ZeroPollution4Water CLUSTER

# REINFORCING EU GROUNDWATER POLICY FOR EMERGING RISKS

## INTRODUCTION

This policy brief makes recommendations to strengthen the protection of groundwater resources and reinforce the Ground Water Directive's (GWD) implementation. It is based on the findings of the ZeroPollution4Water cluster, an initiative originating from the coalition of nineteen different European projects 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 in water ambition, the cluster aims to leverage the cooperation and synergies among these 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.

## MAIN RECOMMENDATIONS

1. **Strengthen Digital and Integrated Monitoring of Groundwater in the EU**
2. **Establish a Microbiological Watch List for Groundwater Monitoring.**
3. **Support sustainable agricultural practices and strengthening targeted monitoring of pesticides in groundwater**
4. **Support the restrictions on the use of Persistent, Mobile, and Toxic substances (PMT) compounds, such as PFAS**
5. **Strengthen Managed Aquifer Recharge (MAR) practices in the GWD and related water policies**
6. **Support deployment of nature-based solutions (NbS) as key tools to mitigate groundwater pollution**
7. **Encourage the adoption of passive samplers for groundwater and NbS monitoring**

## CONTEXT

The GWD (2006/118/EC) establishes the EU framework to protect groundwater from pollution and deterioration, reverse upward pollution trends, and support the achievement of "good status" under the Water Framework Directive (WFD). As a "daughter directive" of the WFD, the GWD operates in conjunction with the Environmental Quality Standards Directive (EQSD), ensuring coordinated monitoring and action across connected groundwater, surface waters, and floodplains.

Groundwater represents around 75% of the EU's drinking water supply and is a strategic resource for agriculture, industry and ecosystem resilience. Yet it is increasingly under pressure from diffuse pollution, emerging contaminants, overexploitation and climate change. Due to its slow recharge rates and limited natural attenuation capacity, groundwater contamination is often long-lasting and costly, if not impossible, to reverse.

Protecting groundwater at source is therefore essential to safeguarding public health, securing drinking water quality, preserving ecosystem integrity. With the Water Resilience Strategy, the Commission is also setting a strategic pathway to strengthen water governance in Europe, supporting simplification, restoring the water cycle, and building a water-smart economy.

# POLICY RECOMMENDATIONS

In this context, improving implementation of the GWD is central to strengthening groundwater protection and resilience towards a Water-Smart Society. Therefore, we recommend to:

## 1. STRENGTHEN DIGITAL AND INTEGRATED MONITORING OF GROUNDWATER IN THE EU

A more coherent and efficient monitoring architecture across EU water legislation is needed to better protect groundwater. The Commission should promote greater digitalisation and interoperability of monitoring systems under the WFD, GWD, EQSD, Floods Directive and Bathing Water Directive.

The current framework remains fragmented, generating duplication, inconsistencies and unnecessary administrative burden. A more integrated monitoring approach would streamline reporting, improve data comparability and support a source-to-sea perspective across the water cycle. The six-year RBMP cycle and Member State flexibility in monitoring design should be maintained, but within a clearer and more coordinated governance structure.

Promoting digital monitoring tools, including Earth observation, in-situ sensors, early-warning systems and Decision Support System (DSS), would strengthen the detection of emerging pollutants, improve trend analysis and support more preventive and data-driven groundwater management.

**BOX – Harmonised Monitoring of contaminant of emerging concern (CEC) and Implementation of DSS (LIFE-CASCADE, MAR2PROTECT and NINFA)**

LIFE-CASCADE has developed harmonized methods for microplastic characterization and detection, including standardized sampling, pre-treatment protocols and interlaboratory validation to ensure comparability across Member States. The framework is transferable to surface water, groundwater, drinking water systems, and sludge/ sediment monitoring, and includes PFAS screening workflows (TOF/ AOF) to support EU monitoring frameworks.

MAR2PROTECT developed a bio-based adsorption process for removing PFAS and pharmaceuticals with lower environmental impact and operational costs. It also created the REACH Modelling Tool, which predicts groundwater quantity, piezometric levels, and vulnerability under climate change scenarios. *MAR2PROTECT Deliverable 6.6*

NINFA is validating an integrated early-warning DSS that will provide enhanced detection of GW pollution incidents by means of deterministic and robust AI-based systems, and will recommend the best prevention/mitigation strategies.

## 2. ESTABLISH A MICROBIOLOGICAL WATCH LIST FOR GROUNDWATER MONITORING.

Establishing a watch list mechanism for microbiological parameters, similar to approaches used for emerging chemical contaminants, could support the progressive integration of virus monitoring into groundwater protection frameworks.

European water regulations have historically relied on bacterial indicators of faecal contamination, such as E. coli and intestinal enterococci, particularly under the Drinking Water Directive and the Bathing Water Directive. However, specific monitoring frameworks for human viruses remain largely absent from EU water legislation. This represents a growing knowledge and policy gap, as several viruses (e.g. norovirus, SARS-CoV-2, HAdV, etc.) are increasingly recognised as relevant indicators of faecal contamination and potential risks to drinking water resources. It could be linked to the European Centre for Disease Prevention and Control (ECDC) by making a reference to it in the WFD and GWD Watch list.

**BOX – Microbiological indicators for Groundwater monitoring (NIAGARA and UPWATER)**

NIAGARA develops innovative solutions to detect and remove the bacterium Helicobacter pylori, a WHO Class I carcinogen associated with gastritis, ulcers, and stomach cancer, that is not regulated at all. A study in eastern Spain detected H. pylori in 16 of 24 drinking water samples, with viable cells found in six. The frequency of occurrence makes them a good indicator for monitoring. NIAGARA Deliverable 5.10

UPWATER detected human adenoviruses (HAdV) in 50% of monitored wells in the Barcelona case study. Due to their high persistence and reliability as indicators of human faecal contamination, the project recommends including HAdV in the EU priority monitoring list. UPWATER *Deliverable 4.4 and Deliverable 6.5*

## 3. SUPPORT SUSTAINABLE AGRICULTURAL PRACTICES AND IMPROVE PESTICIDE MONITORING IN GROUNDWATER THROUGH SUBSTANCE-SPECIFIC TRACKING

Agriculture remains a major source of groundwater pollution in Europe. Promoting sustainable farming practices, such as improved nitrogen management, proper equipment maintenance, reduced pesticide use, and regenerative agriculture, can significantly limit pollutant infiltration into aquifers.

Also, the current "total pesticides" indicator makes it difficult to identify specific contamination sources and design targeted measures. Moving toward substance-specific pesticide monitoring would improve accountability, support evidence-based regulation, and enhance alignment between water, agriculture, and chemical policies, particularly for persistent and mobile compounds relevant to drinking water resources.

**BOX - Technologies to limit pesticide and nutrient leaching (NIAGARA, MAR2PROTECT and NINFA)**

NIAGARA highlights that reliance on total pesticide thresholds may obscure substance-specific risks, as illustrated by imazalil detection patterns across monitored water bodies. Imazalil exemplifies the need for substance-specific tracking due to its detection patterns and environmental behaviour.

MAR2PROTECT developed **FERT-ROOT**, a root-zone fertilizer retention system that reduces nutrient leaching, enhances nitrogen uptake, and decreases soil compaction, helping farmers increase yields while minimizing groundwater pollution. The project also created a real-time algae-based biosensor for ecotoxicity, providing low-cost, near-real-time detection of nutrients and toxic substances, particularly useful for monitoring wastewater treatment plants and industrial discharges. MAR2PROTECT *Deliverable 6.6.*

NINFA developed an integrated treatment of pig manure consisting of the combined use of pre-treatment, transmembrane chemisorption, biological treatment (MBBR) and advanced oxidation processes. This allowed the selective recovery of nitrogen as a high-purity ammonium sulphate fertilizer. By treating pig manure and recovering excess nutrients in the form of fertilizer, prevents them from leaching into groundwater.

## 4. SUPPORT THE RESTRICTIONS ON THE USE OF PMT COMPOUNDS, SUCH AS PFAS

Stronger restrictions on the use of PMT compounds, such as PFAS, are needed to reduce environmental concentrations and promote safer chemical alternatives. While NbS can remove biodegradable compounds, more recalcitrant substances require advanced treatments like ion exchange or oxidation in combined treatment trains to protect groundwater, ecosystems, and human health. The ongoing revision of EU water legislation is a key opportunity to strengthen monitoring, integrate risk-based management tools, and support the EU's Zero Pollution ambition. Based on high frequency and concentrations detected by UPWATER, eight PMT compounds (benzotriazole, losartan, tris(chloropropyl) phosphate (TCPP), 2,4-dichlorophenol, 4-chloro-2-methylphenol, metformin, melamine and trifluoromethanesulfonic acid), with four of them being already on the **Substitute It Now (SIN) list** of 53 hazardous chemicals, should be added, plus all remaining SIN list chemicals, to the WFD priority list or inclusion in Annex I or II of the GWD, or under the EQSD priority substances list.

## 5. STRENGTHEN MANAGED AQUIFER RECHARGE (MAR) PRACTICES IN THE GWD AND RELATED WATER POLICIES.

Under the Urban Wastewater Treatment Directive recast, the reuse of reclaimed water is subject to tighter monitoring of pollutants not previously included (e.g., PFAS, pharmaceuticals, and microplastics). This is highly relevant, as reclaimed water is increasingly reused for aquifer recharge and for agricultural excess irrigation. Nevertheless, MAR implementations should be strengthened in the GWD to provide an efficient guideline for a harmonized risk monitoring framework, including coherence with other water policies and publications. . It is vital to inform policymakers on how to make assessment to ensure that «pollutant concentrations do not present a significant environmental or health risk» and therefore allow for their attenuation in the subsurface.

**BOX – DSS to help with MAR implementation (SafeCrew and MAR2PROTECT)**

Regarding microbial safety for human consumption, **SafeCREW** has shown how to move «beyond purely random sampling towards an integrated risk-based management approach. The approach aims to overcome the analytical constraints associated with detecting pathogens in large volumes of water by utilising ultrafiltration-based microbial enrichment for subsequent use in quantitative microbial risk Assessment (QMRA). SAFECREW *Deliverable 4.3*

MAR2PROTECT has developed a comprehensive visualization and decision-support tool for MAR operators named M-AI-R-DSS (Artificial Intelligence enabled MAR decision support) as a way to predict future groundwater quality and quantity considering different climate change scenarios. This tool addresses MAR performance through mitigation of risks by MAR, innovative pre-treatment performance, and operational risk identification. MAR2PROTECT *Deliverable 6.6.*

## 6. SUPPORT DEPLOYMENT OF NBS AS KEY TOOLS TO MITIGATE GROUNDWATER POLLUTION.

Relevant authorities should encourage the deployment of cost-efficient NbS as a tool for safeguarding groundwater and drinking water quality, while controlling risks to human and environmental health at source, reducing greenhouse gas emissions, and building climate resilience.This approach should be particularly supported by public investment to advance technology readiness and encourage implementation, including in the drafting of upcoming legislation and civil and water infrastructure planning documents.

**BOX – NbS for mitigation groundwater pollution (UPWATER and NINFA)**

UPWATER tested Moving Bed Biofilm Reactors and biofilter (MBBR-biofilter) systems and constructed wetlands with biochar (biochar wetlands) at three demonstration sites polluted with different combinations of high levels of ammonium and metals, emerging contaminants, pesticides and pathogens. Local stakeholders at the Barcelona (Besòs) and Athens case study sites preferred biochar wetlands combined with MAR for improving groundwater quality rather than upgrading wastewater treatment plants with Advanced Oxidation Process (AOP). At the Stengården dumpsite case study, Denmark, further improvement to the MBBR-biofilter system is required to encourage investment in the technology for optimal use in combination with existing treatment based on granular activated carbon (GAC). All UPWATER NbS have a significantly lower cost than AOP/GAC, use less energy, result in low formation of transformation products, and improve biodiversity and landscape outcomes. In Barcelona, key stakeholders emphasised that the alignment of legislative requirements, planning, and proposed works creates a rare opportunity for maximising impact. UPWATER has prepared local policy briefs for each case study. *UPWATER Deliverables 4.2, 4.3, 4.4 and 6.5**

NINFA developed and validated an integrated technology of Nb and Advanced oxidation process (AOP) for the removal of polycyclic aromatic hydrocarbons (PAHs) and microplastics (MPs). The combination of an NbS tile system consisting a sand-biochar configuration and a photo Fenton process using a compound parabolic collector allowed the effective removals of PAHs and MPs. NINFA *Deliverable 3.2*

## 7. ENCOURAGE THE ADOPTION OF PASSIVE SAMPLERS FOR GROUNDWATER AND NBS MONITORING

The use of easy-to-deploy passive samplers for groundwater and NbS monitoring should be further explored to support pollution mitigation. Being easily deployed for days to weeks with continuous diffusive uptake of contaminants, passive samplers provide time–integrated measurements of contaminants present in a water body, whereas conventional grab sampling technology only provides a snapshot of water contamination at one point in time.

UPWATER validated three types of passive samplers for groundwater monitoring: Ceramic Passive Samplers (CPS), Diffusive Gradients in Thin Films (DGTs), and Virus Passive Samplers (VPS) - for measuring CECs, bioavailable metals, and pathogens, respectively. The project demonstrated that VPS are particularly suitable for early-warning systems for waterborne virus contamination, pathogens monitoring being consistently cheaper than grab sampling. *UPWATER Deliverable 2.4 and 5.3*

***FOR FURTHER INFORMATION:***

*Water Europe Expert Group on "Groundwater & Healthy Soils" white paper on «Linking groundwater with soil health for water quality assessment, protection and management», 2026*

https://zeropollution4water.eu/

*Graphic design by SEMIDE partner of the NIAGARA project.*