Interreg
Baltic Sea Region

Co-funded by
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SUSTAINABLE WATERS
EMPEREST

Solutions and tools

for PFAS reduction and micropollutant removal

Results of the EMPEREST project

EMPEREST – Eliminating Micro-Pollutants from Effluents for Reuse Strategies

About PFAS and micropollutants

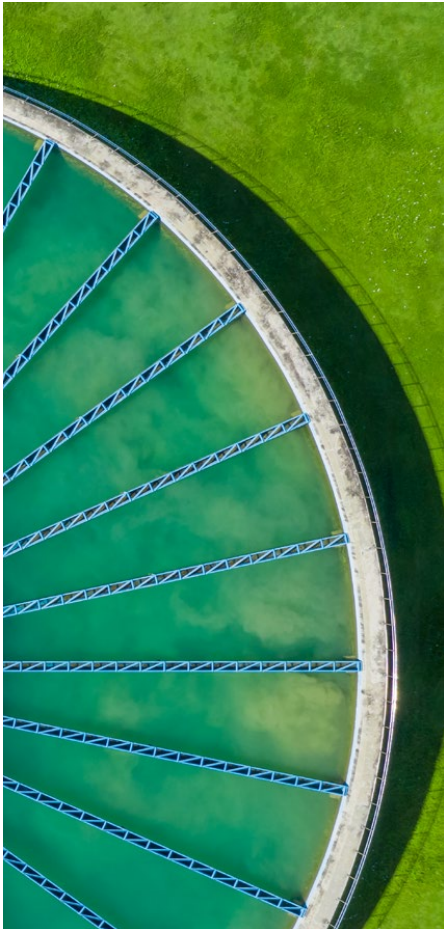
There is a growing concern raised over the pollution caused by hazardous substances. Research shows that high concentrations of varied hazardous substances in the environment, including the water cycle, are harmful for human health and for ecosystems.

PFAS (Per- and polyfluoroalkyl substances) have been identified as a group of priority contaminants in the Baltic Sea marine environment.

PFAS compounds, also known as forever chemicals, are very popular because of their properties: they are repellent to water, oil and dirt and they are very durable under extreme conditions. PFAS are used in firefighting foams, teflon, gore-tex, cosmetics, construction products, and more – but their properties make them extremely persistent and mobile in nature and in the human body.

The EU is addressing the problem of hazardous substances in general, and PFAS in particular, primarily through regulation. For the wastewater treatment sector, new legislation imposes requirements concerning the removal of micropollutants, and EMPEREST supported its implementation in the Baltic Sea Region.

The removal of PFAS and other micropollutants from the water cycle, while vital, is also costly and difficult. Therefore, emphasis must be placed on prevention: what can we do to stop hazardous substances from entering the environment?



About the EMPEREST project

During its implementation in 2023–2025, the EMPEREST project focused on holistically approaching the reduction of hazardous substances pollution in the Baltic Sea Region.

Project activities spanned over different levels of governance and operation, and included the monitoring and assessment of the PFAS pollution in the aquatic environment, prevention of the pollution at city-level, technological removal of PFAS and other organic micropollutants from the water cycle, and capacity building of water professionals.

On its journey towards the Baltic Sea protection, EMPEREST worked with local and national authorities, wastewater treatment operators, water associations, researchers, and other stakeholders crucial in this dialogue.

May 2023

PFAS Roadshow in Stockholm, Sweden. In collaboration with the Zero PFAS II project.

October 2023

PFAS Roadshow in Vilnius, Lithuania. In collaboration with the Zero PFAS II project.

February 2024

Workshop "Raising awareness and initiating actions towards socio-environmental resilience to PFAS" in Tartu, Estonia. In collaboration with the Zero PFAS II project.

June 2024

Workshop "Technical solutions for removing organic micropollutants from wastewater" In Gdańsk, Poland.

October 2024

Workshop "Assessing risks and finding solutions to PFAS in local urban environment" in Riga, Latvia.

May 2025

Workshop "Unlocking innovative solutions and developing capacities in the wastewater sector" in Szczecin, Poland.

November 2025

Conference "The Future of Water in the Changing World: Innovative solutions against PFAS and micropollutants" in Berlin, Germany. In collaboration with the APRIORA project.

Output 1

Regional recommendations for monitoring and assessment of PFAS

In order to reduce the pollution of hazardous substances in the Baltic Sea, we need to have reliable means of assessing it. In the case of PFAS compounds, the environmental assessment of their concentrations in the aquatic environment has been lagging behind – and the EMPEREST project strived to address this gap with developed recommendations for the monitoring and assessment of PFAS in the Baltic Sea and the catchment area. This work was led by the Baltic Marine Environment Protection Commission – HELCOM Secretariat, building on 50 years of experience in supporting regional collaboration for the protection of the Baltic Sea.

Until now, official assessments in the Baltic Sea region have focused solely on PFOS, offering a mixed but not alarming picture of PFAS pollution. However, the upcoming EU-level assessment – soon to be finalized – will expand the scope to 24 PFAS substances, marking a significant shift in how pollution is evaluated. **The EMPEREST project anticipated this change and put together recommendations pertaining to water, biota, and sediment, giving advice on which substances, which species and which tissues could be selected for sampling.**

The project also compiled a **comprehensive database of PFAS monitoring data** from national sources across the region, covering the years 2000–2022. This data was used to perform a preliminary "test" assessment, which revealed a much more serious pollution situation. Preliminary results suggest that **PFAS levels in biota may be even more concerning** than previously understood – when applying the latest environmental quality standards, PFAS concentrations exceeded new thresholds in 9 out of 10 fish sampled across the Baltic Sea region.

To complement the existing data, EMPEREST partners also conducted targeted sampling based on new monitoring guidelines and analysed these samples for over 60 PFAS compounds using advanced laboratory techniques. These analyses showed that while the most concerning substances in biota are largely traditional and well-covered by the PFAS-24 list, newer PFAS compounds contribute significantly to pollution in water bodies. This highlights the importance of **including emerging PFAS in future assessments**, especially for water quality monitoring.

The recommendations report provides practical guidance for national authorities on how to adapt monitoring practices in light of upcoming legislative changes and highlights the effect these will have for the assessment of inland and marine waters, biota, and sediments.

Collecting fish samples near the Estonian coast. Photo: Kirke Paris

Output 2

PFAS risk assessment tool for cities

Due to their high mobility and persistence in the environment, PFAS compounds accumulate in water bodies, soil, plants, and air, posing a growing threat to public health and the environment. Despite widespread contamination cases across the EU and globally, PFAS are not yet actively monitored in drinking water and wastewater in many cities.

It is crucial for cities to proactively map PFAS sources and assess related risks.

In accordance with the Urban Wastewater Treatment Directive revised in November 2024, it is mandatory to conduct a risk assessment and monitor PFAS levels in both the inlet and outlet of wastewater treatment plants serving agglomerations of 10 000 population equivalents (PE) and above. In response to that, the expert group from Riga (City of Riga, Riga Technical University, and Riga Water Ltd.) developed a **PFAS local risk assessment framework and a tool to support local authorities in identifying contamination hotspots and implementing effective mitigation strategies.**

The EMPEREST Excel-based tool offers an **easy 8-step guidance for local authorities to perform PFAS risk assessment** for aquatic environments in a municipality. It looks over the whole municipal water cycle from water abstraction, water treatment, water supply system, sewage collection, and sewage treatment to treated wastewater discharge.

The EMPEREST PFAS risk-assessment tool is available in

During the development of the initial framework, the project identified possible PFAS sources in the nearby environment and narrowed down possible polluters within wastewater collection network. **The framework was tested and enhanced with support from five municipal water-work utilities** who made their own PFAS risk assessment plans. Based on their feedback, a lighter version was launched, to support municipalities that do not yet perform a source tracking, but instead as a starting point want to understand the potential sources of PFAS contamination.

The EMPEREST risk assessment tool contributes to the overall water utility risk management and thus strengthens the safe and sustainable management of drinking water resources and wastewater treatment in municipalities.

EMPEREST partners testing the PFAS risk-assessment framework at the workshop in Tartu. Photo: Mariia Andreeva

Output 3

Technological pilots in wastewater treatment

EMPEREST mobile pilot container arrives to Kaunas after the testing round in Szczecin. Photo: Kaunas Water Ltd.

The revised Urban Wastewater Treatment Directive (rUWWTD) sets new and more stringent measures to safeguard the environment and public health, including the implementation of the quaternary treatment. **By 2045, all wastewater treatment plants over 150 000 PE must adopt quaternary treatment to remove a broad spectrum of micropollutants.**

The implementation of this ambitious goal is where EMPEREST comes in: this project piloted advanced, or quaternary, wastewater treatment technologies across seven cities in the Baltic Sea region to test the removal efficiency of organic micropollutants and PFAS. For that, the project deployed **two sets of mobile pilot containers.**

Pilot testing is essential due to the complexity and cost of advanced treatment technologies, playing a critical role in verifying their effectiveness, feasibility, and sustainability before full-scale implementation. By enabling flexible, real-world testing and comparative performance analysis, it supports wastewater operators in selecting scalable, cost-effective solutions tailored to local conditions and regulatory requirements, while informing evidence-based planning for future infrastructure investments.

Map depicting the journeys of two mobile pilot plants built within the EMPEREST project.

Two sets of pilot plants in container housing were constructed respectively by Gdańsk Water Utilities Ltd. and Tartu Waterworks Ltd., to test the selected proven technologies at the wastewater treatment plants in different combinations with varying process parameters. After the first round of testing, the mobile containers continued their journeys to five more cities. During the testing periods in each site, regular analysis of water samples allowed to assess the effectiveness of the technologies in the removal of micropollutants and thus support the piloting WWTPs in making informed decisions regarding most suitable trains of technologies for their conditions.

The EMPEREST project successfully demonstrated the effectiveness of advanced treatment technologies such as **ozonation, granular activated carbon, ion exchange, and nanofiltration** for removing organic micropollutants listed in the revised UWWTD, **reaching the removal efficiency between 89–100 %** on the pilot scale.

International experts visiting the mobile pilot plant constructed in Gdańsk. Photo: Gdańsk Water Utilities (GIWK)

In addition to the micropollutants, **special attention was given to PFAS compounds, which are notoriously resistant to degradation and conventional treatment processes.** Granular activated carbon (GAC) filtration used alone or in combination with ozonation proved highly effective in removing micropollutants listed in the rUWWTD, but its efficiency in eliminating PFAS compounds was limited and varied depending on compound type and operational conditions (see Figures 1 and 2). Advanced oxidation processes, such as ozonation, can degrade certain pollutants but may unintentionally transform long-chain PFAS into more mobile and persistent short-chain variants, potentially increasing their concentrations in treated effluent. Among the tested technologies, ion-exchange resins showed the highest removal efficiency for long-chain PFAS, although short-chain compounds remain difficult to eliminate. These findings underscore the **importance of combining treatment methods and implementing**

comprehensive analytical screening to accurately assess PFAS removal performance.

In connection with the testing and upcoming deployment of advanced treatment technologies, EMPEREST also fostered **regional collaboration and capacity building**, enhancing the professional readiness for implementing next-generation wastewater treatment strategies.

The mobile piloting activities attracted significant media attention and were discussed on many prominent fora in the Baltic Sea region and beyond.

The activities carried out in the EMPEREST project demonstrated that mobile pilot plants are highly cost-effective tools for supporting the upgrade and development of numerous wastewater treatment plants, without the need to incur the high costs of constructing individual pilot installations.

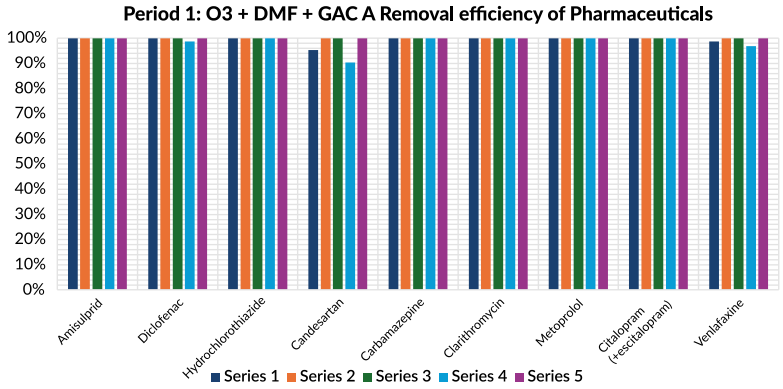


Figure 1: Removal efficiency of indicator pharmaceuticals from rUWWTD removed by ozone treatment, sand filtration and granular activated carbon (GAC) adsorption.

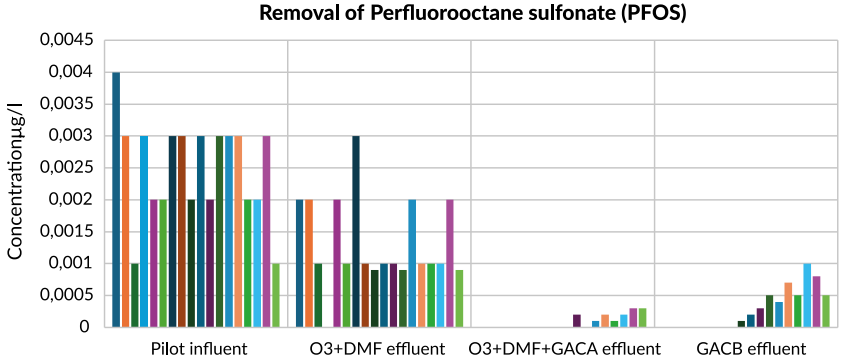


Figure 2: Removal of PFOS using different combinations of treatment technologies: O3 – ozone treatment, DMF – dual media filtration, GAC – granular activated carbon adsorption, across two testing series (A and B). Different colored bars represent different sample collection dates over time.

Output 4

Developing the capacities of water experts

Despite the global occurrence of PFAS that poses a threat to human and environmental health, there is still a knowledge gap, even among water experts. To effectively address the PFAS problem and successfully implement the EMPEREST solutions, stakeholders must first be aware of the problem. To close this knowledge gap, Berlin University of Technology developed a comprehensive **training package targeted especially at water and wastewater operators and local authorities**, whereas the DWA German Association for Water Wastewater and Waste Regional group North-East organised intensive capacity building activities for the target groups.

Throughout the project implementation, EMPEREST drew attention to the topic of PFAS and micropollutants in the water cycle. **Four major workshops attracted a wide international audience and many local events such as workshops and excursions in all partner countries offered opportunities for learning and exchange.** The events were dedicated to raising awareness and transfer of project insights and findings.

Project partners, associated organisations, and relevant wastewater sector stakeholders had the opportunity to learn first-hand about the operation and efficiency of micropollutants' removal in advanced wastewater treatment technologies on pilot and on full-scale, how to organise micropollutants' monitoring incl. the laboratory services, or how to identify and assess PFAS pollution hotspots.

With a social media campaign supported by all partners, Turku University of Applied Sciences brought the topic of PFAS and other micropollutants and related project results to a wider audience. At a personal level, everyone who participated in EMPEREST events or followed our social media campaigns will now pay attention to the chemicals content when buying their next frying pan or outdoors jacket. **This is how we promote a market transition towards a PFAS-free future!**

With the final conference in November 2025 in Berlin, the results and key messages of EMPEREST are transferred to national and local decision-makers.

The EMPEREST open-access training package, displayed online at the **Baltic Smart Water Hub (balticwaterhub.net)**, offers a comprehensive guide into PFAS and other organic micropollutants developed with many international experts tailored to the needs of the target groups. The core of the training package is a selection of short videos on a range of topics related to PFAS and other organic micropollutants in the water cycle.

EMPEREST international workshop in Szczecin, Poland.
Photo: Water and Sewage Company Ltd. of Szczecin

The whole training package is available in English.

The short videos have subtitles in:

- Estonian
- Finnish
- German
- Latvian
- Lithuanian
- Polish
- Swedish

The material is freely available for self-learning or for use in training events.

"The EMPEREST project has excelled in strengthening the collaborative work against PFAS pollution in the Baltic Sea Region. The knowledge shared by EMPEREST experts at numerous roadshows, workshops, campaigns, and trainings has increased the capacities of many stakeholders, and continues to do so. The learning process has been enhanced by the genuine spirit of cooperation and connection which makes this project truly special."

Mayumi Narongin Fujikawa
Baltic Sea PFAS Network Coordinator at
IVL Swedish Environmental Research Institute

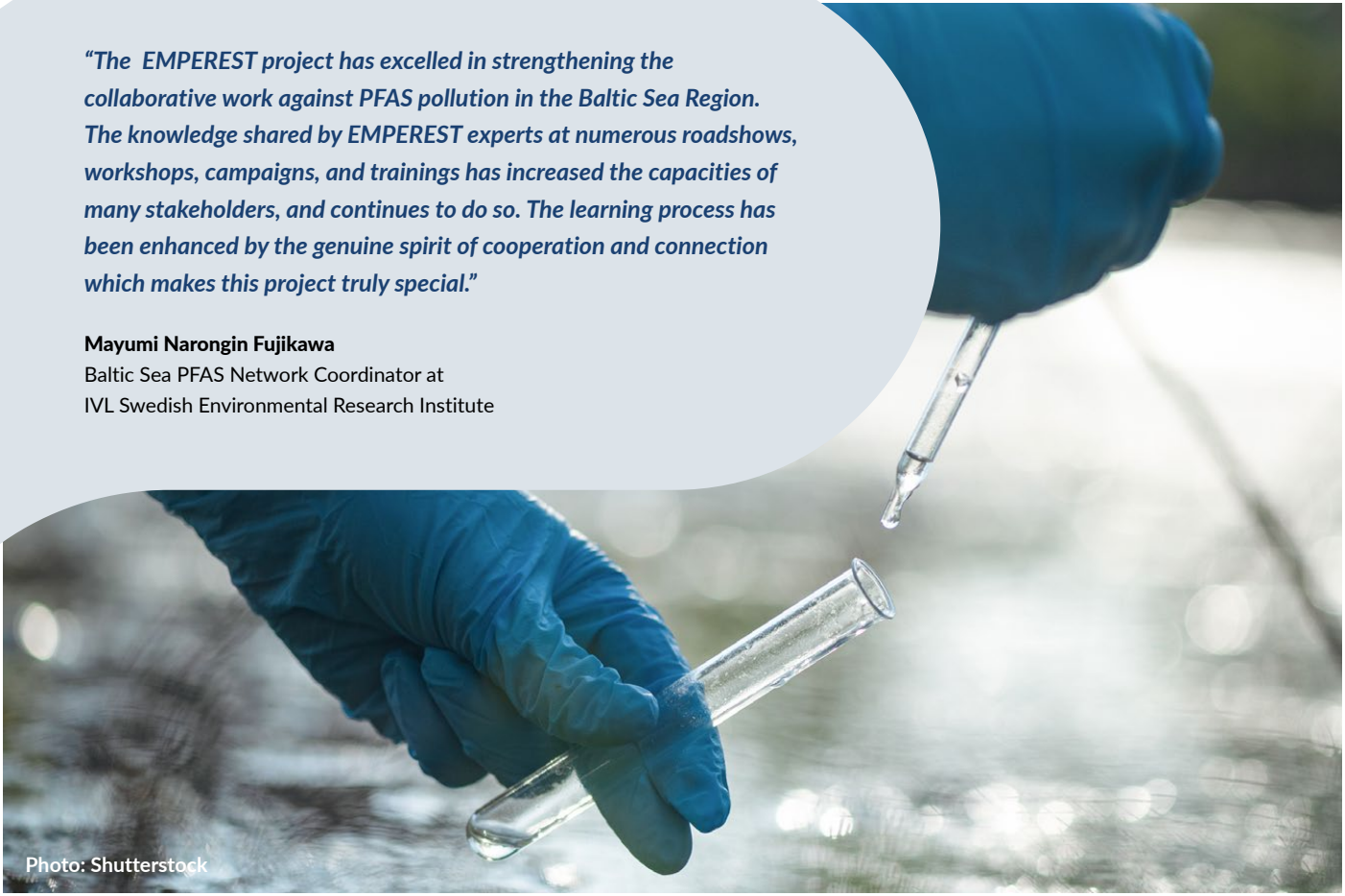


Photo: Shutterstock

EU Green Week 2024 event of the EMPEREST project: international workshop in Gdańsk. Photo: Gdańsk Water Utilities (GIWK)

Partnership

1. Union of the Baltic Cities Sustainable Cities Commission c/o City of Turku (FI) – **Lead Partner**
2. Baltic Marine Environment Protection Commission – Helsinki Commission (HELCOM) (FI)
3. University of Tartu (EE)
4. Berlin University of Technology (DE)
5. Turku University of Applied Sciences (TUAS) (FI)
6. Gdańsk Water Utilities (PL)
7. Water and Sewage Company Ltd of Szczecin (PL)
8. Tartu Waterworks Ltd (EE)
9. Tallinn Water Ltd (EE)
10. "Kaunas water" Ltd (LT)
11. Turku Region Wastewater Treatment Plant (FI)
12. DWA German Association for Water, Wastewater and Waste DWA Regional group North-East (DE)
13. Environmental Centre for Administration and Technology (LT)
14. City of Riga (LV)

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SUSTAINABLE WATERS EMPEREST

The EMPEREST project, co-financed by Interreg BSR Programme, works towards protecting and restoring the clean Baltic Sea.