ZeroPollution4Water Cluster Joint Policy Brief

Responding to the Challenges of Disinfection By-products to Help Ensure Trust in Tap Water

1 What are DBPs, and why are they important?

DBPs are substances that can form when disinfectants (typically chlorine, chlorine dioxide, chloramine, or ozone) react with natural organic matter (or other water constituents such as man-made pollutants) during the treatment of drinking water. Common DBPs include trihalomethanes (THMs), haloacetic acids (HAAs), and bromates. In addition, over 600 DBPs have been identified to date, for many of which the formation mechanisms remain unclear. While disinfection is essential for safeguarding public health by preventing waterborne diseases, viruses, and other pathogens, certain DBPs have been linked to an increased risk of cancer, particularly bladder, liver, and colon cancer[1].

The core challenge for water utilities is to maintain effective disinfection while minimising the formation of harmful by-products. This balancing act is increasingly complicated by the impacts of climate change, which can lead to deteriorating source water quality and a greater need for higher dosing of disinfectants.

With the new Drinking Water Directive (DWD) in force, water operators must incorporate DBP risk management into their operations to ensure the delivery of safe, high-quality drinking water to the public.

1.1 How are DBPs being addressed?

Chlorination remains the most widely used method of disinfecting drinking water due to its residual effect, which ensures continued disinfection throughout the distribution network. However, European water utilities are also applying strategies to reduce or avoid chlorination by measures such as source water control, high maintenance level of water distribution networks, alternative treatment methods, etc.

In European countries, drinking water regulations, including in the DWD, set limits on the concentrations of known DBPs, such as THMs and HAAs, to minimise potential health risks. Nevertheless, existing regulations vary considerably between jurisdictions and often do not account for newly identified (novel) DBPs[2], which remain unregulated despite emerging scientific evidence.

Alternative strategies have been adopted to tackle these challenges by aiming to reduce DBP formation while maintaining effective disinfection. For example, Australia implements a multi-barrier approach, combined with risk-based Water Safety Plans, to proactively manage water quality. To support the sharing of information on different approaches, the H2OforAll project has developed a preventive measures toolbox[3] to Protect Drinking Water from DBP formation.

---

[1] Li, X.; Mitch, W. (2018) Drinking water disinfection byproducts (DBPs) and human health effects: Multidisciplinary challenges and opportunities. Environmental Science and Technology, 52, 1681-1689. https://doi.org/10.1021/acs.est.7b05440

[2] SafeCREW identified previously unknown highly polar sulfonated DBPs. SafeCREW, Test protocol for effect-based in vitro toxicity assessment of disinfection by-products – Deliverable D1.3, 2023 https://safecrew.org/wp-content/uploads/2024/07/SafeCREW_WP1_D1-3_toxicity-assessment_v2.pdf

[3] H2OforAll, *Final Report: Prevention Measures to Protect Drinking Water*, Deliverable 3.3, 2024.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor REA can be held responsible for them.

Table 1 Key recommendations

Key Recommendations	
Consider proactive measures against climate-induced challenges	• Reduce water residence time in the distribution network[4] • Encourage flexible and adaptive water treatment processes • Ensure tailored solutions to the local and regional contexts.
Support investment in water infrastructure	• Invest in DBP precursor and DBP removal methodologies • Encourage monitoring and early warning systems • Address infrastructure issues such as the safe maintenance of pipelines • Improved systems flushing and mixing in tanks • Encourage maintenance of domestic installations.
Communicate smartly with the civil society	• Ensure transparent data sharing and easy access to data • Replicate successful societal initiatives
Upgrade the EU water acquis and guidance to the new challenges	• Establish and enforce regulatory limits for newly identified and currently unregulated DBPs • Encourage proactive planning and source water pollution protection measures.

1.2 The new Drinking Water Directive: an opportunity to tackle DBP challenges

The achievement of the new DBP standards, set by DWD (Directive EU 2020/2184), may require the upgrade of the current treatment trains operated at the water treatment plants to anticipate the challenges posed by DBPs[5]. This transition aligns closely with the European Water Resilience Strategy, which reinforces the need for adaptive, climate-resilient water systems and promotes innovation in monitoring, digitalisation, and pollution prevention. The utilities can adopt different strategies to achieve these new objectives[6]. **The DWD is a key driver for harmonised water quality measures across Europe**, including for DBPs. The implementation of this new directive is an opportunity to:

- **Harmonise DBP monitoring and management standards** as well as integrate DBP monitoring with broader pollution control strategies[7].
- **Develop guidelines on DBPs and Managed Aquifer Recharge** to address DBPs challenges while leveraging the benefits of aquifer recharge. Moreover, coherence should be ensured between Managed Aquifer Recharge and other legislation that could impact DBPs formation.

[4] Water residence time: the duration water remains within distribution systems.
[5] Meritxell Valenti-Quiroga, Maria José Farré, Paolo Roccaro, *Upgrading water treatment trains to comply with the disinfection by-products standards introduced by the Directive (EU) 2020/2184*,Current Opinion in Environmental Science & Health, Volume 39, 2024, 100547, ISSN 2468-5844, https://doi.org/10.1016/j.coesh.2024.100547 .
[6] IntoDBP, *Strategies for DBP minimization* – Deliverable 4.1, 2023
[7] The directive itself does not establish specific measurement methods, but rather refers to accredited standard methods (e.g. European Standards, ISO, National standards bodies guidance). Member States are required to ensure that the methods used have comparable accuracy and detection limits. For new parameters such as haloacetic acids (HAA5), the Commission must provide a method evaluation and guidelines by 2025.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor REA can be held responsible for them.

- **Assess and establish dedicated funding mechanisms to help local and regional authorities (LRAs)** invest in digital solutions and prevention technologies.
- **Encourage the digitalisation of the sector** by setting an interoperable EU-wide monitoring system for drinking water quality and potential risks. For example, the development of generalised methodologies, coupled with the quasi-global coverage of most Earth Observation datasets, can facilitate the monitoring of the nutrient runoff-related processes at the basin scale[8].
- **Encourage trust in tap water in our society** through an awareness campaign to educate the public.

The adoption of preventive measures and innovative treatment technologies for DBPs under the new DWD faces several regulatory and policy challenges:

- **Financial barriers**: Advanced technologies (monitoring and treatment) often require significant upfront investment, which many LRAs struggle to afford. Without external funding or incentives, their implementation remains limited.
- **Limited public awareness**: DBPs are poorly understood by the public, resulting in misconceptions and low demand for action from policymakers.
- **Regulatory complexity**: Complex procedures for approval and integration of new technologies can deter their adoption.
- **Research gap**: There is still a need for more comprehensive studies on DBP occurrence, management, and prevention[9]. Robust scientific evidence demonstrating the benefits of innovative technologies is essential for convincing policymakers of their value.

1.3 How to mitigate the generation of DBPs and secure high-quality drinking water for all?

To overcome existing barriers and harness the available opportunities, the projects involved have developed a series of evidence-based recommendations:

- **Utilities should consider proactive measures against climate-induced challenges** such as rising temperatures and elevated organic matter levels, including upstream contamination management and enhanced risk assessment tools.
    - **Reduce water residence time** - Shortening the duration that water remains within distribution systems[10] can limit the interaction between organic matter and disinfectants, thereby reducing the formation of DBPs.
    - **Encourage flexible and adaptive water treatment processes** - Treatment systems must be flexible enough to accommodate variations in water quality

[8] National Technical University of Athens. (2024, May 30). Early Warning System for nutrient run-off in inland water bodies: A methodological framework utilizing earth observation Data. 2024 IEEE International Geoscience and Remote Sensing Symposium "Acting for Sustainability and Resilience" (IEEE IGARSS 2024), Athens Greece. https://doi.org/10.5281/zenodo.12794920
[9] IntoDBP, *Review of modelling solutions for intoDBP* – Deliverable 3.1, 2023
[10] While not explicitly labeled as a strategy to reduce water residence time, the integration of real-time monitoring tools, distribution system modeling (e.g., EPANET-MSX), and the NESSIE operational platform within the ToDrinQ demonstration cases (Athens and Val de Bagnes) has supported dynamic water quality management and system responsiveness, thereby enabling operational practices that help minimize water age and the formation of disinfection by-products.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor REA can be held responsible for them.

caused by climate-related events such as irregular rainfall, salination, or organic matter surges. Advanced technologies like membrane filtration, adsorption, advanced oxidation or ultraviolet disinfection can be adjusted to ensure effectiveness[11].

  - **Ensure tailored solutions to regional context -** The impacts of climate change on water quality vary significantly by region. Preventive measures must be tailored to specific local conditions, including factors such as climate, geology, and industrial activity. The co-creation approach in ToDrinQ has demonstrated its benefits in fitting with the end-users' needs and local context[12].

- **Utilities should invest more in their infrastructure:**
  - **Monitoring and early warning with flexible strategy -** Continuous monitoring of water sources for contaminants, pathogens, and changes in chemical composition is critical. Early detection systems can alert facilities to potential issues, enabling timely intervention to prevent contamination[13]. Utilities also appreciate optimisation and portability of sensors to adapt their strategy[14] [15].
  - **Disinfection by-product (DBP) precursor and DBP removal methodologies** - Facilities should invest in advanced treatment technologies, such as adsorption, reverse osmosis, or advanced oxidation processes, to efficiently remove DBP precursors, DBPs and other emerging contaminants[16].
  - **Address infrastructure issues –** by developing policies and programs to replace old pipes, particularly in residential buildings, as these can affect water taste and quality. Educate the public on how outdated infrastructure can influence their experience with tap water and what steps are being taken to address these challenges.
  - **Encourage complementary domestic solutions,** such as filters and UV systems whose effectiveness depends on proper use and maintenance.

- **Utilities and LRAs should communicate smartly with the civil society:**
  - **Ensure transparent data sharing and easy access to data**, including relatable health messaging and cost comparison to foster public trust and behavioural change. It includes simplification of the language and digitalisation[17].
  - **Expand successful societal initiatives**, such as replacing bottled water with tap water in public spaces, have demonstrated how targeted efforts can improve

---

[11] In Athens, ToDrinQ project aims to advanced decision-making tools and predictive models. It aims at supporting adapting treatment processes to fluctuating water quality conditions to ensure efficiency and resilience. For more information: https://todrinq.eu/demo-case-athens/
[12] ToDrinQ, *Deploying solutions for better water quality: first interim report*, Deliverable 2.1, 2024. In Amsterdam and Athens, where early and continuous collaboration between utilities WTNT and EYDAP and technology providers enabled the deployment of tailored sensors and decision-support tools that respond to site-specific water quality challenges.
[13] SafeCREW developed an online THM-analyser for parallel identification of 4 species.
[14] ToDrinQ, *Sensors/analysers for inorganic micropollutants (Hard Sensor #1) - online prototypes and technical specifications*, Deliverable 3.1, 2024
[15] H2OforAll, Algorithms and methods for proper placement of the sensing infrastructure along the water distribution network, Deliverable 2.2, 2024
[16] H2oforAll, *Source* water treatment and DBPs removal from disinfected water – Deliverable 4.2, 2022. Advanced technologies such as adsorption using ORMOSIL aerogels, activated carbon, biochar, and advanced oxidation processes, including photocatalysis and ozonation, have demonstrated high efficiency in removing DBPs like bromodichloromethane (BDCM), monochloroacetic acid, and PFAS, highlighting their relevance for broader deployment in drinking water treatment systems. ORMOSIL aerogels exhibited nearly 100% removal efficiency of bromodichloromethane within less than 20 minutes of contact time. The material demonstrated good reusability and maintained performance even after regeneration using ozone and hydrogen peroxide.
[17] Through its NESSIE platform and user-tailored sensor systems, ToDrinQ supports real-time monitoring, simplified messaging, and informed comparisons that utilities can leverage for public health advisories and behavioural change. It illustrates how transparent data sharing, digitalisation, and co-created decision tools can build public trust.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor REA can be held responsible for them.

trust and acceptance by the civil society. Similarly, providing consumers with easy-to-use tools to test water quality or detect plumbing issues can empower them to take a more active role in managing their water usage.

- **The EU Institutions should upgrade the EU water acquis and guidance to address new challenges such as:**
  - **Regulation and threshold values for unregulated DBPs -** Establishing and enforcing regulatory limits for newly identified and currently unregulated DBPs is essential to protect public health[18]. Collaboration between governments, research institutions and water utilities is crucial to facilitate the identification, risk factors contributing to their occurrence and the control of these compounds.
  - **Proactive planning and upstream management** - Water safety plans of the water suppliers should integrate assessments of both surface and groundwater, considering how global and climate change affect DBP precursor and more generally pollutant dynamics[19].

The projects can be contacted via loic.charpentier@watereurope.eu to obtain the relevant contact and information in accordance with this confidentiality framework.

[18] Indrajit Kalita, Andreas Kamilaris, Paul Havinga, and Igor Reva, "Assessing the Health Impact of Disinfection Byproducts in Drinking Water", *ACS ES&T Water* 2024 *4* (4), 1564-1578, https://doi.org/10.1021/acsestwater.3c00664

[19] The Drinking Water Directive encourages risk assessments by water suppliers to follow the so-called "water safety plan" approach of the World Health Organisation together with standard EN 15975-2 concerning security of drinking water supply.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor REA can be held responsible for them.

The Projects

Innovative tools to control organic matter and disinfection byproducts in drinking water.

The intoDBP project, funded by the EU, focuses on disinfection by-products (DBPs) formed during water chlorination. It develops innovative tools for water quality management, emphasizing cost-effective sensors and analytical methods. intoDBP aims to understand DBP precursors, address pollution and risks, and promote sustainable consumer behavior. The project engages society through surveys, contributes to climate change adaptation, and enhances water treatment.

Understanding groundwater Pollution to protect and enhance WATERquality.

The UPWATER project addresses the widespread issue of groundwater pollution by identifying effective regulatory and legislative preventive measures and by developing cost-efficient methods to measure pollutants, identify their sources and to mitigate the pollution. UPWATER focuses on the validation of these methods in three case studies in different EU climates and aims to develop hydrogeological models for decision-making scenarios, considering multiple stressors and climate change projections. Expected outcomes include the adoption of preventive measures, scaled-up bio-based solutions and updated chemical priority lists.

TOolkit for aDaptable, Resilient INstallations securing high Quality drinking water

The ToDrinQ project addresses the impact of climate change and increased pollution on drinking water quality. The project aims to develop real-time water quality monitoring technologies and innovative treatment systems, along with interoperable decision tools. These efforts support evidence-based treatment plant design and enhance operational awareness and response in the overall water system.

Innovative Integrated Tools and Technologies to Protect and Treat Drinking Water from Disinfection Byproducts (DBPs)

The H2OforAll project focuses on disinfection by-products (DBPs) that result from the interaction of disinfectants like chlorine with natural organic materials in water. It aims to develop cost-effective DBP sensor monitoring devices, model contaminant spread, study toxicity and environmental impact, and propose safeguarding measures for the drinking water chain. The project also works on innovative water treatment methods to remove or prevent DBPs, and it aims to create a central knowledge base with reliable data on DBPs in Europe and their effects.

Preventing groundwater contamination related to global and climate change through a holistic approach on managed aquifer recharge

MAR2PROTECT project confronts groundwater contamination resulting from climate change and global changes, with a focus on sustainable water management to meet zero pollution goals by 2030. It employs an innovative managed aquifer recharge (MAR) approach, utilizing the M-AI-R Decision Support System (DSS) that incorporates artificial intelligence (AI) to assess and enhance groundwater quality and quantity.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor REA can be held responsible for them.

Climate-resilient management for safe disinfected and non-disinfected water supply systems

SafeCREW project addresses the challenge of supplying safe drinking water in the face of climate change. It aims to develop new methods for monitoring, treatment, and risk assessment, particularly in disinfection and organic substance removal, safeguarding water quality.

TakiNg actIoN to prevent and mitigate pollution oF groundwAter bodies)

NINFA project confronts groundwater pollution by developing an early-warning decision support system and knowledge database, the NINFA Platform. This innovation enhances groundwater management by expanding knowledge on water flows and the behavior of emerging contaminants like pharmaceuticals and microplastics, safeguarding this vital resource.

The Cluster

The ZeroPollution4Water cluster is an initiative originating from the coalition of seven different projects (see annex I) funded from two Horizon Europe 2022 calls which aim to:

- Prevent groundwater contamination and protect its quality against harmful impacts of global and climate change.
- secure drinking water quality by protecting water sources against pollution, providing innovative monitoring and treatment solutions, and ensuring safe drinking water distribution.

Focusing on the European Union's zero-pollution ambition and the European Green Deal, the cluster aims to leverage the cooperation and synergies among these seven projects to develop advanced prevention and mitigation strategies, effective risk assessment and management systems, and innovative monitoring and treatment solutions for drinking water and groundwater management. It also aims to develop new technologies ready for the market to prevent or tackle water pollution.