resource Recovery

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Data-driven reinforcement learning for multi-stream wastewater pH control in pulp and paper industry

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Abstract

In Pulp and paper mills there exists complex wastewater streams with highly fluctuating pH and alkalinity. When effluents from different process lines mix, they cause variations that make it hard to keep the neutralization process stable. Operators must also meet strict regulatory discharge limits (e.g., pH 6-8), which conventional control systems struggle to maintain pH band under such dynamic conditions. To address these challenges, a physics-based virtual neutralization tank model have been developed that captures wastewater pH dynamics via charge balance, buffering capacity, mixing inflows and residence estimation. This data-driven model integrates stage-wise delays introduced by varying tank volumes, real pH and flow measurements from multiple streams of a paper mill and simulates the effect of incremental chemical dosing on effluent pH. Using this realistic simulation, a Soft Actor-Critic (SAC) reinforcement learning controller is trained in a custom Gymnasium environment for pH regulation. The trained SAC controller significantly outperformed a baseline conditional dosing strategy in simulation trials. It maintained the virtual tank pH within the target range (6-8) for 85.71% of time and used less neutralizing chemical. These approach show that a data-driven RL approach can optimize chemical dosing and ensure consistent regulatory compliance. By optimizing chemical consumption and improving pH stability, the SAC controller reduces operational costs with reliably meeting discharge standards.

Keywords

pH neutralization, reinforcement learning, WWTP, delay, SAC

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A Strategic Framework For Membrane-Based Water Recovery in the Textile Industry

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Abstract

In this paper, the relationship between textile wastewater characteristics and the design of treatment processes is investigated. The system performance assessment is based on both the factory's production-quality control laboratory data and a mixed-method analytical framework. New insights are presented for classifying textile wastewater with respect to appropriate membrane-based water recovery. Specifically, three key indices, TSS, COD, and EC, are identified as the defining factors for selecting the appropriate membrane filtration strategy, namely MF, UF, or RO. A tailored treatment train combining primary and secondary treatments processes with suitable membrane technologies can enable economically viable water reuse. MF and UF are generally sufficient for many low-salinity or lightly colored effluents, whereas high-salinity and dye-rich streams require RO to achieve the desired effluent quality. Integrating photo- and electrocatalytic oxidation as a pre-treatment step further enhances system performance by lowering COD, improving decolorization, and mitigating membrane fouling. Overall, the proposed framework provides a practical and reliable basis for designing water-recovery systems across diverse textile manufacturing operation.

Keywords

Water recovery, Textile, Wastewater, Membrane, Photo-electrocalysis

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Anaerobic Treatment of Waste(water) from the Chemical Industry

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Abstract

The chemical case study of the CORNERSTONE project represents Covestro's strategic approach to developing alternative treatment routes for industrial waste(water), transforming them from energy consumers into energy producers while reducing operational costs. Relevant waste(water) streams were identified with energy potential ranging from 1-100 GWh annually, including streams from existing production sites as well as future process streams from circularity projects. One stream with high potential benefit is liquid waste from resin production for which a treatment concept based on distillation and anaerobic treatment via anaerobic membrane bioreactor was developed. Following distillation simulation and trials, batch testing with Automatic Methane Potential Test System (AMPTS) was done and will be followed by anaerobic tests in continuous operation.

Keywords

chemical industry, anaerobic membrane bioreactor, distillation, reaction water, energy recovery

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Maximizing Petrochemical Wastewater Reuse Through Hybrid Membrane and Electro-Oxidation Technologies

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Abstract

Petrochemical industries generate large volumes of wastewater containing dissolved salts, suspended solids, and recalcitrant organic pollutants, which limit opportunities for internal reuse and demand advanced treatment solutions. This study evaluated a hybrid multi-stage treatment (ultrafiltration (UF), reverse osmosis (RO), electrodeionization (EDI), membrane distillation (MD), and electro-oxidation (EO)) applied to real tertiary petrochemical wastewater from an industrial complex in southern Brazil. The objective was to maximize water recovery while minimizing concentrate generation through integrated membrane and electrochemical processes. UF provided effective pretreatment, enabling stable RO operation with >90% ion removal and permeate quality suitable for EDI. The UF/RO/EDI sequence produced high-purity demineralized water (conductivity below 0.30 µS/cm), demonstrating the feasibility of treating petrochemical wastewater containing 1,700 µS/cm conductivity. MD further valorized RO concentrates, achieving 60 to 82% water recovery and >90% removal of major parameters, generating permeates appropriate for clarified water reuse and, in some cases, compatible with EDI feed. EO applied to MD concentrates achieved reductions in COD (up to 91%) and chloride (up to 56%), although additional polishing is required to control inorganic pollutants. Overall, the integrated system achieved 96 to 98% water recovery, demonstrating strong potential for near-zero liquid discharge (ZLD) in petrochemical operations.

Keywords

Petrochemical wastewater; Water reuse; Membrane separation process; Electro-oxidation; Near-Zero Discharge.

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Leather industry wastewaters: performance of polymer-based hybrid materials in coagulation-flocculation and sludge reduction

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Abstract

The leather industry generates heavily polluted effluents characterized by high organic loads, suspended solids, and toxic metals such as chromium. Conventional coagulants—primarily aluminum and iron salts—are effective yet environmentally burdensome due to high chemical demand, residual metal release, and substantial sludge production. Recent studies have investigated hybrid coagulants combining inorganic metal salts with organic polymers to enhance treatment performance and reduce overall waste production. Hybrid coagulants, which combine inorganic pre-hydrolyzing metallic salts with cationic organic polymers, offer synergistic charge neutralization and polymer bridging, potentially improving removal efficiency while reducing sludge formation. This study evaluates polymeric–inorganic hybrid coagulants for the coagulation–flocculation treatment of real tannery wastewater from a full-scale plant under low- and high-production conditions, focusing on pollutant removal, sludge reduction, and environmental performance. Polymer-based hybrid coagulants proved to be a high-performance and environmentally favorable alternative to conventional alum-based treatment for tannery wastewater, achieving superior pollutant removal at lower chemical dosages, producing less and more easily dewaterable sludge, reducing residual metal loads, and eliminating the need for pH adjustment. Environmental evaluation confirmed the favorable profile of hybrid coagulants, driven primarily by reduced chemical demand and sludge generation. Among the investigated systems, polyamine-based hybrids emerged as particularly promising, combining strong treatment performance with improved environmental behavior and highlighting their potential for sustainable, real-world application in leather industry wastewater management.

Keywords

Tannery wastewater treatment, Hybrid coagulant-flocculants, Sludge reduction, Chromium and organic pollutant removal, Environmental assessment

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Optimizing Water Sourcing Strategies for Large-Scale Hydrogen Production: Balancing Cost, Reliability, and Environmental Impact

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Abstract

Large-scale green hydrogen production will significantly increase industrial water demand. In coastal regions, seawater desalination is often the default supply option, but there are environmental risks from brine discharge. At the same time, treated wastewater effluent represents an underutilized resource with lower environmental impact and lower treatment costs, though availability is constrained by seasonal and day-to-day variability. In order to capitalize on both the high reliability of seawater and low cost and environmental impact of wastewater effluent, we evaluate a mixed approach, using both an advanced water treatment plant that upgrades wastewater effluent to ultra-pure water suitable for electrolysis, and a seawater reverse osmosis plant, which can be used as a back-up source when wastewater is not sufficient. This study presents an optimization model that determines cost-effective and reliable water-sourcing strategies for hydrogen production at scales of 100–600 kton H_2/year. Environmental impacts are incorporated through a financial brine penalty applied per cubic meter of desalinated seawater, while the trade-off between water cost and reliability is explored by varying the selling price of hydrogen. The optimal strategy combines both sources, maximizing the use of low-cost wastewater while relying on seawater as needed to ensure reliability. These findings highlight important opportunities for the water sector: hydrogen producers represent a high-volume, long-term market for reclaimed water. For policymakers, modest brine-discharge fees can shift sourcing toward wastewater without materially increasing total water costs. Together, these strategies support reliable, low-cost, and environmentally-friendly water systems for the growing hydrogen industry.

Keywords

Green hydrogen, seawater desalination, wastewater reuse, mathematical optimization, water storage

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Removal of Trace Organic Pollutants from Industrial Effluents with A Pilot-scale Biofilter Enhanced by Manganese Oxidizing Bacteria

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Abstract

Manganese-oxidizing bacteria (MnOB) mediate the oxidation of manganese ions to form biogenic manganese oxides, which enhance the removal of organic pollutants in wastewater. However, the complex composition of industrial wastewater can inhibit MnOB activity and affect the stability of microbial community. This study investigated the removal efficiency and mechanisms of trace organic contaminants (TrOCs) in a pilot-scale biofilter over 300 days of continuous operation. Under a 12-hour empty bed contact time (EBCT), the system achieved high removal efficiencies for pharmaceuticals (ES, e.g., ofloxacin 94.6%, norfloxacin 99.1%, danofloxacin 98.4%, diclofenac 99.3%) and pesticides (PEST), whereas esters (EST), perfluoroalkyl substances (PFAS), and organic UV filters (UVF) showed negligible or negative removal (approximately –5.7%). The median removal efficiencies for TOC and UV_{254} were 45.1% and 56.1%, respectively. Removal mechanisms varied substantially among contaminants: ES and PEST were predominantly biodegraded, whereas EST (diisobutyl phthalate, di-n-butyl phthalate), triphenylphosphine oxide, and doxycycline were mainly adsorbed. Bisphenol A was removed through combined adsorption and biodegradation. High-throughput sequencing revealed distinct stratification of the microbial community along the filter depth. Alpha diversity was significantly higher in the bottom layer than in the top. Beta diversity analysis indicated that MnOB dominated the top layer, while the bottom layer was enriched with genera such as *Nitrospira* and *Hyphomicrobium*, which are associated with organic degradation and nitrogen transformation. This work offers practical guidance for implementing MnOB-enhanced biofilters in industrial wastewater treatment.

Keywords

Manganese-oxidizing bacteria, biofilter, trace organic pollutants, biological manganese oxides, pilot-scale

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Extraction of silica aerogel by acid-base reaction from coal gasification slag for lead adsorption

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Abstract

Severe lead pollution resulting from rapid industrialization poses a persistent threat to ecosystems and human health. Conventional adsorbent materials, such as activated carbon, are constrained by relatively low adsorption capacity, whereas renewable materials like alginate often suffer from poor stability and high production costs. In this study, coal gasification slag was employed as the raw material to extract amorphous silica for the preparation of silica aerogel. The material composition and structural characteristics of coal gasification slag–based silica aerogel (SA@GS) were systematically characterized to elucidate its Pb adsorption behaviour, which was further analysed using kinetic and isotherm models.

Keywords

Coal gasification slag, Silica aerogel, Adsorption, Lead, Regeneration, Cost

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AnMBRs Coupled with Advanced Oxidation for Removal of Antibiotics and Membrane Fouling Control

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Abstract

Anaerobic Membrane Bioreactor (AnMBR) technology has excellent wastewater treatment performance and energy recovery potential, although membrane fouling remains as the main bottleneck. In this study, a new type of AnMBR reactor coupled with advanced oxidation (UV photocatalysis and UV/O_3 photocatalysis) via backwashing was constructed and operated for a long time, to treat synthetic antibiotic-containing wastewater. Under a frequency of 1 min every 10 min, the fouling rates of AnMBRs were reduced by 56%~70%, when the effluent of intermittent UV radiation was used for backwashing. Under the UV/O_3 photocatalysis stage, the reactor achieved highly efficient removal (97.5%) of antibiotics. DOM molecular transformation in the system, as revealed by Fourier transform ion cyclotron resonance mass spectrometry, indicates that UV/O_3 can effectively degrade PAHs in water, thus reducing the toxicity of effluent. In short, these results suggest AnMBR coupled with AOP-backwashing is a promising technology for industrial wastewater treatment.

Keywords

Anaerobic Membrane Bioreactor (AnMBR); antibiotics; UV photocatalysis; FT-ICR MS

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Integrating Foam Fractionation into the Activated Sludge Process for PFAS Removal from Landfill Leachate.

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Abstract

PFAS-containing waste often ends up in landfills, where non-volatile PFAS can desorb from solid waste and enter landfill leachate. Conventional wastewater treatment plants are generally ineffective at removing PFAS, resulting in their discharge to the aquatic environment. Foam fractionation has been shown to be an effective technique for PFAS removal from landfill leachate, with reported reductions of up to 60% for 32 different PFAS types. However, standalone foam fractionation require additional energy input for aeration and new infrastructure.

To address these limitations, this study evaluates the integration of foam fractionation into existing activated sludge processes. Here, aeration allows microorganisms to biodegrade organic matter and nutrients and, due to the presence of biological and chemical surfactants in the mixed liquor, foam formation is common. As many water-soluble PFAS have surfactant properties, they preferentially partition into these foams. Currently, foam formation is typically suppressed because of operational challenges. This research assesses whether foam removal can be applied for PFAS removal and without compromising the biological treatment.

A continuously operated laboratory-scale activated sludge system was used. During the first phase, conventional operation was applied. In the second phase, the formed foam was continuously collected. The results showed no significant PFAS removal during conventional operation. During integrated foam fractionation, 58% of $\sum_{32}$PFAS could be removed and no negative impacts on biological performance have been observed. These findings highlight the potential of integrating foam fractionation into existing activated sludge systems as an energy-effective method to mitigate PFAS emissions to the environment.

Keywords

PFAS, Foam Fractionation, Activated Sludge Process, Landfill Leachate, Wastewater Treatment

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Integrated Adsorption–Electrochemical Oxidation for Enhanced Pharmaceutical Wastewater Treatment

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Abstract

Pharmaceutical manufacturing effluents require stringent control due to their complex composition and potential to promote antimicrobial resistance. Conventional biological treatments are often insufficient for complete removal, risking residual pollutant discharge if waste streams are poorly managed. Electrochemical advanced oxidation processes effectively generate hydroxyl radicals (•OH) to degrade persistent organics, but their performance is frequently limited by mass transfer, particularly at low contaminant concentrations. To address these limitations, this collaborative study between the National University of Singapore, Pfizer Inc., and Axine Water Technologies evaluates a hybrid adsorption–electrochemical oxidation process for treating real antibiotic manufacturing wastewater.

The process integrates adsorption onto sintered activated carbon with electrochemical oxidation and in-situ electrochemical regeneration in a single undivided reactor. Boron-doped diamond and dimensionally stable anodes were assessed under constant potential and current conditions. Mineralisation was monitored by total organic carbon analysis, while azithromycin degradation and transformation products were quantified using LC-MS and HPLC.

The influent contained azithromycin at 74 mg L^{-1}, underscoring the need for advanced treatment. At 8 V, rapid TOC removal was achieved, with BDD exhibiting faster kinetics than DSA, reaching ~90% mineralisation after 5 h. Both anodes converged to near-complete mineralisation with extended treatment. LC-MS confirmed complete azithromycin removal, while short-chain carboxylic acids were identified as transient intermediates and fully eliminated over time. Total antibiotic removal was achieved at energy consumptions below 10 kWh m^{-3}. These results demonstrate that hybrid adsorption–electrochemical oxidation with simultaneous adsorbent regeneration is an effective and energy-efficient strategy for treating pharmaceutical effluents.

Keywords

Electrochemical Advanced Oxidation Processes, Electrochemical adsorbent regeneration, Pharmaceutical effluents, Industrial Wastewater Treatment

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Evaluation of advanced treatment trains for agri-food wastewater reuse across different food sectors.

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Abstract

The study evaluates advanced treatment trains for wastewater reuse in the agri-food sector, aligned with the Spanish Royal Decree RD 1085/2024. Two industrial effluents with different characteristics and reuse objectives were assessed. Effluent A originated from a food-processing industry (meat, milk, and vegetable) equipped with a membrane bioreactor with ultrafiltration, while Effluent B was from a poultry slaughterhouse treated by primary physicochemical processes. Combinations of membrane technologies (UF, RO, and ED) and advanced oxidation processes (UV and ozonation at 15 mg/L) were evaluated. For Effluent A, both treatment trains produced high-quality reclaimed water compliant with RD 1085/2024 Class Ia.A+. RO-based trains achieved complete COD removal and >5-log reductions of bacterial biomass and antibiotic resistance genes (ARGs) when combined with ozonation. ED-based trains showed lower performance before final oxidation, with some ARG concentration effects, though subsequent ozonation substantially reduced all targets. Microbiological indicators were effectively removed, and all pharmaceuticals were below detection limits. For Effluent B, the UF + RO + O_3 train substantially improved physicochemical and microbiological quality, including >90% organic matter removal, strong ammonium reduction, and complete elimination of indicator microorganisms. ARG reductions followed similar trends, with RO and ozonation achieving 4–5 log decreases. Pharmaceuticals were undetectable in all samples. Overall, advanced membrane-based trains with UV or ozonation effectively enable safe water reuse in the agri-food sector. The reclaimed waters met RD 1085/2024 quality classes Ia.A+, Ia.A, and R.A+, supporting industrial reuse, direct aquifer recharge, and circular water management strategies.

Keywords

agri-food wastewater, advanced technologies, recovery water, emerging contaminants, legislation.

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Efficiency of Ultrafiltration and Nanofiltration in Removing Pharmaceuticals from Water

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Abstract

Pressure-driven membrane processes (PDMPs) have become increasingly important for water and wastewater treatment due to their ability to ensure high-quality purification and effectively retain emerging contaminants such as pharmaceutically active compounds (PhACs). These contaminants are frequently detected in global water bodies, raising environmental and public-health concerns. This study evaluates the performance of different PDMPs—ultrafiltration (UF) and nanofiltration (NF)—in removing three representative PhACs commonly found in natural waters: sulfamethoxazole, atenolol, and rosuvastatin. Raw water collected from Lake Guaíba (Porto Alegre, Brazil) was spiked with controlled concentrations of each compound to simulate realistic environmental conditions. Experiments were conducted in a LabUnit M20 system equipped with one NF membrane and two UF membranes with distinct molecular weight cutoffs, under tangential feed velocity of 0.76 m/s and transmembrane pressures of 2–8 bar. NF exhibited superior rejection performance, achieving removal rates above 85% for all compounds at 8 bar, alongside permeate fluxes of approximately 30 L/(m²·h). In contrast, UF demonstrated limited capability, with sulfamethoxazole rejection ranging from 28–37%, rosuvastatin between 36–64%, and negligible retention of atenolol, reflecting the inherent limitations of low-pressure membranes for small organic molecules. Although NF proved highly effective, it generated a concentrated retentate stream enriched with pharmaceuticals, accounting for roughly 15% of feed flow. This by-product requires additional treatment to prevent environmental release. Integrating advanced oxidation processes is recommended to degrade residual contaminants and ensure complete remediation. The findings reinforce the relevance of NF within sustainable treatment trains aimed at mitigating pharmaceutical pollution.

Keywords

Contaminant of emerging concern; Water treatment; Pressure-driven membrane process; Nanofiltration.

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Catalytic ozonation with high-entropy oxides for water treatment

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Abstract

This study investigates, for the first time, the application of a high-entropy oxide (HEO) synthesized via a sol-gel method for catalytic ozonation in water treatment. Using benzotriazole (BTA) as a model pollutant, the catalytic performance of HEOs calcined at different temperatures (450–900 °C) was evaluated. The HEO with a calcination temperature of 500 °C exhibited the highest degradation efficiency, corresponding to a second-order kinetic constant of 507.1 M^{-1} s^{-1}. Characterization confirmed the formation of a single-phase spinel structure with homogeneous elemental distribution. The results demonstrate that the enhanced catalytic activity and stability of the HEO/O_3 system are attributed to the high configurational entropy and synergistic effects among the five metal components (Fe, Co, Ni, Mn, Zn), highlighting the promising potential of HEOs in advanced oxidation processes.

Keywords

Advanced oxidation Free radical Emerging contaminant Tertiary treatment Biomineralization

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Bridging the gap from lab to implementation – a decade of applied research in electrochemical oxidation of real industrial wastewater

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Abstract

Electrochemical advanced oxidation processes (EAOPs) are well suited to industrial wastewater treatment because they generate highly reactive hydroxyl radicals (•OH) in situ that rapidly degrade persistent organics, especially aromatic, cyclic, and unsaturated compounds common in sectors like textile, pharmaceutical, chemical, food-processing, reverse osmosis (RO) concentrates, landfill leachates, etc. These effluents often have high organic loads and salinity, which reduce mass-transfer limitations and provide a "natural electrolyte," improving process efficiency; however, very high loads do increase treatment time and energy demand. Overall, EAOPs offer a "green" alternative with minimal chemical handling and secondary wastes, but feasibility depends on optimizing energy use, electrode costs/scale, and integrating with conventional treatments where appropriate. Most of the investigations on electrochemical processes have been carried out in bench-scale reactors making use of synthetic solutions of target pollutants or simulated waste streams. However, the use of synthetic solutions avoids real conditions, which are crucial for the development of large-scale treatment systems. This work summarizes a decade of work at the National University of Singapore focusing on electrode design and applications to real industrial wastewater.

Keywords

Boron-Doped Diamond, Dimensionally Stable Anode, Electrochemical Advanced Oxidation Processes, Electro-Fenton, Real-matrix validation

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Learnings from the pilot testing of innovative technologies for the removal of marine plastic litter

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Abstract

In the EU, 150.000 to 500.000 tonnes of plastic waste enter the oceans every year with 75.000 & 300.000 tonnes of microplastics (MPs) released into the environment. As over 300 million tons of plastic are produced every year, the pollution will continue until legally binding international agreements to address marine plastic pollution is in place. One of the technical approach for the removal of these plastics is the joint solution. Technologically, the joint solution initially consisted of a small bubble flow which will guide the plastics in the bypass to the drum screen for microplastics removal followed by an ultrasound-based technology or a membrane technology to agglomerate or concentrate particles from 1-2000 nm to larger particles of about 2 µm or more respectively. This is then followed by the addition of biodegradable and environmentally friendly flocculants to grow the particles to 18 µm (minimum sieve size) for >85% of the particles present. The Joint solution is aimed at cleaning nano- and micro-particles contained in industrial cooling water intake streams. The main intake cooling water flow can range from 45 to 200 m^3/s.

The envisaged joint solution did not exist as an integrated solution at the start of the project. After the development of each of the individual technologies (TRL 5) an integrated system and or individual technologies were tested at several industrial cooling water locations (TRL 7). Significant ad-hoc challenges were encountered during the testing campaigns which are valuable lessons to further optimize the integration aspects of the joint solution.

Keywords

Microplastics, Industrial cooling water systems, Aquatic ecosystem, Nanoparticles

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Development of a Membrane-Based Treatment Train for Water and Solute Recovery in a Bio-Based Industrial Stream

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Abstract

Bio-based chemical production requires large volumes of water for reaction, washing and purification steps, generating aqueous effluents that contain valuable dissolved solutes. As production capacity increases, efficient water reuse and solute recovery become essential to reduce wastewater discharge and improve process circularity. Within the Horizon Europe R3VOLUTION project, membrane based Zero Liquid Discharge (ZLD) strategies are being developed for several industrial sectors. This work focuses on the bio-based case, addressing a process stream derived from the conversion of cellulose into high-value chemical products.

The investigated stream contains mixed sugars, inorganic salts, low concentrations of aldehydes, and traces of organic solvent, posing challenges for separation selectivity and membrane compatibility. A membrane-based treatment train combining nanofiltration (NF), reverse osmosis (RO) and membrane distillation (MD) is being developed. Extensive NF screening was performed using both polymeric and ceramic membranes, including native and chemically functionalized variants, at 20 °C and 40 °C.

Stable fluxes were obtained for all tested membranes under realistic process conditions. Polymeric NF membranes showed strong retention of sugars and aldehydes with partial passage of monovalent salts. Ceramic membranes exhibited distinct retention behavior, generally allowing higher salt and small-organic passage while maintaining substantial sugar retention. Functionalized ceramics showed selectivity governed by a combination of size exclusion and affinity-driven interactions. RO polishing of selected NF permeates produced high-quality water suitable for internal reuse. MD is currently under investigation and forms part of the envisioned full ZLD treatment train.

Keywords

bio-based industry, nanofiltration, reverse osmosis, ceramic membranes, zero liquid discharge

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Non-target Wastewater Monitoring In An Industrial Cluster And Its Downstream Municipal Wastewater Treatment Plant

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Abstract

Industrial clusters discharge complex, variable wastewater that can impair municipal wastewater treatment plants (WWTPs) and is often insufficiently regulated. Early-warning, sludge-based systems help detect inhibitory effects before sewer entry, but linking chemical composition to biological impact remains challenging. This study assessed non-target screening (NTS) as a complementary approach for connecting chemical information with early-warning observations to better understand industrial wastewater influence on treatment processes. NTS enables broad detection of known and unknown compounds and supports retrospective evaluation. Hierarchical cluster analysis was explored as a low-effort tool for matrix-based evaluation.

Between July 2021 and October 2023, 16 sampling campaigns were conducted at the influent and effluent of an industrial cluster's biological treatment stage and at corresponding municipal WWTP points. LC-HRMS-based NTS generated ranked lists of the most intense mass signals (Top 20 and Top 100) and identified compounds for each event.

Evaluation strategies revealed recurring features, such as a mass signal at 185 Da ($C_{12}H_{11}NO$), later confirmed as the pharmaceutical pirfenidone. Top 20-NEW and Top 20-HIGHER analyses highlighted emerging or highly increasing signals, linking operational disturbances to industrial activities. Hierarchical cluster analysis identified temporal and substance-related patterns aligned with production schedules, with effects observable in municipal effluent, demonstrating downstream influence.

NTS provides substantial insight into wastewater composition, revealing similarities and differences across complex matrices. Combined with hierarchical cluster analysis, it allows efficient prioritisation of periods for detailed evaluation. Together with early-warning systems, these approaches enhance understanding of industrial discharges and support the early identification of potential impacts on biological treatment processes.

Keywords

Non-target screening, industrial wastewater monitoring, indirect discharger, industrial cluster, municipal wastewater treatment

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Life-cycle assessment of two effluent reclamation plants for hydrogen production in Denmark

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Abstract

Water resource management for Power-to-X (PtX) is key for the alignment of the water and energy sector and for achieving net-zero emission while preventing any adverse effects to the aquatic environment on a global level. In Denmark, the investment in effluent water reclamation plants is important to reach national ambitions for green hydrogen production. The study brings insights from Lolland Utility, a water utility experiencing high groundwater stress, and where new PtX facilities are planned. The study consists of a technical, economical and LCA analysis of different water reclamation plants to supply water for hydrogen production (PtX) as well as other industries. The study puts UF-RO and NF-RO with disinfection forward as the most suitable technologies to reclaim wastewater effluent and treat for non-potable water reuse in industrial applications with high-quality water demands in Nakskov, Denmark.

Keywords

non-potable reuse, water reclamation, water for green hydrogen, lifecycle assessment, holistic decision support

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Closing nutrient loops from municipal wastewater and industrial process water in the Netherlands: Life Cycle Assessment of recovered fertilizers

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Abstract

Ensuring adequate soil fertility while reducing reliance on fossil-based fertilizers is a major challenge for sustainable agriculture. Conventional fertilizers depend on energy-intensive processes for nitrogen and finite reserves for phosphorus and potassium, raising concerns about resource depletion and environmental impact. This study explores the potential of fertilizers recovered from municipal wastewater and industrial process water as circular, safe, and sustainable alternatives. Within this project, three representative products were assessed: mineral concentrate from source-separated human urine, liquid ammonium sulfate recovered via ammonia stripping at a municipal wastewater treatment plant, and aerobic biomass (sludge) from the aerobic process water treatment system in a brewery.

A Life Cycle Assessment (LCA) was conducted to compare the environmental performance of these recovered products with conventional fertilizers of equivalent agronomic function. The system boundary spans from residue availability to final purification, excluding field application. Results are expressed per kilogram of nitrogen, phosphorus, and potassium. Impact categories include climate change, eutrophication, toxicity, water use, and resource depletion, using the ReCiPe 2016 method.

Preliminary findings suggest that energy use, chemical inputs, and transport are key contributors to environmental impacts. Previous studies indicate energy consumption is a major driver for conventional fertilizers, highlighting substitution potential for reducing resource use. However, processing steps for recovery may introduce additional burdens. Opportunities for improvement include process integration and optimization of concentration levels. This research provides insights into environmental trade-offs and supports the transition toward circular nutrient management in agriculture.

Keywords

LCA Nutrients Recovery Fertilizer Wastewater

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Membrane Distillation for Reverse Osmosis Brine Management

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Abstract

Landfill leachate is a complex and highly contaminated effluent, and although nanofiltration (NF) and reverse osmosis (RO) are widely applied as advanced treatment steps, they generate a concentrated residual stream that requires further management. This study evaluates direct contact membrane distillation (DCMD) as a post-treatment strategy for RO concentrate produced from the tertiary treatment of real landfill leachate. A home-made 5 L DCMD system equipped with a hydrophobic polyethylene membrane (0.3 µm pore size, 76 µm thickness, 85% porosity, contact angle 107°, LEP > 3.8 bar) was operated for 30 h under feed and permeate temperatures of 60 °C and 20 °C, respectively. The DCMD process produced high-quality permeate, with removal efficiencies above 95% for all monitored parameters, indicating clear potential for reuse and compliance with discharge regulations. The permeate flux initially measured 10.48 kg m^{-2} h^{-1} and stabilized at 5.56 kg m^{-2} h^{-1} after approximately 23 h, likely due to feed saturation and surface fouling, which reduced the effective membrane area. A volumetric concentration factor of 2.47 was achieved, corresponding to a water recovery rate of 60%. Despite this improvement, roughly 40% of the initial feed remained as a concentrated residual stream, which may require additional treatment such as electrochemical oxidation or crystallization to minimize environmental impacts. Overall, the results demonstrate that DCMD is a promising technology for RO brine management, enhancing resource recovery and supporting more sustainable treatment chains for landfill leachate.

Keywords

Leachate treatment; Brine management; Membrane distillation; Water recovery

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Towards Safe Discharge: Electrochemical Degradation of Antibiotics in Concentrated Aquaculture Effluents

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Abstract

The intensification of aquaculture industry has led to the widespread use of antibiotics, resulting in effluents containing persistent micropollutants that conventional treatment systems are unable to remove. Membrane-based processes such as ultrafiltration (UF) and nanofiltration (NF) improve water quality but generate a concentrated stream enriched in antibiotics and organic matter, posing challenges for disposal and environmental safety. This study evaluates electrochemical advanced oxidation processes (EAOPs) as a post-treatment strategy for aquaculture-derived membrane concentrates containing sulfamethoxazole (SMX), sulfadiazine (SULF), and norfloxacin (NOR) at initial concentrations of 2.5 mg L^{-1} each. Experiments were conducted in a filter-press reactor equipped with a boron-doped diamond (BDD) anode and a $Ti/TiO_2–RuO_2$ cathode under current densities of 0.5–5 mA cm^{-2} and recirculation flow rates of 7–60 L h^{-1}. Results showed that increasing the flow rate enhanced degradation kinetics due to improved mass transport, enabling faster interaction between pollutants and oxidizing species. At 5 mA cm^{-2}, all antibiotics achieved 85% degradation within 15 min and 37% TOC removal after 60 min. NOR exhibited the greatest persistence, particularly at low flow rates, reflecting its higher structural stability. The most energy-efficient condition, 0.5 mA cm^{-2} at 60 L h^{-1}, enabled complete degradation of SMX, SULF, and NOR while reducing energy demand by a factor of 32, achieving 32.7% TOC removal. These findings demonstrate the potential of EAOPs for treating antibiotic-rich concentrates, supporting safer discharge practices and contributing to sustainable aquaculture wastewater management.

Keywords

Advanced Oxidation Technologies; Micropollutant Mitigation; Brine Management; Safe Discharge Practices

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Water and resource recovery from industrial effluents using oscillatory flow-enhanced membrane distillation (OMD)

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Abstract

Membrane distillation (MD) is a thermally driven membrane process for recovering clean water and valuable resources from industrial effluents, but it is constrained by temperature polarization, limited feed-side mixing, and high energy demand. Oscillatory flow membrane distillation (OMD) superimposes controlled oscillations on the feed, inducing near-membrane turbulence and enhancing mass transfer at lower recirculation rates.

Within the CORNERSTONE project, a lab-scale OMD facility was developed to quantify how oscillation amplitude and frequency affect water and resource recovery from pulp & paper and steel effluents. The OMD feed and permeate loops operated at 60 and 20 °C, respectively. Hydrophobic polypropylene hollow-fiber membranes were installed in baffled contactor modules; two fiber lengths (16 and 32 cm) were tested at amplitudes of 0–12.5 mm and frequencies of 0–2 Hz with deionized water and both effluents. After 20 h, samples were analyzed by ion chromatography and for crystallization potential. Water flux was measured gravimetrically, and pH, conductivity, pressure, temperature, and flow velocity were monitored to calculate water recovery, ion rejection, and specific energy consumption.

Oscillation increased flux for all water matrices, peaking at 12.5 mm and 2 Hz (4.01, 3.85, and 4.08 kg m^{-2} h^{-1}), for DI-water, pulp & paper, and steel, respectively, translating into 52–86% gains versus non-oscillating MD operation and indicating a favorable energy–performance trade-off.

Keywords

water recovery, resource recovery, membrane distillation, oscillatory flow reactor, hollow fiber membranes

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Advanced water recovery from groundwater NF concentrate

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Abstract

This study assesses the treatment of a nanofiltration (NF) concentrate stream produced by Heineken brewery, aiming to recover fresh water for further use as process water. The NF concentrate was generated in the existing NF process that produces clean water from anaerobic groundwater.

Long-term testing at pilot-scale was performed by Lenntech to assess the sustainability of the following treatment: (i) oxidation by air to precipitate metals, (ii) ultrafiltration (UF) to remove the precipitated species, (iii) acidification to reduce bicarbonate concentration, and (iv) high-recovery reverse osmosis (HRRO) to remove dissolved ions and produce fresh water.

UF was continuously operated at a water recovery of 94.5-95.3%, and HRRO at 65% recovery. The treatment chain successfully achieved the treatment requirements for water reuse, by continuously producing treated water below 50 µS/cm.

Keywords

Heineken Brewery Wastewater recovery Pilot system Industry

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Industrial Wastewater characteristics in Addis Ababa, Ethiopia

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Abstract

The assessment examines the status of wastewater characteristics generated from the beverage, paint, textile, and leather manufacturing industries in Addis Ababa, Ethiopia. Wastewater samples were collected to determine the physicochemical parameters. The average TSS concentration of beverages, paint, textiles, and tannery wastewater was 431.6(mg/l), 3135.8(mg/l), 761(mg/l), and 851.6 (mg/l), respectively. The average BOD value of beverage, paint, textiles, and tannery wastewater was 1270.5(mg/l), 70.8(mg/l), 260(mg/l), and 761.6(mg/l), respectively. The average COD value of beverages, paint, textiles, and tannery wastewater was 10913.7(mg/l), 6286.9(mg/l), 961(mg/l), and 1930 (mg/l), respectively. The average Pb concentration of paint factory and textile wastewater was 16.78 (mg/l) and 0.015(mg/l), respectively. The average Cr concentration of paint, textiles, and tannery wastewater was 0.91(mg/l), 0.001(mg/l), and 268.9(mg/l), respectively. The laboratory results indicate that wastewater discharged from manufacturing industries in the city contains high amounts of pollutants, which cause environmental pollution and public health concerns. Hence, strong monitoring and regulatory measures should be conducted to reduce the pollutant load of the wastewater generated from manufacturing industries in Addis Ababa, Ethiopia.

Keywords

TSS, DOB, COD, Pb, Cr

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Sustainable operation of semi-batch reverse osmosis for industrial effluent treatment using artificial intelligence

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Abstract

The increasing global water scarcity has intensified efforts to reuse industrial water. At the same time, persistent concerns regarding reclaimed water quality necessitate advanced and reliable treatment technologies. To date, reverse osmosis (RO) is widely applied in industrial effluent treatment due to its high permeate quality, while limited water recovery constrains process efficiency and increases brine management burdens. Alternatively, semi-batch reverse osmosis (SBRO) emerges as a configuration that can achieve higher recovery within existing membrane infrastructure. However, industrial implementation continues to face challenges related to membrane scaling and elevated energy consumption. Therefore, this study advances sustainable SBRO operation for high-recovery industrial effluent treatment by systematically elucidating scaling behavior and optimizing SBRO operation. The effects of feed conditions and operating variables on normalized water permeability during SBRO operation were quantitatively evaluated. Shapley additive explanations (SHAP) analysis indicates that scaling dynamics are predominantly governed by feed hydraulic pressure and flow-related variables, whereas concentration effects and induction time play a secondary role. These insights establish a mechanistic foundation for flow-regulation-based strategies aimed at mitigating scaling and stabilizing SBRO operation under industrially relevant conditions. In parallel, critical SBRO design variables influencing energy efficiency were identified. Guided by SHAP-based interpretability and meta-heuristic optimization algorithms, an integrated operational strategy was developed through coordinated regulation of operating variables. Overall, the results strengthen the sustainability and industrial feasibility of SBRO by linking scaling mechanisms with AI-driven optimization, offering practical guidance for sustainable operation and energy-efficient process design in industrial water reuse applications.

Keywords

semi-batch reverse osmosis, industrial effluent, scaling mechanism, specific energy consumption, artificial intelligence

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A Hybrid IoT–Satellite Framework for Real-Time, Scalable Water Quality Monitoring

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Abstract

This study presents a multi-scale water quality monitoring framework integrating conventional laboratory analysis, IoT-based real-time sensing, and satellite-derived indicators to support resilient water management. Although the study area is Keenjhar Lake in Pakistan, the methodology is designed for universal applicability across diverse geographical and climatic contexts. IoT sensors measuring pH, turbidity, temperature, and TDS were assembled via Arduino ESP8266 and validated against laboratory tests, confirming high accuracy for continuous monitoring. Sentinel-2A remote sensing was processed using Google Earth Engine to retrieve NDWI, NDTI, chlorophyll-a, BOD, COD, nitrate, DO, TSS, and organic matter, enabling large-scale spatial water quality assessment. Results demonstrate strong agreement between sensor and laboratory datasets, while satellite indices captured pollution gradients and ecological variability at basin scale. The integrated framework offers an efficient, scalable approach for early-warning detection and holistic water quality surveillance, aligning with global water resilience priorities.

Keywords

IoT sensors; satellite remote sensing; water quality monitoring; NDWI/NDTI; real-time analytics

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Analysis, Comparison and Review of Water Policies for Governance and Management in Sub-Saharan Africa

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Abstract

In Sub-Saharan Africa, there is abundance of groundwater availability due to it recharge from rainfall, however, of recent there has been decrease in groundwater aquifer recharges as climate change has affected rainfall patterns. Although same cannot be said of groundwater accessibility. This article provides an overview of the current groundwater governance, management and policy literature. Using the Earth System Governance project, I elaborated and analyzed water policy documents on groundwater architecture, its allocation and access, accountability, adaptation and agencies for effective groundwater governance and management. Drawing from the analysis, I also compared policy documents. I find that groundwater isn't clearly defined but captured generally under water. Governance and management are fragmented and uncoordinated, weak regulation, poor monitoring and evaluation, lack of transparency and implementable sentences. Water governance is a grand challenge problem and has become one of humanity's foremost priorities, however, they can be turned into opportunities in sub-Saharan Africa.

Keywords

Groundwater, governance, management, policy, Sub-Saharan Africa

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Chemical-Free Scaling Control as RO Pretreatment: Performance Gains Across Fresh, Brackish and Seawater Desalination

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Abstract

Scaling and inorganic fouling remain critical constraints on the performance, energy efficiency and sustainability of reverse osmosis (RO) systems in industrial water treatment and desalination. Conventional chemical antiscalants mitigate these challenges but increase operating costs, environmental burden and system complexity. This paper presents the evaluation of a chemical-free, inline water conditioning technology applied as RO pretreatment, focusing on its impact across freshwater, brackish water and seawater matrices.

Independent laboratory testing assessed membrane permeability, flux decline, ion passage and fouling behaviour using synthetic feed waters representative of industrial and desalination applications. Results demonstrate consistent performance improvements following pretreatment, including increased membrane permeability, reduced flux decline rates and enhanced rejection of key scale-forming ions such as calcium, sulphate and chloride. The strongest relative benefits were observed in freshwater and brackish water systems, with meaningful gains also achieved under seawater desalination conditions.

The technology operates without consumables, sacrificial media or bulk precipitation and is installed inline upstream of RO membranes, requiring minimal maintenance. By disrupting ionic activity rather than relying on chemical inhibition, it enables cleaner membrane operation, reduced cleaning frequency and lower energy demand.

These findings highlight the potential of chemical-free scaling control as a practical pathway to improving RO performance, reducing operational expenditure and supporting sustainability objectives in desalination and industrial water reuse. The study provides a strong basis for pilot- and full-scale implementation in low-chemical and low-carbon water treatment strategies.

Keywords

Reverse Osmosis (RO) Desalination Scaling Control Chemical-Free Pretreatment Membrane Performance

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Effect of superhydrophobic lamellar plates on particle settling velocity under abrasive sedimentation conditions

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Abstract

Solid–liquid separation by lamellar sedimentation is widely used in water treatment and mineral processing due to its high efficiency and compact design; however, particle adhesion and fouling of inclined plates often limit performance, particularly at low inclination angles. This work evaluates the effect of lamellar plate surface material on particle settling velocity and durability under abrasive batch sedimentation conditions. A laboratory-scale lamellar sedimenter with adjustable plate inclination (20°, 40°, and 60°) was used to compare smooth poly(vinyl chloride) (PVC) plates with superhydrophobic polymer plates based on surface-modified foamed PVC, using quartz suspensions as model sediment.

Settling performance was quantified by tracking the temporal evolution of the suspension–supernatant interface. Superhydrophobic plates consistently exhibited faster interface descent than conventional PVC across all tested angles, with the largest enhancement observed at 20°, where particle adhesion strongly affected the control material. The improved performance is attributed to reduced particle–surface adhesion and fouling, facilitating particle transport along the inclined plates. Importantly, the superhydrophobic material retained contact angles above 150° after repeated exposure to abrasive quartz suspensions, demonstrating strong resistance to mechanical wear. These results highlight surface material selection as a complementary strategy to geometric optimization for improving lamellar sedimentation efficiency and operational robustness.

Keywords

lamellar sedimentation; settling velocity; superhydrophobic surfaces; particle–surface interaction; water clarification

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Ammonium removal and recovery from industrial digestates

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Abstract

Biogas production in the Netherlands is expected to increase due to a national blending obligation law, leading to increased digestate production. These digestates cannot be directly applied to land or discharged to surface waters because of strict nitrogen discharge limits and high total ammonia nitrogen (TAN) concentrations. Conventional TAN treatment technologies are energy-intensive, complex, or do not enable nutrient recovery. Electrodialysis (ED) offers a chemical-free, electricity-driven alternative for decentralized digestate treatment and nutrient recovery.

This study investigated the feasibility of ammonia and potassium (K) recovery from industrial digestates using an integrated pilot-scale system consisting of ED, bipolar membrane electrodialysis (BPMED), and direct contact membrane stripping (DCMS). The investigation focused on repeatability, fouling behavior, and product concentrations. Approximately 1.2 m^3 of digestate was treated in batch mode.

The ED process consistently removed 85–84% of TAN and K, reducing influent concentrations of 2.6 g/L TAN and 1.4 g/L K to 0.4 g/L and 0.2 g/L, respectively. Electrical resistance remained stable at 3.9 $\pm$ 0.5 ohm over more than 25 batches, indicating the absence of irreversible fouling or scaling. The integrated system produced a high-purity ammonium sulfate solution containing more than 70 g/L TAN and an alkaline K product mainly consisting of KOH with concentrations exceeding 13 g/L K.

These results demonstrate that the integrated pilot-scale ED, BPMED, and DCMS system can recover TAN and K from industrial digestates without performance deterioration, offering an alternative to conventional treatment methods.

Keywords

biogas, digestate, ammonia, ammonium recovery, nitrogen crisis

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Determination of C0-C2 Alkylphenols in Stripped Water using UPLC-Q/Orbitrap HRMS

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Abstract

Stripped water accounts for up to 80% of the total process wastewater flow at petroleum refineries in China. Volatile phenolic compounds (VPCs) with high concentrations at 200-500 mg/L, which have been identified as phenol (C0-alkylphenol), cresol (C1-alkylphenol), C8H10O (C2-alkylphenol) and C9H12O (C3-alkylphenol), are the dominant contributors of COD. With the implementation of the national dual carbon development strategy, it is of great significance for the energy industry to carry out stripped water reuse and carbon resource recycling; and quantification components is the basis for the recovery and utilization of VPCs. Individual isomers of C1-C2 alkylphenols cannot be quantified in a single injection by conventional GC-MS or LC-MS methods due to co-elution of isomers. In this study, a UPLC-Q/Orbitrap HRMS method is established to quantify individua C0-C2 alkylphenols in stripped water and to resolve the precise seperation of co-eluted isomers without sample enrichment and derivatization.The method detection limits were 0.24-0.65 μg/L. The sensitivity of the method was 1-2 orders of magnitude higher than that of the conventional GC-MS method (HJ744-2015). The method achieved analytical rates of over 92.7% for VPCs in stripped water. The method was simple, accurate and sensitive, and successfully applied to stripped water, sour water and coal gasification wastewater.

Keywords

Ultra-high performance liquid chromatography-quadrupole/orbitrap high resolution mass spectrometry (UPLC-Q/Orbitrap HRMS), Volatile phenolic compounds, Alkylphenol, Isomer, Stripped water

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Enabling Circular Water Transitions: Integrating AI-driven Governance, Feasibility, and Stakeholder Adoption

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Abstract

Artificial intelligence is emerging as a crucial technology governance tool with the potential to plan, manage, and transform urban water systems towards circular resource use. However, limited stakeholder adoption persists due to institutional, operational, and cognitive limitations. The current research examines the technological perceptions and operational feasibility to support the integration of artificial intelligence in the circular economy for circular water solutions. Using a mixed-methods approach, the study compares data from six global cities, employing a survey-based empirical methodology (N = 37) that involves key stakeholders from technology, policy, utilities, and academia. The results in the study highlight perceived feasibility as a stronger predictor of adoption support than institutional or financial enablers. The present study introduces the concept of digital circularity as a type of institutional entrepreneurship. Furthermore, advancements in technology governance demonstrate that artificial intelligence functions as a governance-integrating mechanism, aligning policy coherence, stakeholder confidence, and operational viability, in addition to enhancing efficiency. Participatory experimentation and institutional alignment are two crucial factors that support artificial intelligence-driven circular transitions, resulting in diverse socio-institutional contexts and sustainable technology management, which accelerates the development of circular water systems. Thus, the research can be used to improve future-focussed planning for the deployment of artificial intelligence technologies in urban infrastructure.

Keywords

Artificial intelligence; Circular economy; Water reuse, Governance, Stakeholder adoption

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The All-in-one AI and ML N_2O solution[DN1] for low-carbon wastewater treatment

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Abstract

Nitrous oxide (N_2O) is a potent greenhouse gas with a global warming potential nearly 300 times greater than carbon dioxide, making its mitigation a priority for wastewater treatment facilities. However, comprehensive physical monitoring of N_2O emissions is often constrained by limited sensor coverage, data gaps, and high implementation costs. This study presents an integrated artificial intelligence (AI) and machine learning (ML) approach using Cobalt Water Global's N2ORisk Decision Support System (N2ORisk DSS) to support real-time prediction, risk assessment, and mitigation of N_2O emissions in wastewater treatment processes.

Site-specific ML models were developed using historical and real-time process data, including dissolved oxygen (DO), ammonia, and N_2O measurements. Supervised learning techniques were applied and validated using independent datasets, with model performance assessed using statistical metrics and relative accuracy against reference measurements. The N2ORisk DSS combines data-driven ML with knowledge-based AI to generate dynamic N_2O risk profiles, identify high-emission operating conditions, and recommend operational control strategies.

Results from a municipal wastewater treatment plant demonstrated strong predictive performance, with relative accuracy within regulatory acceptance thresholds. Analysis confirmed that N_2O emissions were highly sensitive to DO control, with elevated emissions occurring under both high and low DO conditions via distinct biological pathways. Maintaining DO within an optimal operating range significantly reduced N_2O concentrations while preserving process efficiency.

Keywords

Machine Learning (ML) Artificial Intelligence (AI) Greenhouse Gas Emissions Wastewater Treatment Nitrous oxide

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Industrial Effluent: Treatment, Reuse and Safe Discharge Strategies for Sustainable Industrial Development in Bangladesh.

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Abstract

Rapid industrial growth in Bangladesh, particularly in the textiles, leather, food processing, pharmaceuticals, and chemicals sectors, has significantly increased industrial wastewater generation, which contains a high organic load, color, salinity, and toxic constituents. Inadequate treatment and unsafe discharge have resulted in severe degradation of surface water bodies and increasing pressure on groundwater resources. This outline paper presents an integrated perspective on industrial effluent treatment, reuse, and discharge practices under Bangladesh industrial conditions. Current physico-chemical, biological, and advanced treatment technologies are reviewed, with emphasis on compact and energy-efficient systems suitable for space- and resource-constrained industries. Field-based evidence indicates that integrated treatment systems combining dissolved air flotation, fixed-film biological reactors, and membrane-based reuse can achieve 90–95% COD removal and reduce freshwater abstraction by up to 70%. The paper emphasizes the importance of circular water management for meeting regulatory compliance requirements, addressing buyer sustainability demands, and aligning with the Sustainable Development Goals (SDGs).

Keywords

Industrial Effluent Treatment Plant (ETP), wastewater reuse, Zero Liquid Discharge (ZLD), sustainability, SDGs

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Development and characterization of ultrafiltration membranes made with residual polymers: Phase inversion method application

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Abstract

The problem of industrial wastewater is global, driving the search for sustainable, cost-effective treatment technologies. This study evaluates the fabrication of ultrafiltration membranes from waste polymers using the phase inversion method as a viable alternative for treating industrial discharges. Recycled polypropylene (PP), polyurethane (PU), and polyvinyl chloride (PVC) were analyzed as raw materials, using dimethylacetamide (DMA) as the solvent at concentrations of 18, 20, and 21% w/w. PP and PU showed limited compatibility with DMA, preventing the formation of collodions suitable for membrane fabrication. In contrast, recycled PVC showed good solubility, enabling the production of stable, uniform collodions required for the phase inversion process. PVC membranes were manufactured at coagulation temperatures of 4, 6, and 8 °C and evaluated in a laboratory-scale ultrafiltration system at operating pressures of 1–2.5 bar. Water permeability results showed that it depends primarily on the polymer concentration, manufacturing temperature, and operating pressure. In particular, membranes fabricated with 20 % w/w PVC at coagulation temperatures of 6 and 8 °C achieved permeabilities within the ultrafiltration range, operating efficiently at low pressure. These findings confirm that recycled PVC is a viable waste polymer for the manufacture of ultrafiltration membranes, advancing sustainable, energy-efficient technologies and contributing to target 6.3 of SDG 6.

Keywords

Ultrafiltration, recycle polymers, permeability, phase inversión method, safewater

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Electrocoagulation Treatment of Mature Landfill Leachate: Performance Evaluation and Energy Reduction via Pulsed Current

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Abstract

Landfill leachate is a high-strength and heterogeneous wastewater stream that poses significant challenges for conventional treatment technologies. This study evaluates the performance of electrocoagulation (EC) for the treatment of mature municipal landfill leachate and investigates the potential of pulsed electric current to improve process energy efficiency. Electrocoagulation experiments were conducted using iron and aluminum electrodes at current densities ranging from 10 to 25 mA/cm². Treatment performance was assessed based on total organic carbon (TOC) removal and UV–Vis absorbance at 254 and 455 nm. The leachate was characterized by high organic and nitrogen loads and low biodegradability, typical of mature landfill leachate. Under optimal operating conditions (20 mA/cm², 60 min), EC achieved approximately 60% TOC removal, over 65% removal of humic-like organic matter, and more than 90% color removal. The application of pulsed electric current provided comparable TOC removal (up to 45%) to continuous DC operation while reducing specific energy consumption by approximately 48%. These results demonstrate that electrocoagulation is an effective treatment option for mature landfill leachate and that pulsed current operation can significantly enhance its energy efficiency, supporting its potential for sustainable landfill leachate management.

Keywords

Electrocoagulation, Landfill leachate, Industrial wastewater, TOC, Pulsed electric current

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A Life Cycle Analysis of Bismuth Vanadate During Solar Photocatalysis

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Abstract

Photo-electrocatalytic (PEC) treatment using bismuth vanadate ($BiVO_4$) photoanodes offers a promising route for the removal of pharmaceutical contaminants from wastewater. However, the environmental sustainability of such systems remains insufficiently explored. This study presents a cradle-to-gate life cycle assessment (LCA) of a $BiVO_4$-based PEC system applied to the degradation of propranolol, a widely detected β-blocker in urban wastewater. The assessment followed ISO 14040 and ISO 14044 standards and evaluated three sequential stages: $BiVO_4$-QAC material synthesis, photoanode fabrication, and PEC treatment of 150 mL of wastewater. Environmental impacts were quantified using SimaPro 9.0 with the Ecoinvent database and ReCiPe midpoint and endpoint methods.

Experimental PEC treatment under visible solar irradiation achieved effective removal of propranolol (10 µg/L) within 2 h. LCA results identified electricity consumption as the dominant contributor to impacts during the treatment stage, while chemical inputs governed impacts during material synthesis and electrode fabrication. Climate change potential and freshwater ecotoxicity emerged as key impact categories. Uncertainty analysis revealed a low coefficient of variation (0.025%), confirming the robustness of the results.

Overall, the study demonstrates that although $BiVO_4$-based PEC systems are technically effective for pharmaceutical removal, their environmental performance is strongly influenced by energy and material inputs. Integrating LCA with experimental PEC research provides critical guidance for optimising system design and advancing more sustainable wastewater treatment technologies.

Keywords

LCA, Photo-electrocatalytic treatment, wastewater, pharmaceuticals

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Selective Nitrate Recovery from Chloride-Rich Wastewater via Ion Exchange and Bipolar Membrane Electrodialysis

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Abstract

High chloride concentrations limit reuse of nitrate-rich wastewater as liquid fertilizer, particularly in hydroponic and soilless cultivation. Selective nitrate–chloride separation remains intrinsically challenging due to the similar physicochemical properties and strong competitive behavior of these anions in ion-exchange systems. Here, an integrated ion exchange–electrodialysis (IX–ED) concept is evaluated for selective nitrate–chloride separation and internal chemical recycling. Binary nitrate–chloride adsorption experiments showed preferential nitrate uptake on both resins, with comparable equilibrium selectivity coefficients for Amberlite IRA96 (4.07) and IRA402 (4.64). However, regeneration performance differed markedly: IRA96 was fully regenerated within 2.7 bed volumes of 0.7 M KOH, whereas IRA402 reached only ~80% regeneration with substantially higher chemical demand; IRA96 was therefore selected. Displacement was implemented by recycling a nitrate-rich product fraction as displacer, increasing chloride removal from ~75% under frontal loading to ~98.5%; under optimized conditions, 36% of the product stream was internally recycled and the resulting effluent returned to the feed tank, enabling up to ~40% feed savings. The chloride-rich ion-exchange effluent was subsequently valorized by bipolar membrane electrodialysis (BPM-ED). Operation at an optimized constant current of 0.5 A (≈102 A m^{-2}, maximum voltage 10 V) yielded current efficiencies of 0.70–0.83 and a specific electrical energy demand of 2–3 kWh kg^{-1} HCl, supplying approximately 69% of the acid and base required for resin reconditioning and regeneration. Overall, the integrated process enables selective nitrate–chloride separation with partial closed-loop operation and produces nitrate-rich streams suitable for liquid fertilizer applications, demonstrating a resource-efficient recovery strategy.

Keywords

nitrate–chloride separation; competitive anion exchange; displacement operation; bipolar membrane electrodialysis; closed-loop chemical recycling

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From wastewater to process water: a novel reutilization system of stripped water

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Abstract

Technologies for wastewater utilization within oil refineries have been gaining interest at an extensive rate due to the large volume of wastewater generated, high dependency of water and increasingly severe scarcity of water resources. The reuse of stripped water as process water within refineries is predominantly hindered due to phenolic contaminants. This study set up a method for wastewater resource utilization of stripped water with segregated collection at the source of high-phenol and low-phenol stripped water along with segregated treatment of double strippers system. The method achieved a fit-for-purpose wastewater utilization and direct reuse approach, which ensured high-quality stripped water for high-demand process uses and low-quality stripped water for low-demand process water uses predominantly in the light of phenol pollutant level, thereby systemically improved the wastewater resource utilization efficiency of stripped water of an oil refinery, and boosted the reuse ratio of stripped water from less than 60% to more than 90%. This novel approach has potential economic advantages and will promote the sustainable development of wastewater utilization of oil refineries.

Keywords

Wastewater Utilization, Stripped Water, Petroleum refinery, Phenol, Process water

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Hybrid Transformer-driven autonomous soft-sensing system for N_2O emissions in a full-scale wastewater treatment plant: Sensor fault reconstruction, quantification, and self-recalibration

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Abstract

Quantifying nitrous oxide (N2O) emissions from wastewater treatment plants (WWTPs) is critical for climate neutrality, yet deploying physical sensors is economically infeasible across thousands of WWTPs. Existing soft-sensing approaches struggle with long-term temporal dependencies and sensor noise. Hence, this study proposes an end-to-end autonomous soft-sensing system (EASSy) integrating: 1) categorical boosting (CatBoost)-based autonomous sensor fault reconstruction, 2) a Hybrid Transformer-based soft sensor for autonomous quantification of long-term N2O emission, and 3) autonomous self-recalibration when soft-sensing performance degrades below 0.8 of R2. The results indicated that EASSy framework can maintain the soft-sensing accuracy above 0.9 of R2 under various disturbances. Thus, EASSy can be utilized as a practical solution for reliable N2O quantification WWTPs under disturbances by maintaining the sensing performance in autonomously and predictively.

Keywords

Hybrid Transformer, N2O quantification, Self-recalibration, Sensor fault reconstruction, Net-Zero

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Full-Scale Application of Anaerobic Sequential Batch Reactor for Efficient Treatment of High-Fat Ice Cream Wastewater

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Abstract

Ice cream manufacturing generates wastewater with high fat content and extreme chemical oxygen demand (COD) fluctuations during daily operations.This study showcased the full-scale application of Anaerobic Sequential Batch Reactor technology, specifically Biothane's Sparthane™ system, for treating high-fat ice cream wastewater. Both pilot and full-scale phases confirmed that AnSBR with a controlled feast-famine regime of feeding was a robust process handling large fluctuations in feed composition. The technology achieved consistently high removal efficiencies (TCOD >90%, SCOD >95%) while maintaining operational stability under highly variable loading conditions, including daily COD fluctuations from 2.5 to 10 g/L.

Keywords

Anaerobic Sequential Batch Reactor (AnSBR), ice cream wastewater, high-fat wastewater treatment, anaerobic wastewater treatment

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Treatment and Reuse of Piggery Effluent: Integrating Solar & Recycled Combustion Gases in a Bubble Column Evaporator

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Abstract

Effective treatment and reuse of animal effluent are key challenges for the primary industry seeking sustainable water management. This study evaluates a Bubble Column Evaporator (BCE) pilot system capable of treating farm wastewater at 120 L/h to produce sterilized water for irrigation, facility cleaning, and distilled water suitable for animal consumption. The system supports on-farm water recycling and reduces reliance on external water sources.

A major innovation in this work is the first-time integration of solar energy to heat the inlet gas stream, significantly lowering overall energy demand. When combined with biogas combustion gases, this hybrid approach enhances thermal efficiency, reduces operational costs, and decreases greenhouse gas emissions.

The results demonstrate that BCE technology offers a practical, low-emission solution for treating animal effluent while enabling safe reuse and discharge. This approach provides a scalable pathway for improving wastewater management in the pork sector and other livestock industries.

Keywords

Bubble column, , primary industry, solar, water treatment, water reuse

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Model predictive control for optimum condensate reuse

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Abstract

Freshwater scarcity is a growing issue in Europe and worldwide, highlighting the need for efficient water use and consumption. Amongst the sectors affected by the water stress, industrial processes stand out, as those require large quantities of high quality water. A way to reduce the pressure on natural water resources is water reuse; and process condensates are a valuable industrial resource that serve as a direct freshwater alternative via (on-site) polishing and reuse. By employing a model predictive control (MPC), condensate reuse can be maximized whilst obeying process constraints. In this study, Dow proposed a new configuration of their condensate return system and an MPC was theoretically applied, with data of a two-months period, to simulate and evaluate the impact of the new configuration on optimizing the system: maximizing condensate reuse within constrained operational values. The simulation showed that the proposed configuration, coupled to the control strategy, provides a potential increase of condensate use from 50% to 57% (from the total water demand) in the base case, and up to 64% if more condensate (40% increase) can be supplied whilst maintaining the same water demand. Additionally, the MPC successfully controlled the variables to obey the systems' level and temperature constraints to the desired ranges, proving to be a powerful tool for system optimization.

Keywords

Dynamic modelling, water reuse, model predictive control, optimization, condensate return

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Reducing N_2O Emissions in Wastewater Treatment with Pure Oxygen Aeration: A Full-Scale Study

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Abstract

Nitrous oxide (N_2O) is a significant contributor to the greenhouse gas (GHG) footprint of wastewater treatment plants (WWTPs), with a global warming potential approximately 300 times that of CO_2. This study investigates the effectiveness of pure oxygen-based aeration as a novel strategy to mitigate N_2O emissions in high-strength industrial wastewater treatment. Conducted at a full-scale composting facility in the Netherlands, the research utilized a multi-faceted approach combining computational fluid dynamics (CFD) modeling, drone-based surface flux measurements, and continuous in-situ sensor monitoring to evaluate various aeration scenarios.

CFD simulations projected that replacing conventional surface aerators with pure oxygen injection could achieve over a 98% reduction in N_2O emissions. These findings were corroborated by field measurements: drone-based quantification demonstrated a 67% reduction in N_2O flux under hybrid aeration (a mix of air and pure oxygen), and in-situ sensors frequently detected negligible dissolved N_2O concentrations during stable pure oxygen operation. The study identified that pure oxygen improves hydrodynamic mixing and eliminates localized dissolved oxygen (DO) limitations—the primary triggers for N_2O production.

Furthermore, a comprehensive carbon footprint analysis revealed that pure oxygen systems exhibit significantly lower overall GHG emissions than conventional air-based systems, primarily due to superior energy efficiency and reduced gas stripping. Collectively, these results position pure oxygen aeration as a highly effective, sustainable technology for N_2O abatement, offering a promising solution for facilities aiming to meet increasingly stringent environmental regulations.

Keywords

Nitrous oxide emissions mitigation, Industrial wastewater treatment, Pure oxygen aeration, Greenhouse gas mitigation, carbon footprint reduction, activated sludge process

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Industrial Wastewater Reclamation in Cosmetics Industry

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Abstract

This study investigates the performance and long-term viability of an integrated ultrafiltration (UF) and closed-circuit reverse osmosis (CCRO) treatment process to reclaim pre-treated wastewater effluent from a Beauty & Personal Care manufacturing facility. The objective was to produce high-quality process water while ensuring operational stability and enabling scalability to similar industrial facilities.

UF was continuously operated at a water recovery of 97.5-98% throughout the entire monitoring run, showing stable performance with regular backwashes and periodical CEB cleaning. CIP was not required.

CCRO was operated at 70-75% recovery for a duration of 4 months before requiring a CIP, proving the benefits of CCRO on fouling reduction applied to wastewater treatment. CIP successfully recovered the flow (fouling) factor.

The results demonstrate that the combined UF-CCRO process provides a reliable and resilient solution for industrial wastewater reclaim in the cosmetics sector. High recovery, stable permeate quality, and extended cleaning intervals confirm the process's suitability for long-term operation. These findings support the replicability of the approach and highlight its potential to advance water circularity across similar industrial facilities.

Keywords

Cosmetics, wastewater, reclamation, circularity, CCRO

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1,4-Dioxane treatment in industrial wastewater using ozone-based advanced oxidation

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Abstract

1,4-dioxane is a solvent used in a wide range of industrial processes. Due to its carcinogenicity, regulations of dioxane levels in drinking water, consumer products, and wastewater are on the rise [1,2,3]. Conventional drinking and wastewater treatment processes cannot remove dioxane due to its limited biodegradability and physicochemical properties [3].

Advanced oxidation processes (AOPs) have successfully been applied to remove dioxane due to the high oxidation capacity of hydroxyl radicals. Among the options to create hydroxyl radicals, ozone based AOPs are promising due to their efficiency and scalability. Ozone produces hydroxyl radicals from decomposition at very basic conditions (pH > 11) or under moderately basic conditions (pH > 8) with addition of hydrogen peroxide.

In this presentation, we will give an overview on dioxane regulations, treatment options, and treatment parameters for ozone based AOP. The treatment performance and combination with biological post-treatment to remove the transformation products [4] will be showcased with laboratory tests and full-scale applications, as well as cost considerations [5].

Keywords

1,4-dioxane, industrial wastewater, ozone, advanced oxidation

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Recovery of gadolinium sulphate octahydrate salt under super saturated condition using nanofiltration

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Abstract

Ultra-sensitive detectors used in experimental physics often employ gadolinium sulphate octahydrate ($Gd_2(SO_4)_3 \cdot 8H_2O$, GdSO)-doped aqueous systems to suppress neutron-induced background signals, leveraging gadolinium's exceptionally high neutron capture cross section. During detector operation and maintenance, substantial volumes of gadolinium-containing solutions must be managed, creating a need for efficient volume reduction strategies. This study explores nanofiltration (NF) technology as a viable approach for this purpose.

In the present case, the original solution volume of 700 m^3 needs to be concentrated to approximately 12 m^3, corresponding to a volume reduction factor of about 58. Under these conditions, the concentration of GdSO salt considerably exceeds its theoretical solubility limit of ~25 g/L. Different NF configurations were tested to achieve concentration beyond the saturation limit while minimizing crystallization on the membrane surface. To facilitate this, the required volume reduction was carried out in two consecutive steps. In the first step, a NF system with standard configuration was employed (NF1), whereas in the second step a closed-circuit NF, or CCNF, configuration (NF2) was applied to achieve further concentration of the solution.

The results demonstrated that the volume of the original GdSO could be effectively reduced by approximately a factor of 58, resulting in a final solution that substantially exceeded the solubility limit of the incorporated salt. Additionally, the majority of the valuable GdSO salt was retained in the concentrated fraction, allowing for its reuse in subsequent reactor operations.

Keywords

nanofiltration, closed-circuit NF, salt recovery, volume reduction, gadolinium sulphate octahydrate

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Water and Wastewater Streams and Reuse Opportunities in TOPCon Solar Cell Production

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Abstract

The TOPCon silicon solar cell technology represents one of the main n-type cell architectures following the p-type PERC cell technology as the globally most important solar cell structure. The water consuming and wastewater generating processes of a 4 GWp/a TOPCon manufacturing factory were identified and the resulting water and wastewater streams were calculated based on actual manufacturing tools and wet chemistry recipes. Composition, temperature and pH value of all water and wastewater streams of said factory were simulated. A reference wastewater treatment system was modelled and simulated. Three optimization strategies were derived and assessed: Reclamation of rinse waters, cascading of acidic process baths for the cleaning of deposition and diffusion tubes and concentration of alkaline process baths for the generation of valuable alkali silicates. The strategies were assessed economically and ecologically. The technical feasibility was partially demonstrated in laboratory experiments. All three optimization strategies showed economic benefits with return of investment (ROI) mostly smaller than 2 years. All strategies combined, overall cell production costs could be lowered by 3.2%. Water demand and wastewater discharge could be reduced up to 40%. The consumption of process chemicals could be reduced up to 20%. Introduction of all strategies could achieve a 2% mean reduction across 15 environmental impact categories.

Keywords

Photovoltaics, Solar Cells, Industrial Wastewater, Wastewater Reuse, Valorization

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PFAS occurrence and removal in semiconductor wastewater using electrochemical oxidation

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Abstract

PFAS are under the spotlight due to their ubiquity in environment, their persistence and toxicity. They can be found at high concentration in semiconductor manufacturing of electronic microchips. As there is no PFAS free alternatives and chip production is expected to increase, it is crucial to develop treatment technologies able to degrade PFAS. However, their C-F bonds make them extremely stable, and their remediation from contaminated effluents is challenging.

We developed a graphene-based sponge that degrades PFAS during electrochemical oxidation. We will demonstrate the efficacy of this technology, by presenting PFAS removal achieved in several samples: a mix of PFAS standards in water (Up to 86% removal for PFOA), a commercially available and industry relevant top antireflective coating TARC in water (up to 90% removal), and a real wastewater stream from semiconductor facilities. In parallel a characterization of semiconductor wastewaters will be presented. Combustion Ion Chromatography results illustrated that the highest level of fluorine is found after the lithographic process. Target analysis with liquid chromatography coupled to mass spectrometry detected and quantified well-known PFAS. In addition, suspect and non-target analysis with high resolution mass spectrometry (coupled to liquid and ion chromatography) highlighted compounds potentially present but yet not in the monitoring list. This study demonstrated several complementary analytical methods to assess PFAS contamination. When applied to wastewater from semiconductor facilities, the results showed that the treatment of this stream is both needed and feasible. Although challenges remain, electrochemical oxidation using graphene-based sponge appeared to be a promising treatment.

Keywords

Per-polyfluoroalkylated substances, wastewater treatment, graphene-based sponge, mass spectrometry

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Integrated MBR-RO process for water recycling at a multi-user manufacturing site in Ho Chi Minh City at demonstration-scale

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Abstract

Industrial water recycling is an efficient way to increase production capacity and reduce water pollution. The partners of the InReUse project have demonstrated the feasibility of an integrated membrane bioreactor and reverse osmosis (MBR-RO) system in an industrial park in Vietnam. A systematic approach was taken, and the ideal location and best application of the MBR-RO system was identified during the project. The developed solution was optimized with the local stakeholders, and the technology adapted to the requirements on site. In an industrial park on the outskirts of Ho Chi Minh City, a plant with a treatment capacity of 10 m^3 per day was operated in various process configurations. For example, the MBR was able to achieve 50% lower COD effluent concentrations of 120 mg/L compared to the conventional activated sludge plant. This already meets the Vietnamese minimum requirement for the treatment of such heavily contaminated industrial wastewater. With the RO, a COD reduction to 5 mg/L was achieved with a simultaneous reduction in conductivity, so that reuse would be possible. However, due to the very low price of fresh water in Vietnam, which is currently around € 0.28 per cubic meter, reuse only makes sense if there are corresponding legal requirements or internal company specifications to minimize freshwater consumption.

Keywords

industrial park, membrane bioreactor, reverse osmosis, recycling, reuse

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Electrochemical Oxidation of PFAS using Boron doped Graphene coated Ti/RuO_2 Anode

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Abstract

Per- and polyfluoroalkyl substances (PFAS) are a group of persistent, anthropogenic environmental contaminants known for their bioaccumulation and toxicity. Conventional water and wastewater treatment processes are unsuccessful at removing these chemicals. Electrochemical oxidation using boron-doped diamond (BDD) anodes offers good removal efficiency, but their high cost deters their application in large-scale treatment plants. Pb- and Sn-based anodes are significantly cheaper than BDD but suffer from leaching and toxicity issues. There is a need for inexpensive, efficient, and environmentally friendly anode materials for the degradation of PFAS in large-scale plants.
Ti/RuO_2 anodes are well known for their high electrocatalytic activity, stability, and for being relatively cheaper than BDD. On the other hand, graphene offers high conductivity, a large surface area, and fast electron transfer. Doping graphene with heteroatoms significantly improves its charge-transfer properties. This study explores the use of boron doped graphene coated on Ti/RuO_2 anodes, BG/Ti/RuO_2, for the degradation of PFAS. The BG/Ti/RuO_2 anode degraded 99% of PFAS in 30 minutes at 80 mA/cm^2, which is significantly higher than 70% in 60 minutes with bare Ti/RuO_2. A higher removal rate was observed at neutral pH, eliminating the need for additional chemicals. BG/Ti/RuO_2 could be a promising low-cost, non-toxic, and highly efficient anode for the degradation of PFAS in industrial-scale treatment plants.

Keywords

PFAS, Emerging contaminants, Advanced oxidation process, Electrochemical oxidation, Water Pollution

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Optimized Energy for Water Production (Desalination) and Transmission in Hilly Terrains with Moderate Solar Flux

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Abstract

Introduction

State-of-practice seawater reverse osmosis (SWRO) typically consumes between 3–4 kWh/m³ at modern recoveries, with levelized water cost (LWC) commonly between $0.5–$2.0 per m³ depending on energy price, scale, and pretreatment. Transmission up steep gradients adds significant operating cost

Recent research and projects indicate strong synergies between solar PV, pumped-storage hydropower (PSH), and RO—from concept studies (Cornell/IEEE Spectrum; elevation-distributed multistage RO) to real islanded systems (Gran Canaria). These show that co-locating storage and RO can reduce costs, share infrastructure, and improve night-time operation. Furthermore, multiple reviews document that integrating solar with desalination can materially cut LWC in sunny regions, even at moderate capacity factors [1]

This work develops a region-specific solarwaterstorage concept integrating high-yield solar PV from the Thar Desert, coastal seawater desalination in Gujarat, and pumped storage hydropower (PSH) within the Aravalli hills. The Thar Desert provides 5.56.0 kWh/m²/day of solar irradiance, making it among Indias most productive solar regions. Gujarats coastline already hosts major desalination assets such as Dahej (100 MLD), while the Aravalli range offers elevation suitable for high-point reservoirs that enable gravitational distribution and night-time energy recovery. Integrating these three geographic advantages provides a pathway to reliable, low-carbon potable water supply at scale.

The system architecture consists of utility-scale PV in the Thar Desert generating power for desalination; seawater reverse osmosis Gujarats coast producing 100 MLD of potable water; and pumping this water to a 250 m high-point reservoir in the Aravalli hills.

Keywords

Desalination, Solar PV, Pumped Storage Hydropower, Aravalli, Water-Energy Nexus

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SmartBrine: Feasibility of SWRO brine valorization in northeastern Brazil

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Abstract

Seawater reverse osmosis (SWRO) plants planned in Ceará, Brazil will produce large amounts of brine, a hypersaline stream typically treated as waste and discharged to the coast due to simplicity and low cost. However, this discards valuable salts that could be converted into useful products. Ceará's expanding industrial sector and plans for a green hydrogen hub increase demand for process chemicals and treated water, creating opportunities for brine valorization.

The SmartBrine project explores this through an integrated feasibility study combining technological assessment, process design and stakeholder engagement. The technological pathway focuses on converting brine into value-added products via conditioning and electrochemical steps. Nanofiltration and cation exchange remove divalent ions and reduce scaling, enabling electrolysis to produce sodium hypochlorite for disinfection, and bipolar membrane electrodialysis (BMED) to convert sodium chloride into hydrochloric acid and sodium hydroxide. These products are relevant for water treatment and industry, creating circular value loops between desalination facilities and nearby users.

The study also engages regional stakeholders to identify use cases and barriers. Early feedback indicates interest from water and industrial actors in chemicals or treated water from brine, suggesting alignment between brine valorization and regional needs.

Engineering work produced a concept for a containerized pilot combining SWRO, double-pass nanofiltration, cation exchange, electrolysis and BMED modules. This modular design supports transport, installation and testing near future desalination sites and industrial consumers. Initial results indicate viable configurations and stakeholder interest, highlighting a pathway for brine to supply useful chemicals and increase circularity while reducing reliance on virgin chemicals.

Keywords

brine valorization, seawater desalination, circular economy, electrochemical processes, nanofiltration

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Integrated Wastewater Remediation and Antibiotic Detection Using Silica Hybrid Adsorbents

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Abstract

In this work, we present a sustainable method for synthesizing amino- and phenyl-functionalized silica nanoparticles (SiO_2NPs) from natural quartz-rich minerals via hydrometallurgical extraction. These dual-use nanomaterials first serve as effective adsorbents for the removal of REEs or textile dyes and are subsequently employed as fluorescent sensors for the detection of antibiotics such as doxycycline and norfloxacin in aqueous media.

A novel strategy for industrial wastewater treatment has been developed that combines the sorptive and sensing capabilities of functionalized silica-based nanomaterials. Using a natural quartz-containing mineral as a sustainable raw material, highly purified amorphous silica nanoparticles were synthesized via an environmentally friendly, high-efficiency process. Surface functionalization with amino and phenyl groups endowed the materials with adsorption capacity toward lanthanide ions and synthetic dyes from aqueous media, addressing critical demands of modern water treatment technologies.

A unique feature of this approach is the ability to repurpose the pollutant-loaded materials as fluorescent sensors for detecting pharmaceutical residues, particularly antibiotics. Experimental results demonstrated that the presence of lanthanides or dyes on the surface of modified particles activates rather than suppresses their sensing properties, offering high sensitivity and selectivity toward compounds such as doxycycline and norfloxacin.

Overall, the study highlights the potential of multifunctional silica adsorbents as a dual-purpose platform for both water purification and real-time environmental monitoring, directly supporting SDG 6 (Clean Water and Sanitation). This approach promotes resource efficiency, reduces treatment and quality control costs, aligning with SDG 12 (Responsible Consumption and Production), and meets current sustainability standards in industrial water management.

Keywords

Functionalized silica nanoparticles, amino surface modification, REE adsorption, dye adsorption, antibiotic detection

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Reactor-Scale and Local Transport Phenomena in Fungal Trickle-Bed Bioremediation

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Abstract

The presence of emerging organic pollutants is a growing concern in terms of water quality. Bioremediation, particularly the use of white rot fungi, is a promising advanced treatment technique. The present study takes a multiscale approach. It considers both the trickle-bed reactor as a whole and the flow on a single carrier in idealised conditions. This allows us to evaluate the wettability of the reactor, as well as the impact of flow conditions on the mycelial growth structure and the resulting limitation of mass transfer. Mycelium was inoculated onto a 30 x 8 mm wooden dowel using the basidiomycete *Coriolopsis gallica* 1184 strain. The trickle-bed reactor had a treatment volume of 4 L, with continuous flow at 5 mL/min. The inoculated dowel was then placed in a system with controlled low-flow falling film and full wetting. Remazol Brilliant Blue R degradation and phase proportions were measured at different growth stages. Biomass production, lignin-modifying enzyme activity and oxygen microprofiles were also determined in order to characterise the thickness of the biofilm and the structure of the liquid film. Continuous degradation of 30% was achieved on the reactor scale. The liquid phase accounted for 3.33% of the total volume, while the solid phase accounted for 49%. These results were compared with those of previous experiments involving *Trametes versicolor* under identical conditions, which exhibited significantly lower degradation performance. These differences were attributed to variations in the mycelial structure, emphasising the importance of structure in relation to the system's overall treatment capacity.

Keywords

Micropollutants, Bioremediation, Biofilm, Fungi, Mass-transfer

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Bridged Polysilsesquioxane-Magnetite Adsorbents with Tunable Amino/Thiol Interfaces for Multicontaminant Water Treatment

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Abstract

Magnetically separable mesoporous hybrid adsorbents were synthesized by coating Fe_3O_4 (magnetite) nanoparticles with bridged organosilica networks derived from ethylene- or phenylene-bridged bissilanes and introducing complexing groups (–NH_2, –SH, or –NH_2/–SH) via one-pot fluoride-catalyzed sol–gel co-condensation. The template-free conditions preserved the crystalline magnetite core and produced porous polysilsesquioxane shells. Nitrogen sorption revealed open mesoporosity with surface areas of up to ~980 m^2/g, and elemental analysis indicated total functional-group loadings of up to ~2.5 mmol/g. SEM/TEM evidenced uniform porous shells, while XRD confirmed retention of the magnetite phase after functionalization. Adsorption was evaluated for contaminants relevant to wastewater treatment, including textile dyes (Acid Red 88 and Methylene Blue), As(III), and the antibiotic doxycycline; selected heavy-metal cations were also tested to benchmark N/S donor-site affinity. Langmuir fits described the isotherm data well, suggesting predominantly monolayer uptake on accessible sites predominantly. Ethylene-bridged materials achieved high dye removal capacities for Acid Red 88 and for Methylene Blue. In the phenylene-bridged series, thiol-rich shells favored As(III) binding. In contrast, amino/thiol bifunctional shells enhanced doxycycline removal, consistent with complementary coordination, hydrogen bonding, and non-ionic interactions supported by the aromatic bridge. The sorbents were rapidly collected by a magnet and are designed for reuse, minimizing secondary sludge and simplifying operation. Overall, these bridged organosilica–magnetite composites combine tunable porosity with rapid magnetic recovery, offering reusable adsorbents for complex water matrices.

Keywords

Magnetic mesoporous silica; Bridged bissilanes (ethylene, phenylene); Bifunctional surfaces; Heavy metal adsorption; Water treatment

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Water Efficiency Evaluation in a Rapidly Expanding Organized Industrial Zone in Türkiye

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Abstract

This study evaluates water use patterns and the adoption of Best Available Techniques (BAT) for water efficiency in a rapidly expanding Organized Industrial Zone (OIZ) in Türkiye, a country already experiencing water stress with an annual per-capita water availability of about 1300 m^3. Industrial growth and urbanization continue to intensify pressure on limited water resources. Climate change is expected to worsen these challenges through reduced precipitation and rising temperatures of up to 5–6 °C in coming decades, emphasizing the need for integrated water management.

The research is based on survey data from 34 factories and site visits to water-intensive sectors. Information collected includes production capacities, NACE codes, water use, wastewater characteristics, water treatment methods, and BAT compliance. Results indicate an annual water consumption of 3.8 million m^3 in the target OIZ, with summer demand 40% higher than in other seasons. Food, textile, and clothing sectors—162 facilities in total—account for 55% of total water use among 470 factories. However, only 24% of surveyed facilities implemented water reuse, and only 6% utilized alternative resources such as rainwater harvesting, revealing limited progress toward circularity.

BAT compliance levels varied widely across sectors and categories. Food, textile, and clothing industries showed inconsistent adherence to sector-specific, management, precautionary, and auxiliary-process measures, with compliance ranging from minimal to full adoption. The study concludes that advanced treatment technologies and increased institutional capacity are necessary to enhance water efficiency and reduce competition among industrial, agricultural, and urban uses under worsening climate impacts.

Keywords

best available techniques, compliance, organized industrial zone, water efficiency, water reuse

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BODAC®; A sustainable biological regenerable activated carbonfilter for biofouling control and micropollutant removal

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Abstract

Growing water scarcity has intensified the need for reliable, sustainable treatment technologies, particularly for systems depended on reverse osmosis (RO). RO is effective for producing high-quality water but has high operational costs due to frequent cleaning and membrane replacement. Traditional pretreatment approaches have not sufficiently contributed to membrane longevity. Meanwhile, rising prices and logistical complexity have reduced the attractiveness of conventional activated carbon solutions.

BODAC®—a biological activated carbon filtration technology developed by NieuWater—offers a robust alternative. Using specially prepared BioActive® granular activated carbon combined with continuous pure oxygen dosing, BODAC® maintains aerobic conditions that enhance biodegradation and oxidation processes.

At the full-scale Emmen ultrapure water plant in the Netherlands, producing 8,200 m^3/day, BODAC® filters have operated for 15 years without replacing the BioActive® carbon or downstream RO membranes. The two-filter configuration effectively removes manganese (>99%), iron (up to 79%), nitrogen, and phosphorus. Oxygen dosing drives biological and abiotic removal mechanisms, while periodic backwashing preserves filter performance.

The system consistently also removes 70–90% of different organic micropollutants (OMPs). Overall, BODAC® significantly reduces chemical use, extends RO membrane life and provides a sustainable, low-carbon footprint pretreatment solution for both municipal and industrial water systems. Next first full scale installation and several pilots at WWTP in the Netherlands show that the concept can be copied to other municipalities for micropollutants removal.

Keywords

Reuse, biofouling prevention, micropollutants removal, no carbon regeneration

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Enhancing PFAS Removal Through Vacuum Airlift FoamFractionation: Lab-Scale Optimization for IndustrialDeployment

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Abstract

The goal of this study is to optimize the balance between PFAS removal efficiency and achievable
concentration levels, considering both hydraulic and technological aspects of the of the VAL-FF. Rather than
maximizing removal efficiency at the expense of excessive foam production, the focus is on identifying
operating conditions that can deliver effective PFAS capture while producing stable manageable foam. This
study is carried out using real industrial water matrices ensuring that the performance reflects true field
conditions. The laboratory experiments are designed to systematically evaluate key process parameters and
to understand how they influence both removal behavior and concentration outcomes. The purpose of the
lab-scale program is to narrow and refine the operating window for the pilot system deployed on the
industrial site

Keywords

PFAS, Scale-up, laboratory, pilot

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Towards Chemical-Free Nitrogen Recovery: AdvancingResource-Recovery Oriented Wastewater Treatment

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Abstract

Nitrogen removal remains a critical challenge in municipal wastewater treatment, both from an environmental
and resource recovery perspective. Conventional biological pathways are energy-intensive and can lead to
significant emissions of nitrous oxide (N_2O), a greenhouse gas with high global warming potential.
Physicochemical recovery technologies provide an alternative route, enabling both the mitigation of emissions
and the recovery of nitrogen as a valuable product.
The ByoFlex technology, a physical-chemical stripping–scrubbing system, has been implemented in full scale
at several municipal treatment plants in Norway, the Netherlands, and Germany. Long-term operation
demonstrates high and stable nitrogen removal efficiencies, while simultaneously reducing N_2O emissions by
avoiding extensive biological conversion pathways

Keywords

Nitrogen, Recovery, Chemical Free

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Achieving Water Positivity Through Metered Water consumptions and CSR-Led Replenishment Across Multi-Sector Sites in India

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Abstract

India's growing freshwater stress, driven by rapid urbanization, industrial growth, and climate variability, calls for water stewardship approaches that extend beyond efficiency gains to deliver net positive outcomes. Although water positivity frameworks are increasingly adopted, based on verified, operational data across multiple sectors remains limited. This study addresses this gap through a large-scale, metered assessment of water consumption, reuse, and replenishment across diverse operational contexts. The analysis covers 25 operational sites of the Dharampal Satyapal (DS) Group, spanning industrial facilities, hospitality units, corporate offices, and agricultural operations across multiple Indian states. The assessment relies exclusively on metered data to develop site-level water balances, accounting for municipal supply, groundwater extraction, tanker and bottled water use, wastewater treatment and reuse (STP and CETP/ETP), rainwater harvesting, and process recovery streams such as RO reject and backwash water. No estimated or extrapolated values were used. An organizational water balance and Water Positive Index (WPI) were derived by aggregating site-level deficits and integrating off-site replenishment achieved through corporate social responsibility initiatives. The total annual freshwater demand across all sites was approximately 4.03 million kL. While on-site reuse and rainwater harvesting significantly reduced freshwater dependence, residual deficits persisted at certain locations. These were offset through CSR-led water replenishment projects, including groundwater recharge and community rainwater harvesting, resulting in an overall WPI of 1.8. The study demonstrates water positivity at scale is achievable through integrated demand management, water reuse and strategically aligned off-site replenishment, offering transparent and replicable model for corporate water stewardship in water-stressed regions.

Keywords

Water Positivity, Water Performance Index, Corporate Social Responsibility (CSR), Water management, GRIHA Council

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Recent advances in Industrial Water Reuse: Technologicaloutcomes of Pulp and Paper end of pipe wastewater reuse andbrine management

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Abstract

Potable freshwater availability for drinking water production is increasingly under pressure in the Netherlands due to a growing economy, a rising population, and the impacts of climate change. The Dutch National Institute for Public Health and Environment (RIVM) indicates that there is no certainty that the supply of both groundwater and surface water will suffice for the supply of drinking water to the Dutch population in 2030. With this increasing pressure, provinces such as Gelderland (The Netherlands) are actively assessing options to mitigate this stress (van Leerdam et al., 2023). Moreover, the pulp and paper industry is a major extractor of freshwater due to its water-intensive processes. In the Netherlands, this industry consumes between 369–501 m^3/ton of paper produced (van Oel, Mekonnen and Hoekstra, 2009), with an annual production of 2.2 million tonnes, leaving a significant mark on local water resources. This study evaluates the technological feasibility of end-of-pipe effluent reuse and brine management strategies to alleviate pressure on the local water supply

Keywords

Reuse, Paper industry, water reclamation, membranes

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Industrial Fluorinated Liquid Crystal Monomers in E-Waste-Impacted Rivers and their Environmental Interactions

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Abstract

Liquid crystal monomers (LCMs), building blocks for LCD panels, are emerging persistent organic pollutants from electronics manufacturing. Global LCD shipments hit 198 million m^2 by 2018, yielding 214 tons of discarded LCMs in 2017 alone [1-2]. Fluorinated LCMs (FLCMs) persist near e-waste sites due to high viscosity and hydrophobicity (log K_{ow} = 4–13), driving mobility and sediment accumulation across their lifecycle. Their co-occurrence with microplastics (MPs) in benthic sediments raises concerns over combined fate and risks, yet remains underexplored. This study quantifies FLCMs in the Beigang River receiving e-waste discharges from a Guangdong village, a former e-waste hub lacking prior FLCM data. Water, sediment, suspended solids, and MPs were sampled upstream to downstream and analyzed via optimized protocols. All five target FLCMs occurred variably: up to 46.6 ± 1.5 ng/g d.w. in upstream sediments and 55.2 ng/L in water. Suspended solid sorbed FLCMs were below detection limits, likely due to low solids. Laboratory tests showed strong EDPB adsorption onto MPs (Qmax: PE > PS > PP > PVC; up to 849.5 μg/g) via hydrophobic, electrostatic, and π-π interactions under fresh/seawater conditions (Figure 2). Microcosms revealed EDPB-MP composites alter sediment microbiomes, fostering unique communities and impairing nitrogen cycling. This study provides compelling evidence of FLCM distribution in industrial aquatic compartment and synthesize quantitative basis for assessing the environmental partitioning and potential ecological risks associated with FLCM-MPs composite pollutants.

Keywords

Fourinated Liquid Crystal Monomers, Microplastics, River matrices, FLCM-MPs composite, interactions

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Water reclamation for industrial use potential for Maputo

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Abstract

This study particularly addresses the potential of water reclamation practices for industrial use to alleviate urban water stress. Through a case study of the city of Maputo, Mozambique, an applicable method was developed for cities to assess the water reclamation potential. Based on the City Blueprint Framework, additional indicators were designed to better address water reclamation for industrial purposes. The indicators were developed to be easy to understand, timely, and relevant, and with minimal computation efforts. By applying this newly developed assessment, the main gaps, opportunities, and priorities were identified for Maputo. Overall, we, amongst others, found that sanitation infrastructure and wastewater treatment are key priorities for increased wastewater reclamation for industrial use, as almost 90% for of the city's population rely on on-site sanitation and less than 20% of the generated wastewater is treated at a central treatment plant. However, the city's industry is relatively close to the sewage water sources, which, on the other hand, is an opportunity to reclaim wastewater for purposes that require less stringent water quality such as cooling processes. The potential savings in water consumption at reduced overall costs of water reclamation, may, thus, pose a promising solution to increase Maputo's water sustainability

Keywords

water reclamation, industry, wastewater, water treatment, environment

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Source-Dependent Functionalization of Silica with Pectin for Heavy Metal Removal from Industrial Wastewater

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Abstract

The removal of heavy metals (HM) from industrial water remains a critical challenge due to their toxicity, persistence, and adverse environmental and health impacts. This has driven the search for efficient and cost-effective adsorbent materials. In this study, three silica-based adsorbents functionalized with pectin from different sources were developed. Pectin, a polysaccharide rich in carboxyl groups, provides effective binding sites for metal ions, but its direct application is limited by swelling and partial dissolution in aqueous environments. Incorporation into a silica framework overcomes these limitations, providing structural stability and high surface area. Therefore, the pectin source was found to influence the physicochemical properties and adsorption behavior of the resulting hybrids, enabling either selective or broad-spectrum HM adsorption.

The obtained samples are abbreviated as follows: SiO2/pectin from Tekhnologika – SP1, SiO2/pectin from citrus peel – SP2, and SiO2/pectin from apple – SP3.

From the results, the hybrid materials SP1–SP3 show distinct physicochemical properties and particle morphologies. Their adsorption behavior depends on the nature of the pectin used: SP1 selectively removes lead, SP2 effectively adsorbs all tested metals, and SP3 preferentially removes lead and nickel. These results demonstrate that the choice of pectin allows tuning the sorbent for either selective or broad-spectrum HM uptake.

Keywords

silica, source of pectin, sol-gel method, adsorption, wastewater.

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BiOI–ZnO Heterojunctions Integrated PES Ultrafiltration Membranes for Photocatalytic Degradation and Separation of Contaminants of Emerging Concern.

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Abstract

The presence and accumulation of contaminants of emerging concern (CECs) originating from increasing production of pharmaceuticals, personal care products, pesticides, plastic components, coatings, textile manufacturing, and industrial dyes contribute to environmental hazards and adverse health effects. Advanced oxidation via photocatalysis is emerging as a promising alternative technology in the realm of water purification, and bismuth oxy-iodides (BiOI) have drawn significant interest due to their outstanding visible light absorption and electron-hole pair separation. However, low quantum efficiency and poor recoverabilty are stll major challenges. Designing heterostructure-based composite photocatalysts helps separate charge carriers at the interface, reducing recombination and boosting activity. In this work, we have co-synthesized BiOI-ZnO (BiZnOI) heterostructure in one-pot using modified solvo-hydro thermal method and characterised it by means of XRD, SEM, EDX, TEM, XPS, UV-Vis DRS, and BET. The Photocatalytic activity of the product against the colourless BPA and Rose Bengal was checked under the irradiation from a 50 W white LED lamp. This study proposes an innovative approach to water purification by integrating polyethersulfone (PES) flat-sheet membranes, recognized for their high porosity and separation efficiency, with co-synthesized BiZnOI. The hybrid system intends to simultaneously enhance physical filtration and photocatalytic degradation of CECs. The formed heterojunction BiZnOI showed superior activity compared to both pristine BiOI and ZnO, degrading more than 80 % of the pollutant within 30 minutes and thus mitigating the accumulation of adsorbed contaminants on the membrane, ultimately supporting progress towards the next generation of water treatment technologies.

Keywords

Bisphenol A, Water Treatment, Advanced Oxidation, Photocatalysis, Ultrafiltration

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Biochar-regulated MnO_2 for catalytic ozonation of benzotriazole: performance, mechanism and practical application

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Abstract

This study aimed to address the inherent limitations of MnO_2 by supporting it on biochar, thereby enhancing its catalytic ozonation efficiency. An optimal MnO_2/biochar composite was synthesized through controlled preparation parameters. Its catalytic performance was systematically evaluated under varying reaction conditions using a model pollutant (benzotriazole). The degradation mechanism was elucidated by identifying the reactive oxygen species involved and quantifying their contributions. The efficiency of materials was further validated with real wastewater. Comprehensive toxicity assessment was conducted using zebrafish (*Danio rerio*), evaluating both developmental and in vivo toxicity endpoints. This work provided deep insights into the synthesis-performance-mechanism-toxicity nexus and offered a rational design strategy for developing efficient and environmentally benign catalytic ozonation systems.

Keywords

Catalytic ozonation, Biochar, Benzotriazole,Reactive oxygen species, Toxicity

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Beyond carbon and conventional LCA of wastewater treatment projects: Integrating PMTs and MPs into a cradle-to-grave life cycle assessment of a nature-based tertiary treatment

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Abstract

Global water security is under increasing pressure due to population growth, industrialisation, and climate change, making wastewater reuse critical for sustainable water management. However, persistent, mobile, and toxic chemicals (PMTs) and micropollutants (MPs) in wastewater streams are not completely removed by conventional treatments, limiting safe water reuse and posing risks to ecosystems and human health. Although advanced treatment technologies can effectively remove these impurities, they are often energy and cost-intensive and may generate secondary pollution. *Daphnia*-based technology (DBT) is an emerging nature-based solution that employs *Daphnia*'s biofiltration capacity to remove a wide range of PMTs, MPs, nutrients, and suspended solids while operating at short hydraulic retention time with no need for additional chemical or land use. This study presents the first cradle-to-grave life cycle assessment (LCA) of DBT. The LCA model went beyond conventional LCA studies by systematically integrating PMTs and MPs into the life cycle assessment—an aspect often neglected in WWTPs LCA models—enabling a more accurate quantification of the net environmental benefits of treatment technologies. Results show that the DBT achieves a near zero environmental footprint while reducing ecotoxicity and eutrophication potential with net benefits of about 28 CTUe and 3.5E-05 kg P-eq, respectively. End-of-life scenario modelling shows that recycling of infrastructure material at the EoL stage can significantly reduce metal and mineral resource depletion, while reducing carbon footprint and water use across the technology's life cycle. The finding emphasize comprehensive LCA is critical for optimizing water infrastructure decisions at every stage.

Keywords

Life cycle assessment, Tertiary treatment, Persistent mobile toxic chemicals (PMTs), Micropollutants (MPs), Bioremediation

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Recovery of Hyper Saline Wastewater using Hybrid Forward Osmosis – Membrane Distillation (FO-MD)

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Abstract

The need to secure sustainable water supplies to meet future water demands urgently requires measures to conserve ground water while maximizing dependence on seawater and reuse of wastewater discharges. However, conventional desalination and water reuse technologies face associated challenges such as high-energy requirements, escalated investment costs, and more stringent environmental regulations for brine and wastewater discharge. Emerging processes such as forward osmosis (FO) and membrane distillation (MD) have shown several advantages over conventional methods with significant progress achieved in the development of these technologies in recent past.

This work involves development of patented hybrid FO-MD technology capable of treating high saline wastewater streams like produced water and desalination reject for sustainable water management. Novel Hybrid FO-MD study was carried out in collaboration with King Abdullah University of Science and Technology (KAUST), investigated the feasibility and performance of a novel, integrated FO-MD hybrid system for simultaneous treatment of saline wastewater streams like produced water, desalination reject and desalter effluent from an Oil & Gas (O&G) facility. The successful results obtained include 75% overall recovery with improved flux, distillate quality < 50 µS/cm conductivity, 97-100% inorganics removal, 88% organics removal, and FO-MD energy distribution ratio of 0.64.

The study outcome provided successful Proof of Concept with good basis for further scale-up and piloting. A project is being undertaken for field testing to demonstrate its performance.

Keywords

Hypersaline, Wastewater, Produced Water, Forward Osmosis, Membrane Distillation, FO-MD

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A Multi-Criteria Review and Geospatial Analyses for Air Conditioner (AC) Condensate Water Reuse

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Abstract

Air conditioner (AC) condensate water a promising water source for potable and non-potable purposes. There is evidence from multiple studies showing the potential of AC condensate water in contributing to a sustainable water supply. However, there exists a literature gap and a clear deficit of publications that furnish structured, practical decision-making frameworks for using AC condensate water as potable and non-potable water. Using the PRISMA literature review approach, 20 existing studies were sampled and reviewed from Scopus and Google scholar databases. Five main criteria were set to evaluate AC condensate water studies via the Analytic Hierarchy Process and Multicriteria Decision-Making Analysis. Water quality analysis (WQA= 32.87%) and well-defined research methods (WDM= 26.10%) appeared as the most important criteria often looked at when considering AC condensate water for use. Criteria like cost benefit analysis (CBA=15.10%) and roadmap for installation (RMFI =8.5%) were the least considered criteria despite their importance in the water recovery process. A 15-year Geospatial analysis shows high humidity (>80%) in Ghana, favourable for AC condensate water capture. Meanwhile, CBAs for small and large institutions with approximately 10–20 ACs had a payback on investment in 6.41–3.21 years. A pictorial RMFI of AC water systems and the Strengths, Weaknesses, Opportunities and Threats (SWOT) of this system was provided. The findings of this study are significant to implementers; they support decision-making and assist organisations in setting priorities when consulting studies as guides to AC condensate water use in countries where water supply is under intense stress.

Keywords

Condensate water, Payback, multi-criteria review, multi-criteria Decision Analysis, relative humidity

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Automated non-destructive, in-situ monitoring of (bio) fouling layers - Embodying Optical Coherence Tomography on a portal robot

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Abstract

Within the TARGiM project (DFG 512064678), we investigate plasmid transport through dynamically forming biofilm and fouling layers. Horizontal gene transfer in the environment via plasmids drives antimicrobial resistance spread, and retention in MBR systems is incomplete. Yet their transport as colloidal macromolecules through growing layers on top of porous membranes and through them is poorly understood. To address this, we developed a test apparatus enabling parallel operation of multiple stirrer cells as membrane test cells, where a portal robot performs automated, non-destructive, in-situ optical coherence tomography (OCT) measurements. A Flask interface coordinates digital communication to the robot (G-code) and OCT system (Python script), enabling fully automated, time-resolved, 3D imaging of fouling layer development. Measurements are non-destructive and in situ, without disrupting biological or chemical processes. Repeatability of the measuring instrument is assured via HYCNC 66SR precision sensors and validated using 3D printed mock-ups. Continuous in-situ monitoring yields spatially and temporally resolved data on fouling layer dynamics. Optical observation alone doesn't provide mechanistic insight, but are essential for its derivation. Within TARGiM, experimental data serve as input for transport equations to derive transport coefficients for plasmid movement. These coefficients are indispensable for modelling the colloidal solute transport under environmentally relevant conditions, enabling rigorous parameterisation and validation of transport models. The control and data-acquisition workflow is open-source, ensuring transparency, reproducibility, and adaptability without dependence on proprietary vendors. This enables interoperability across platforms, lowering adoption barriers for other research groups and fostering interdisciplinary applications in environmental engineering, water technology, and beyond.

Keywords

OCT, automation, Python, membranes, biofilm & fouling characterisation

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Phosphorus Control at Wastewater Treatment Works by Enhanced Adsorption with Water Works Sludge

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Abstract

Increasingly stringent phosphorus (P) discharge limits, driven by eutrophication control and regulatory frameworks, demand cost-effective and sustainable alternatives to conventional chemical and biological removal processes. This study evaluates the potential reuse of alum and iron-based waterworks sludge (WWS) which is a by-product of drinking water treatment known as low-cost adsorbents for phosphorus removal in wastewater treatment applications.

Batch experiments were conducted to assess the influence of key operational variables, including initial phosphorus concentration (2–50 mg P/L), adsorbent dosage, pH, contact time, and mixing conditions. Alum sludge exhibited adsorption capacities ranging from 0.794 to 27.95 mg P/g and followed the Freundlich isotherm model, while iron sludge showed lower capacities (0.018–3.215 mg P/g) consistent with the Langmuir model. Adsorption performance increased with higher initial phosphorus concentrations and was strongly influenced by pH and particle characteristics.

To evaluate engineering feasibility, alum sludge was pelletised using carboxymethyl cellulose (CMC) and tested under continuous-flow column conditions. Breakthrough times of 168 and 96 minutes were observed for influent concentrations of 12 and 20 mg P/L, respectively, with exhaustion times extending up to 45 days. The results demonstrate that pelletised alum sludge can effectively operate in fixed-bed systems while maintaining structural stability.

Overall, this research highlights the technical feasibility of repurposing WWS for phosphorus control, supporting circular economy principles by transforming a waste by-product into a functional treatment medium. Further optimisation and full-scale validation are recommended to confirm long-term operational and economic viability.

Keywords

Phosphorus Removal Waterworks Sludge Adsorption CMC (carboxymethyl cellulose) Circular Economy

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Boosting Biogas Production with a Non-Conventional AnSBR Treating Protein- and Lipid-Rich Wastewater: Pilot Evaluation

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Abstract

Treating protein and lipid-rich wastewater using cost-effective and simple-structured single-stage reactors presents several challenges. In this study, we applied an anaerobic sequencing batch reactor (AnSBR) to treat slaughterhouse wastewater. An average biomethane potential of 307 $NmlCH4.gCOD_{substrate}^{-1}$ of the slaughterhouse wastewater was obtained at an inoculum to substrate ratio (I:S) of 4, which was equivalent to an anaerobic biodegradability of 87%. Similar anaerobic biodegradabilities were obtained for all FOG:Protein ratios (0, 0.25, 0.5, 0.75, 1) in the range of 75-82%, with no signals of VFAs accumulation or inhibition. The pilot AnSBR system proved to be efficient for treating slaughterhouse wastewater. Stable performance was reached at VLR 3 $gCOD.L^{-1}.d^{-1}$, achieving a total COD removal efficiency of about 75%. Furthermore, it also showed to be robust to concentration fluctuations when concentrated wastewater was added to the system. Volumetric loading rates of up to 6.2 gCOD/(L.d) were applied to the system, with significant daily variations in load. The system coped with the increase in load and performed in a very stable manner despite the variations. By comparing the energy and nutrient balance of the conventional DAF+UASB with the AnSBR based on the pilot trials results and the full-scale data, the biogas production and energy recovery of the AnSBR is about 25% higher, enabling also lower operational costs and foot-print and a more cost-effective post-treatment. .Our results provide valuable insights to optimise the design and operation of AnSBR for efficient treatment of protein and lipid-rich wastewater.

Keywords

AnSBR, protein, lipids, pilot scale, slaughterhouse wastewater

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Optimizing Foam Fractionation as a Key Concentration Technology for PFAS Removal

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Abstract

As PFAS destruction technologies become more widely available, the need for a concentration step prior to destruction is increasingly evident, especially due to volume constraints and high energy demands of destruction methods. Foam fractionation offers a powerful solution, with the addition of soap and air, the hydrophobic and hydrophilic nature of PFAS is used, achieving over 30,000-fold volume reduction. However, its performance varies significantly depending on water type and the way it is operated.

The effect of PFAS type and water matrix on foam fractionation efficiency was investigated. Using the same fractionation settings, results showed that C2 type PFAS (TFA) are influenced more by the water matrix than longer chain PFAS. This means that for implementation of the technology, optimization of the design or pretreatment of the water is required to enhance removal. Furthermore, surfactants that are used as booster could influence effluent toxicity limiting application.

This project focuses on optimizing and validating an operational foam fractionation prototype suitable for a wide range of PFAS containing waters, including industrial wastewater effluent, and landfill leachate. The aim is to minimise the foam volume and maximise PFAS concentration in the foam.The research encompasses biodegradable surfactant application, process optimization, effluent toxicity assessment by bioassays, and pilot scale testing. A full PFAS mass balance will be established over the entire process to quantify removal and support system design. End-users can evaluate whether pretreatment, posttreatment or alterations in fractionation design are needed to ensure a high concentration factor with the required level of PFAS removal.

Keywords

Foam Fractionation; PFAS; Removal; industrial wastewater; optimization

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Thermo-economic optimisation of low-grade waste heat recovery in CHP-driven wastewater treatment plants

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Abstract

Wastewater treatment plants operating combined heat and power (CHP) engines continuously reject heat through exhaust gases and jacket-water cooling systems. Although these streams are persistent, their practical recovery potential depends on temperature grade, variability and site integration constraints.

This work presents recent results from an ongoing study focused on auditing and modelling waste heat availability in a full-scale CHP-driven wastewater facility. Two years of operational data were analysed to quantify exhaust and low-temperature heat streams, including their magnitude and seasonal variability. The analysis indicates sustained multi-hundred kilowatt reject heat across both high- and low-grade streams.

A modelling framework has been developed to evaluate potential recovery pathways, including heat recovery steam generation, Organic Rankine Cycle systems, and electrically driven heat pumps for upgrading low-temperature heat. Thermodynamic performance is assessed alongside preliminary techno-economic indicators under operational constraints such as stack temperature limits and site heat demand.

The work is still developing, but early findings suggest that system-level optimisation significantly influences technology selection and expected economic performance. The poster will present updated audit results, optimisation structure, and comparative assessment of recovery options relevant to industrial decarbonisation and electrification strategies.

Keywords

Waste heat recovery; CHP systems; Thermo-economic optimisation; Industrial decarbonisation; Heat pumps

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Water Efficiency Framework developed as part of the AQUASPICE project

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Abstract

Industrial process industries are under growing pressure to reduce freshwater abstraction, increase wastewater reuse and strengthen resilience to water scarcity, climate variability and tighter environmental requirements. Yet water management often remains fragmented, with limited connection between process operations, water quality needs, digital monitoring, governance and investment decisions. Developed within the EU Horizon 2020 AquaSPICE project, the Water Efficiency Framework (WEF) provides a structured, adaptive methodology to support the transition from linear water use to circular and climate-resilient industrial water management. The framework guides users through four interconnected phases: assessment of the current situation and targets; inventorisation of process, circular and digital innovation opportunities; evaluation of technologies, indicators and expected outputs; and policy, governance and business-model development. By integrating technical assessment, digital readiness, stakeholder engagement and implementation planning, the WEF helps industries move beyond isolated water-saving measures towards scalable, decision-ready strategies. It supports the identification of reuse opportunities across processes, factories, industrial symbioses and wider value chains, while enabling monitoring, optimisation and informed investment. Overall, the WEF offers a practical pathway for reducing freshwater demand, increasing wastewater reuse and accelerating the transition towards circular industrial water systems for technology providers, utilities, policymakers and industrial operators seeking practical, bankable water efficiency solutions.

Keywords

Water efficiency framework, industrial water reuse, circular water management, digital water innovation, process industry

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Assessment of the Treated Effluent Discharge Effects on Aquatic Receiving Systems in Lusaka: Implications for Environmental Compliance and Ecological Health

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Abstract

Background: Urban river systems in Lusaka District, Zambia, are critical for domestic, ecological, and agricultural needs, yet they remain vulnerable to pollution from industrial effluents and runoff. This study assessed variations in physicochemical parameters, heavy metals, and bacteriological indicators from six major treated effluent receiving rivers.**Methods:** Water samples were collected from Ngwerere, Chunga, Chamba, Chongwe, Kafue, and Ngwenya rivers during hot dry, hot wet, and cool dry seasons, and fish samples from Kafue and Chongwe rivers. Six water samples were collected from each river using wide mouth 500 ml sterile bottles. 3 of the six samples were for microbial analysis and the other 3 for chemical analysis. 3 fish samples were obtained from Kafue and Chongwe River. Standard protocols were employed for physicochemical analysis, heavy metal quantification, and bacteriological assessments. Results were compared against WHO and ZABS guidelines.**Results and Discussion:**Ammonium concentrations exceeded permissible limits in Chunga (29.80±8.27,41.59±6.94) and Ngwerere rivers (2.48±0.67 and1.95±0.88), while high COD values were recorded in Chunga (up to 1827.00 ± 641.28 mg/L). Heavy metals, including cadmium, mercury, and lead, surpassed regulatory guidelines in some rivers and seasons (0.01±0.00 Hg in Chunga and Chongwe). Bacteriological contamination was demonstrated, with *E.coli* and faecal coliform counts far exceeded WHO and ZABS standards in Chunga(*E.coli*CFU/Ml;1385.00±163.02,Faecal coliform CFU/Ml;3078.33±1498.41) and Chamba rivers (*E.coli*CFU/ml; 134.67±65.69, Faecal coliform;C FU/Ml 65.67±23.73).The findings showed marked deviations from WHO and ZABS guidelines, underscoring critical water quality and public health concerns.

Keywords

Bacteriological indicators, Bioaccumulation; Heavy metals; Industrial Effluents; Pollution.

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Performance of CO_2 Degasification in a Lab-scale Stripper with Activated Carbon Bed

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Abstract

Water scrubbing is one of biogas upgrading technologies that produces purified biomethane under high pressure conditions by dissolving CO_2 into water. Since water can be recycled, the process is suitable for medium- and large-scale plants. Because high concentrations of dissolved CO_2 may negatively affect preceding CO_2-dissolving performance, conventional water scrubbing process was restricted for continuous reuse of water. This study aimed to develop a lab-scale stripper to effectively degasify dissolved CO_2. A cylinderical stripper (10 cm diameter) packed with granular activated carbon was operated under down-flow conditions. The variations in total dissolved CO_2 (TDC) between inlet and outlet water (ΔTDC) were analyzed. CO_2-rich inlet water (1,000 ± 100 mg/L as CO_2) was prepared by directly injecting 95% CO_2 gas into tap water; each TDC concentration was calculated using pH and T-alkalinity, and validated through total inorganic carbon (TIC) obtained from a TOC analyzer. The results showed that ΔTDC at linear velocity of 4.5 m/hr with 30 cm packing depth was 254 – 427 mg/L as CO_2, whereas that at 9.0 m/hr was 133 – 264 mg/L as CO_2. At packing depth of 60 cm with linear velocity of 9.0 m/hr, ΔTDC ranged over 214 – 313 mg/L as CO_2, indicating higher CO_2 degasification efficiency than that at 30 cm packing depth under the same linear velocity. This CO_2 removing behavior through the bed may be attributed to the porous hydrophobic surfacial degasification mechanism of activated carbon, which weakens hydrogen bonding interactions between CO_2(aq) and water molecules.

Keywords

CCUS, CO2, Total dissolved CO2, Total inorganic carbon, Total alkalinity

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Toward Sustainable CO_2 Mineralization: Reaction-Controlled Hydromagnesite Formation with High-Value Material Potential

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Abstract

Hydromagnesite is a representative basic magnesium carbonates (BMC) formed in Mg-based CO2 mineral carbonation systems; it facilitates a promising material for semi-permanent carbon sequestration and additional inorganic applications. This study investigated the formation behavior and reaction pathway of hydromagnesite in Mg(OH)2–CO2–H2O system under controlled reaction conditions. Batch experiments were conducted by supplying CO2 to Mg(OH)2 slurry according to pH and aging time selected as key variables. Reaction processes were evaluated by monitoring residual Mg^{2+} concentrations using ion chromatography (IC), while solid-phase transition and morphology were characterized using X-ray diffraction (XRD) and scanning electron microscopy (SEM). The results indicate that hydromagnesite formation follows a sequential dissolution–crystallization–precipitation mechanism, which involves the dissolution of Mg(OH)2 and subsequent reaction with dissolved carbonate species by pH conditions. At pH 8.5, nesquehonite was the dominant phase during early and intermediate aging stages, suggesting that lower pH condition favors its formation. At pH 9.0, hydromagnesite / dypingite-type of BMC became predominant. In contrast, at pH 9.5, substantial amount of Mg(OH)2 was remained after aging, indicating that higher pH suppresses Mg(OH)2 dissolution and eventually limits further carbonation. With increasing aging time, meta-stable hydrated phases progressively transformed into hydromagnesite as the stable crystalline phase. Experimental findings were consistent with the thermodynamic equilibrium modeling results obtained from Visual MINTEQ, particularly regarding the pH-dependent saturation behavior of hydromagnesite. These results demonstrate that hydromagnesite formation can be controlled through the reaction condition optimization in Mg-based CO2 mineral carbonation systems.

Keywords

CCUS, Hydromagnesite, MgCO3, Mineral Carbonation, Reaction Mechanism

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Enabling High-Temperature, Scaling-Free Multi-Effect Distillation of Red Sea Seawater through Nanofiltration Pretreatment

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Abstract

Scale deposition in thermal desalination processes remains a challenge. Scale formation, particularly calcium sulfate ($CaSO_4$), limits the top brine temperature (TBT) and efficiency of multi-effect distillation (MED) when treating high-salinity seawater as that of the Red Sea. This study evaluates nanofiltration (NF) as a chemical-free pretreatment to enable scaling-free MED operation at elevated temperatures. Raw Red Sea seawater, reverse osmosis (RO) permeate, and permeates from NF270 and NF90 membranes were tested under reflux conditions at 80 °C and 90 °C for 96 hours. Scaling propensity was evaluated via alkalinity trends, morphological characterization of crystal formation patterns using scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS). NF90 pretreatment effectively prevented scale formation at 90 °C, with no detectable Ca or S on titanium or stainless-steel coupons and stable alkalinity throughout the experiment. In contrast, NF270 showed partial scaling, while untreated seawater exhibited severe CaSO4 and NaCl deposition. The absence of hard scale precursors in NF90 permeate, which is consistent with its high divalent ion rejection, demonstrates its potential to replace chemical antiscalants and enable high TBT MED operation. These findings support NF90 as robust, sustainable pretreatment for next-generation thermal desalination in water-scarce regions, particularly where integration with green hydrogen or zero liquid discharge systems demands ultra pure, scaling-free feed water.

Keywords

Thermal desalination; Scales formation, Calcium sulfate scaling, Nanofiltration pretreatment, Top brine temperature, Red Sea water

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Water Literacy and Sustainable Water Use: Behavioral Drivers of Water Demand Management among University Students – A Systematic Review

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Abstract

Water security is increasingly threatened by climate change, population growth, declining water quality, and ineffective water management, particularly in arid and water-scarce regions. While water literacy is widely recognized as a foundation for sustainable water management, global evidence suggests that increased knowledge does not always translate into conservation-oriented behavior. Sustainable water systems, including industrial water management, therefore require not only technological innovation but also demand-side water conservation practices within society. Universities play a critical role in shaping future professionals and decision-makers who will influence water governance, policy, and resource management. Understanding how water literacy translates into sustainable water behaviors among university students can provide valuable insight for developing long-term strategies to reduce water demand and support sustainable water use across sectors.

This study presents a systematic review examining how water literacy influences sustainable water behaviors among university students and identifies the determinants of the persistent Knowledge–Action Gap (KAG).

Thematic analysis identified five dominant domains influencing water-related behavior: the Knowledge–Action Gap, socio-cultural and behavioral barriers, curriculum design and Education for Sustainable Development (ESD), technological and institutional reinforcement, and engagement and governance mechanisms. Across studies, habits, social norms, and structural constraints often emerged as stronger predictors of behavior than knowledge alone. The findings highlight the need for integrated strategies combining education, behavioral interventions, policy support, and technological feedback systems to strengthen water conservation practices. Enhancing water literacy among young generations can contribute to sustainable water demand management and complement technological innovations aimed at improving long-term water security.

Keywords

Water Literacy, Sustainable Water Practices, Water Conservation, Knowledge–Action Gap, Environmental Education, University Students

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Amino- and Imidazole-Functionalized Silica Adsorbents for Cr(VI) Removal from Industrial Wastewater

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Abstract

Industrial wastewaters from electroplating, tanning, petroleum refining, and coke production frequently contain chromium(VI) together with aromatic organic compounds, highlighting the need for robust sorbents applicable to complex effluents. In this work, two bifunctional particulate silica adsorbents bearing amino (SiO_2PartAF) or imidazole (SiO_2PartImiF) groups together with trifluoropropyl functionalities were synthesized and compared. The materials were characterized by elemental analysis, nitrogen physisorption, vapor adsorption, zeta potential measurements, DRIFT spectroscopy, SEM/EDXS, and XPS. Both samples exhibited well-developed porosity and high specific surface area, reaching 367 m^2/g for SiO_2PartAF and 388 m^2/g for SiO_2PartImiF, with total pore volumes of 0.833 and 0.385 cm^3/g, respectively. The surface group concentration was 2.0 mmol/g for amino functionalities and 1.5 mmol/g for imidazole-containing groups. Adsorption performance toward Cr(VI) and 4-chlorophenol (4-CP) was evaluated. Both sorbents showed similarly high Cr(VI) uptake, up to 99 mg/g. XPS analysis after adsorption confirmed chromium binding and partial reduction of Cr(VI) to Cr(III) on the modified silica surface. For 4-CP, the adsorption capacity reached up to 100 mg/g, with SiO_2PartImiF outperforming SiO_2PartAF, likely due to stronger π–π interactions and higher surface hydrophobicity. The results demonstrate that amino- and imidazole-functionalized silica particles are promising candidates for industrial wastewater treatment, provide a foundation for further studies on competitive Cr(VI)/phenol removal in realistic binary systems, and support the development of one-reactor treatment concepts for low-concentration yet toxic effluents.

This research was funded by Recovery and Resilience Plan for Slovakia under project No. 09I03-03-V04-00708.

Keywords

Functional silica; N-containing groups; Cr(VI) adsorption; 4-chlorophenol; Water treatment.

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Spatial Prioritization of Treated Wastewater Use in Urban Areas

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Abstract

This study presents a novel framework for prioritizing optimal sites for treated wastewater (TWW) reuse by integrating hydrological modeling with a fuzzy-based multi-criteria decision-making (MCDM) approach, Fuzzy TOPSIS. Key criteria for TWW application were established using the DPSIR (Driving-Pressure-State-Impact-Response) framework across technical, social, economic, and environmental dimensions. To address inherent uncertainties in weighting values and input data, triangular fuzzy numbers and expert interviews were incorporated into the decision matrix. The proposed framework was evaluated across ten alternative locations in an urban watershed in South Korea. Hydrological simulations of water quantity (drought/low flows and instream flow satisfaction) and water quality (BOD concentration and target water quality satisfaction) revealed high interannual variability, which fuzzy numbers captured more effectively than deterministic approaches. Comparative analysis showed that Fuzzy TOPSIS produced significantly different site rankings than the traditional weighted sum method (WSM). Ultimately, this research highlights the critical role of fuzzy set theory in managing hydrologic uncertainty, proving Fuzzy TOPSIS to be a highly effective and robust tool for spatial decision-making in urban water resources management.

Keywords

Optimal site, MCDM, Fuzzy TOPSIS, Treated wastewater, Hydrological simulation

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Economic real-time operation of membrane bioreactors in wastewater treatment via constrained economic model predictive control with Koopman modeling and meta learning

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Abstract

The application of membrane bioreactors (MBRs) in wastewater treatment has enabled improved effluent quality, reduced plant footprint, and higher allowable loading rates. Meanwhile, the real-time operation of such MBR systems has been hindered by high energy consumption and membrane fouling-induced time-varying dynamics, which challenges the deployment of many existing advanced control strategies.

In recent years, Koopman operator theory has provided powerful tools for process modeling in various applications. Koopman operator enables the linear representation of nonlinear systems with collected data and is appealing for the design of efficient controllers, highlighting the potential value to wastewater treatment systems. Nevertheless, when considering a high-dimensional and time-varying nonlinear system such as the MBR process, more sophisticated models are required.

In this study, we propose a new data-driven modeling and control framework to achieve the real-time economic operation of MBR systems under nonstationary fouling conditions. A meta-learning-based deep Koopman model with a shared neural network and task-specific Koopman operators is first developed to approximate the nonlinear and time-varying system dynamic behaviors. Based on the learned model, a constrained economic model predictive control (EMPC) design is formulated to minimize the economic cost of the MBR system, while satisfying effluent quality constraints and mitigating membrane fouling through explicit consideration of transmembrane pressure dynamics. Online model adaptation is incorporated throughout the stages for fine-tuning in unseen operating conditions. Simulation studies demonstrate that the new framework achieves improved economic performance while effectively slowing fouling progression compared with existing Koopman-based EMPC methods used previously.

Keywords

membrane bioreactor, energy-efficient operation, economic model predictive control, Koopman operator, meta learning

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Data-enabled predictive control for membrane-based wastewater treatment processes

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Abstract

Membrane-based wastewater treatment plants (WWTPs) play a crucial role in safeguarding public health and supporting sustainable water management. Their operation involves highly nonlinear biological and chemical processes and significant external disturbances, which make control and optimization particularly challenging. In practice, process operations must ensure that effluent quality satisfies regulatory requirements while simultaneously reducing operational costs such as aeration energy and chemical consumption [1].

To address these challenges, we aim to propose a convex data-enabled economic predictive control approach for membrane-based WWTPs. This method extends our previous work in [2] to the economic optimization of membrane-based WWTPs. Within the data-enabled predictive control framework, the proposed approach relies solely on historical data rather than explicit first-principles models. A neural network is trained to map measured outputs into a latent representation where the nonlinear economic cost can be approximated by a quadratic function, enabling the resulting economic predictive control problem to remain convex and computationally tractable.

The effectiveness of the proposed approach is demonstrated through extensive simulations on a membrane-based wastewater treatment plant. We will showcase the efficacy of the proposed data-driven control method that does not require first-principles process modeling, and the advantages of the new method in terms of energy savings.

Reference

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Keywords

Data-enabled predictive control; machine learning; water treatment; economic operations; simulations.

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Human-in-the-loop reinforcement learning for safe economic operation of membrane bioreactor processes in wastewater treatment

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Abstract

The advancement of membrane bioreactor technology has significantly improved the efficiency of wastewater treatment; however, its complicated operation still relies heavily on human operators. Operators need to monitor and analyse several factors including weather changes, fluctuating demands, and other disturbances before making necessary adjustments to the plant, and this conservative process can take hours every day. Despite the expert knowledge, operators can not operators cannot supervise plant operations at all times, leaving systems vulnerable to unexpected events such as illegal discharges during off-duty hours. Therefore, there is a need for digitalization and automation in all water systems for more efficient operations and smoother process control.

Reinforcement learning (RL) has been widely used in various applications thanks to its advantage in fast decision-making. Nonetheless, conventional RL method is challenged by from safety and sample-efficiency issues during training. These issues can be resolved by combining human in the learning loop of RL agent, so that human can guide the learning of RL agent and interfere whenever unsafety arises.

In this study, we propose a human-in-the-loop safe RL framework that can minimize the economic cost in MBR operation and mitigate membrane fouling simultaneously. During training, we incorporate expertise knowledge from human in the training of RL agent to avoid abrupt increase in transmembrane pressure that can result in severe fouling. Simulation results demonstrate that human intervention can accelerate the training process, and the resulting RL agent achieves improved economic performance with less severe fouling compared to baseline RL methods.

Keywords

membrane bioreactor, human-in-the-loop, safe reinforcement learning, economic operation, automated process control

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Assessing the feasibility of reclaiming process water from industrial wastewater effluent by using Closed-Circuit Reverse Osmosis and evaluating options for treating the resulting brine

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Abstract

Evides Industriewater (EIW) is dedicated to deliver reliable and sustainable water solutions for industrial clients in the Netherlands. With rising pressure to reduce freshwater consumption and minimize environmental impact, innovative approaches to water reuse and effluent quality improvement are essential. In this context, EIW has initiated a pilot study in which industrial wastewater effluent from 60 different industries is treated to produce process water, while parallel efforts focus on improving quality of the resulting brine.

This research investigates Dissolved Air Flotation Filtration (DAF(F)) – Closed-Circuit Reverse Osmosis (CCRO) as an alternative to the traditional Ultrafiltration (UF) - Reverse Osmosis (RO) setup. This combination offers significant economic and environmental advantages, with CCRO being a promising option - supported by EIW's successful research application on another industrial effluent, and DAF(F) representing a cost-effective pre-treatment and core expertise of EIW. However, most of the experience was with surface water, so its applicability to industrial effluent remains explorative.

This study will provide insights into the potential for reusing challenging industrial effluent to produce process water. Initial results show that DAF(F) removes 78% total suspended solids, while the CCRO recovers 70% of the influent (conductivity 7500 µS) with permeate quality equivalent to process water (220 µS). Using CCRO enables higher recovery while producing more concentrated brine at reduced volume.

The final highly concentrated brine will be subsequently tested using different destruction technologies to determine whether complete mineralization is achievable. This approach will provide a fully closed-loop, zero-waste treatment that supports circular-economy strategies in industrial operations.

Keywords

effluent reuse, process water, brine management, micropollutants destruction, industrial wastewater, CCRO

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Ultra Short Chain (USC) PFAS Removal from Process Water at Chemours Netherlands

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Abstract

Chemours is continuously exploring to further reduce emissions and optimize existing PFAS abatement technologies. Conventional PFAS abatement technologies are largely optimized for the removal of (individual) medium- and long-chain PFAS (>C4) from relatively clean water matrices, while industrial process waters remain challenging due to the presence of ultra-short-chain (USC) PFAS, high salinity, metals, and competing organic and inorganic species.

Extensive laboratory testing using representative process-water samples demonstrated that the Lewatit® MDS TP108 ion-exchange resin achieves substantially improved USC PFAS removal compared with conventional ion-exchange resins. The technology has subsequently been successfully implemented at the Chemours facility in Dordrecht, the Netherlands.

Keywords

Ultra-Short-Chain PFAS removal Lewatit TP108, Lewatit MDS TP108 PFAS removal with presence of competing high salinity, metals, organic and inorganic species

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Optimizing the Water-Energy-Carbon Nexus in a wastewater treatment plant through advanced aeration control and hybrid renewable integration.

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Abstract

Achieving carbon neutrality in the water sector is a critical challenge, with wastewater treatment plants (WWTPs) accounting for a significant portion of public sector emissions. This study proposes an integrated decision-making framework to balance the inherent trade-offs between effluent quality, energy consumption, and carbon footprint. A 275,000 m^3/day capacity WWTP (MLE) in Incheon, South Korea, was utilized as a case study to simulate advanced aeration strategies—including Dissolved Oxygen-Based (DOBAC) and Ammonia-Based Aeration Control (ABAC)—using the SUMO22 simulator. Simultaneously, a hybrid renewable energy system (Solar PV, Small-hydro, and Biogas) was modeled via Homer Pro to evaluate energy self-sufficiency. To address the complex coupling of these factors, this study used the Water-Energy-Carbon Coupling Index (WECCI) and applied the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method for scenario optimization. Key findings indicate that while ABAC strategies significantly reduced energy consumption, they triggered a noticeable increase in greenhouse gas emissions under low-DO conditions, highlighting a critical trade-off. The integration of hybrid renewables improved energy independence to 22.8%, yet underscored the necessity of combining operational optimization with grid-scale energy transitions.This research confirms that achieving carbon neutrality in WWTPs is not a single-objective optimization but requires a complex balance between water quality, energy, and carbon. It underscores that a sustainable, net-zero operational strategy is only possible when operational efficiency and renewable energy integration are pursued in tandem. This study was funded by the major project of the Korea Institute of Civil Engineering and Building Technology (KICT) (grant number 20260131-001).

Keywords

WEC Nexus, Wastewater Treatment Plants, Energy-Carbon Neutrality, TOPSIS, Ammonia-Based Aeration Control (ABAC)

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Sustainable Adsorptive Removal of PFAS Using Waste-Derived Activated Carbons: Role of Surface Chemistry and Pore Structure

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Abstract

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants requiring efficient and sustainable removal strategies. This study investigates adsorption performance of activated carbons derived from spent coffee grounds, bamboo, and waste coke under identical synthesis conditions. Distinct precursor-dependent physicochemical properties resulted in markedly different adsorption behaviors. Waste coke-based activated carbon exhibited superior performance, achieving rapid removal (>98% within 10 min) and high adsorption capacities for long-chain PFAS, attributed to its graphitic structure and hydrophobic surface. Bamboo-based carbon showed moderate and consistent adsorption, while coffee-ground-derived carbon demonstrated selective affinity toward short-chain PFAS due to oxygen-rich surface functionalities and negative charge. Kinetic analysis followed a pseudo-second-order model, and equilibrium data were well described by the Freundlich isotherm, indicating heterogeneous multilayer adsorption. The results highlight the critical role of surface chemistry and pore structure in governing PFAS adsorption mechanisms and demonstrate the potential of waste-derived activated carbons as sustainable alternatives for water treatment applications. This work was supported by the Korea Environment Industry & Technology Institute (KEITI) through a grant funded by the Ministry of Climate, Energy and Environment (MCEE), Republic of Korea (RS-2026-25501225).

Keywords

PFAS, Waste-derived activated carbon, Adsorption mechanism, Surface chemistry

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Microalgal Phycoremediation of Pulp and Paper Wastewater: From Strain Screening to Pilot-Scale Validation

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Abstract

Microalgae offer a sustainable approach for nutrient and lignin recovery from wastewater generated by the pulp and paper industry. This study evaluated the efficacy of microalgal treatment through laboratory-scale screening and pilot-scale validation using polishing pond effluent from a Swedish total chlorine-free kraft pulp mill. In the laboratory phase, several isolated microalgal strains were assessed across different wastewater streams, with polishing pond effluent supporting the highest biomass growth and treatment efficiency. Among the tested strains, *Desmodesmus* sp. showed the strongest overall capacity for simultaneous removal of nutrients and lignin, achieving 36% chemical oxygen demand (COD), 52% total nitrogen (TN), 97% ammonium (NH_4^+), 94% phosphate (PO_4^{3-}), and 17% lignin removal under controlled conditions. Pilot-scale validation was conducted at Södra Cell Mönsterås using a Green Wall Panel photobioreactor (GWP-II; 3,200 L, 100 m^2). Under continuous operation, the system achieved maximum removal efficiencies of 30% COD, 33% TN, 92% NH_4^+, 95% PO_4^{3-}, and 48% lignin, with sustainable microalgal growth. Biomass productivity of 0.83 g m^{-2} d^{-1} (2.49 t ha^{-1} yr^{-1}) under wastewater-driven conditions, demonstrating the dual function of the treatment and biomass generation. Overall, the results provide rare pilot-scale evidence that microalgal photobioreactors can deliver robust nutrient and lignin removal under industrial conditions. The study highlights microalgal phycoremediation as a viable tertiary treatment option with clear potential potential to support circular bioeconomy strategies through nutrient recovery and biomass valorisation in the pulp and paper industry.

Keywords

Phycoremediation, Pulp and Paper Wastewater, Desmodesmus sp, Lignin, Nutrient recovery

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Compost or Digest? A Life Cycle and Net Present Value Comparison for Managing MBBR Sludge at a Mexican University Campus

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Abstract

Decentralized wastewater treatment systems are increasingly adopted in institutional settings such as university campuses to reduce sewer infrastructure costs and enable onsite water reuse. While effluent management is well-established, sludge handling remains a critical environmental and operational challenge. This study compares the existing aerobic composting strategy with a proposed anaerobic digestion (AD) system for managing sludge from a moving bed biofilm reactor (MBBR) plant serving approximately 7,000 users at a Mexican university campus.

Using life cycle assessment (LCA) and a net present value (NPV) analysis, we evaluate both technologies across multiple environmental impact categories and financial indicators. Composting requires lower capital investment and simpler operation but demands substantial land area, may release uncontrolled greenhouse gases and odors near academic zones, and offers no energy recovery. AD operates in a sealed environment that minimizes fugitive emissions, captures methane for biogas-based energy generation, and achieves greater volumetric sludge reduction, albeit with higher upfront costs and technical complexity.

Preliminary results indicate that no single technology dominates across all criteria. Composting is favored when land is available and capital budgets are constrained; AD becomes increasingly attractive when odor control, greenhouse gas mitigation, and long-term energy recovery are prioritized. The final recommendation depends on how institutional stakeholders weigh immediate financial feasibility against long-term environmental performance. This study provides actionable decision criteria for decentralized sludge management applicable to campuses, hotels, and small industrial facilities.

Keywords

MBBR sludge, Anaerobic digestion, Composting, Life cycle assessment (LCA), Net present value (NPV), Decentralized wastewater treatment, Biogas recovery, Circular Economy

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Efficient Removal of Emerging Contaminants from Water using Sustainable Bio-Aerogel Materials for Circular Economy

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Abstract

Per- and polyfluoroalkyl substances (PFAS), widely released from industrial and consumer sources into aquatic environments, are known as “forever chemicals” due to their highly stable carbon–fluorine (C–F) bonds, resulting in extreme persistence, bioaccumulation, and ecological toxicity. Their resistance to conventional treatment technologies highlights the urgent need for sustainable and efficient PFAS remediation solutions. Existing adsorbents such as powdered activated carbon often suffer from poor selectivity, difficult recovery, and generation of secondary waste, limiting their long-term sustainability for PFAS remediation. To address these challenges, this study proposes the development of a sustainable magnetic bio-aerogel filtration material comprise of chitosan, biochar, and Fe_3O_4 nanoparticles for efficient PFAS removal from contaminated water. A bio-based hydrophobic coating was further introduced to enhance fluorophilic interactions and selective PFAS adsorption. Aligned with circular economy principles, the sustainable bio-aerogel reutilizes waste-derived biochar to develop environmentally friendly and scalable filtration materials. The lightweight porous aerogel structure with interconnected transport channels enables efficient continuous PFAS capture from contaminated water. The synergistic combination of porous biochar, amine-rich chitosan, magnetic Fe_3O_4, and hydrophobic surface functionality enabled multiple adsorption mechanisms, including hydrophobic interaction, electrostatic attraction, and π–π interactions between amphiphilic PFAS molecules and the adsorbent beads. The developed aerogel system demonstrated potential for rapid PFAS capture, facile magnetic recovery, regeneration, and reusability while minimizing secondary contamination. The proposed approach offers a scalable, low-cost, and environmentally benign strategy for advanced PFAS remediation, supporting circular material reuse and sustainable water purification technologies for emerging contaminants.

Keywords

PFAS Removal, Bio-aerogel, Water Treatment, Reusable Material, Circular Water Economy

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Alkalized TripolyPhosphate Cross-linked Chitosan Beads Synthesized from Mushroom Waste (agaricus bisporus brunnescens) Were Developed as a Sustainable Biosorbent for the Batch Removal of Toxic Heavy Metals Cr (VI), Cu (ii), and Pb (ii)

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Abstract

Alkalized tripolyphosphate cross-linked chitosan beads synthesized from mushroom waste (Agaricus bisporus brunnescens) were developed as a sustainable biosorbent for the batch removal of toxic heavy metals Cr (VI), Cu (II), and Pb (II) from aqueous solutions. The chemically modified chitosan beads were characterized and evaluated under optimized batch adsorption conditions. Process optimization using a Box–Behnken response surface design demonstrated that adsorbent dose, pH, temperature, and initial metal concentration significantly influenced removal efficiency. Maximum adsorption capacities of 7.09 mg g^{-1} for Cr(VI), 6.67 mg g^{-1} for Cu(II), and 5.10 mg g^{-1} for Pb(II) were achieved, with removal efficiencies exceeding 98% under optimal conditions. Adsorption equilibrium data were best described by the Langmuir isotherm, indicating monolayer adsorption on a homogeneous surface, while kinetic data followed the pseudo-second-order model, suggesting adsorption controlled by surface interactions. Thermodynamic analysis revealed negative Gibbs free energy values, confirming spontaneous adsorption, and positive enthalpy and entropy changes, indicating an endothermic process with increased interfacial randomness. These findings demonstrate that alkalized tripolyphosphate cross-linked chitosan beads derived from mushroom waste are an efficient, low-cost, and environmentally benign biosorbent for heavy-metal removal in wastewater treatment.

Keywords

Alkalized chitosan beads; Mushroom waste valorization; Heavy metal adsorption; Adsorption

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Start-up and operation of a sulfidogenic reactor seeded with methanogenic sludge using the COD/SO_4^{2-} ratio and free H_2S as control parameters

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Abstract

Sulphate-rich wastewaters, such as acid mine drainage (AMD), cause environmental hazards. Anaerobic sulphate reduction offers a promising treatment route, as sulphate-reducing bacteria (SRB) convert sulphate to sulphide, which can subsequently precipitate metals as metal sulphides. However, when conventional methanogenic anaerobic sludge is used as inoculum, methanogens compete with SRB for available electron donors, often resulting in low sulphate reduction efficiency and electron donor utilization for sulphidogenesis. Therefore, effective start-up strategies are required to selectively enrich SRB and redirect electron donors from methanogenesis to sulphate reduction.

This study investigated the start-up of a granular sludge reactor for treating sulphate-rich wastewater using methanogenic seed sludge. To favour sulphidogenesis over methanogenesis, the influent COD/SO_4^{2-} ratio was decreased below the stoichiometric threshold of 0.67 g COD/g SO_4^{2-}, creating electron donor-limiting conditions. Under this selective pressure, SRB progressively outcompeted methanogens, and the majority of electron donor conversion was redirected towards sulphate reduction. However, during prolonged operation, part of the methanogenic community resisted the accumulated sulphide stress and gradually regained a larger share of COD conversion. Subsequent operation at pH below 7 increased the fraction of free H_2S and again shifted COD conversion towards sulphidogenesis.

Notably, methanogenesis remained detectable under highly inhibitory free H_2S concentrations exceeding 600 mg H_2S-S/L. These results suggest that sulphide-tolerant methanogens developed during long-term operation, while SRB remained dominant in COD conversion. The findings highlight the combined importance of COD/SO_4^{2-} ratio and free H_2S control for establishing and maintaining sulphidogenic reactors from methanogenic seed sludge.

Keywords

sulphate-reducing bacteria; substrate competition; hydrogen sulphide inhibition; methanogens

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Electrochemical Ammonia Recovery from Anaerobic Digestion Reject Water

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Abstract

The increasing concentration of ammonium (NH_4^+) in reject water from sludge of anaerobic digestion (AD) represents both an environmental challenge and an opportunity for resource recovery and further utilization. This research demonstrates the application of selective electrodialysis reversal (SEDR), bipolar membrane electrodialysis (BPMED) and vacuum membrane stripping (VMS) for the removal and recovery of total ammoniacal nitrogen (TAN) from AD reject water. The objective of this work is to produce reusable aqueous ammonia ($NH_3{\cdot}H_2O$). Firstly, the NH_4^+ ion is selectively concentrated electrochemically by SEDR before being converted by BPMED to NH_3. For the practicality of the process, the acid solution is excluded in the BPMED and it was operated as two-compartments bipolar membrane stack with cation-exchange membranes (BPC). In addition, the volatile NH_3 is stripped and recovered as $NH_3{\cdot}H_2O$ by the VMS module. The SEDR–BPC–VMS route demonstrated high energy efficiency under controlled pH generation. However, its performance is strongly influenced by the complex composition of real reject water affecting the energy consumption for NH_4^+ removal and the stack resistance for both SEDR and BPC. Overall, the SEDR–BPC–VMS route achieved a minimum NH_4^+ removal efficiency of 70% and energy consumptions of 3.5–9.8 $kWh{\cdot}kgN^{-1}$ under pH-controlled conditions, although performance variability was observed due to feed composition and membrane fouling. The recovered $NH_3{\cdot}H_2O$ concentration in product from the VMS module was approximately 10 $g{\cdot}L^{-1}$ indicating the necessity for future optimization of the NH_3 recovery route to achieve higher concentrations.

Keywords

electrodialysis, ammonia recovery, ammonia removal, bipolar membrane, anaerobic digestion reject water

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(Bio)Electrochemical Solutions for Environmental Sustainability: Water Remediation, Biohydrogen Production and Resource Recovery

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Abstract

An integrated waste-to-resource framework based on electrochemical and bioelectrochemical technologies for environmental remediation, energy recovery, and soil enhancement is essential for achieving circular and climate-resilient infrastructure. Advanced electrooxidation, electro Fenton, and bio-electro-Fenton systems enable the effective degradation of emerging contaminants such as pesticides, microplastics, endocrine-disrupting compounds, PFAS, parabens, phthalates, and pharmaceutical residues. Green synthesis of functional nanomaterials using wastewater-grown aquatic biomass supports contaminant removal while reinforcing circular wastewater treatment. Electrochemical impedance–based approaches provide a scalable route for microplastic detection and quantification. Hybrid microbial electrolysis cell systems facilitate biohydrogen production from organic waste streams, demonstrating direct energy recovery from waste. Electrokinetic techniques improve soil engineering properties through electro-osmosis, electromigration, and electrodeposition, offering solutions for weak, contaminated, and waterlogged soils. Collectively, these electrochemical and bioelectrochemical platforms enable simultaneous pollution control, resource recovery, and soil stabilization, supporting sustainable water–energy–soil nexus applications aligned with circular economy principles.

Keywords

Bioelectrochemical systems; Biohydrogen; Electrochemical oxidation; Electrochemistry; Emerging contaminants; Microplastics

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Water Footprint Assessment and Setting Water Efficiency Strategies in the Refractory Industry

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Abstract

The refractory industry, dependent on extensive cooling and domestic water usage, faces increasing pressure to optimize its water consumption amid global water scarcity. A leading magnesite and refractory producer in Türkiye, initiated a comprehensive water management program to evaluate and systematically reduce its water footprint. This study presents the findings of a three-year continuous water efficiency initiative between 2023-2025, aiming to transition from a baseline water efficiency assessment to achieving the national "Blue Water Efficiency Certificate". The objective is to demonstrate how sector-specific Best Available Techniques (BAT) can be effectively integrated into operational workflows to optimize the water footprint and reach zero liquid discharge targets without compromising production quality. In conclusion, water footprint profiles vary significantly based on processing methods. Intensive cooling in Fused Magnesite drives the highest direct water use. The systematic deployment of water mitigation strategies address the high direct water use and establish a sustainable growth in refractory manufacturing.

Keywords

Water efficiency, Water footprint, Refractory industry, Zero Liquid Discharge (ZLD)

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Recovering Ammonia and Organic Acids from Residual Streams via Bipolar Membrane Electrodialysis

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Abstract

Ammonia stripping and scrubbing is an established technology for treating high-ammonia wastewaters; however, it relies on highly corrosive mineral acids for ammonia capture, raising handling and safety concerns while typically producing low value ammonium sulphate. Organic acids offer safer and potentially more sustainable alternatives, but their high cost has limited their widespread implementation. This work demonstrates how bipolar membrane electrodialysis (BPMED) can overcome this limitation by enabling simultaneous organic acid regeneration and the recovery of a more versatile ammonium product.

Aspen Plus simulations first showed that citric and malic acids were promising alternatives to sulphuric acid. Subsequently, their regeneration was evaluated using BPMED and compared with sulfuric acid. Organic acids resulted in higher current efficiencies while reducing energy consumption of the BPMED by 35 %. Building on these findings, the BPMED was optimised for citric acid regeneration by evaluating membrane stack configurations and the influence of feed characteristics and operating conditions on recovery efficiency, current efficiency, and energy consumption. An operating window was identified that simultaneously maximized recovery efficiency and minimized energy consumption, resulting in one of the lowest reported energy consumptions for BPMED-based ammonia recovery.

Finally, pilot-scale validation of the optimised BPMED configuration demonstrated that comparable energy consumption could be achieved within an operating window while revealing transport-limitation regimes that could not be identified at laboratory scale, providing new mechanistic insights for BPMED scale-up. Overall, this work demonstrates a technically feasible and scalable approach for ammonia recovery from high-ammonia wastewaters.

Keywords

Bipolar membrane electrodialysis; Ammonia recovery; Organic acids, Resource recovery; Nitrogen recovery

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Current challenges in industrial water management

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Abstract

Water is becoming a strategic resource for industrial transformation, competitiveness, and site resilience. As climate change intensifies droughts, heavy rainfall, and water quality fluctuations, industrial water management is shifting from an operational issue to a central business and innovation priority. At the same time, European and national policy frameworks - including circular economy, zero pollution, wastewater, and water reuse regulations - are increasing the pressure to manage water more efficiently and systematically.

This contribution highlights current challenges and emerging perspectives in industrial water management, with a particular focus on the process and life science industries. It shows how water availability and quality are increasingly linked to industrial competitiveness, production security, and location decisions. The presentation also emphasizes the strong water relevance of key transformation sectors such as artificial intelligence and data centers, microelectronics, biotechnology, hydrogen and Power-to-X applications, and climate-neutral mobility.

Against this background, industrial water management must evolve toward integrated, data-driven, and circular approaches. Key fields of action include optimization of water use in industrial processes, reduction of freshwater dependency, cost-efficient wastewater treatment, increased water reuse, and stronger coupling of water, energy, heat, and material flows. Digitalization and “Industrial Water 4.0” can play a decisive role in improving transparency, maturity, and resilience.

Overall, water should be understood not only as a utility, but as an enabler of innovation, transformation, and sustainable industrial development.

Keywords

Industrial water management, Water resilience, Circular water use, Industrial transformation, Water-energy nexus

Looking forward to WIN2028....