

# New Approaches & Technologies For Tackling Emerging Pollutants In Drinking & Wastewater

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## Introduction

In recent decades, emerging pollutants from pharmaceuticals, industrial chemicals, and large-scale agriculture have posed new challenges for the water management sector. Coupled with demographic changes, climate change, as well as aging and deteriorating water infrastructures, research and innovation in the water sector have become increasingly important for ensuring the long-term sustainability and quality of water resources.

## The need for innovation

Despite these challenges, the adoption of appropriate practices and technologies that effectively address and tackle such emerging pollutants remains low. Improved knowledge transfer and better science communication among key stakeholders, including scientists, the private sector, and water utilities have been identified as central to addressing the low rate of uptake of appropriate technologies. In particular, small and medium-sized enterprises (SMEs) have emerged as key go-betweens for increasing innovation in the water sector and encouraging knowledge dissemination and uptake of research.

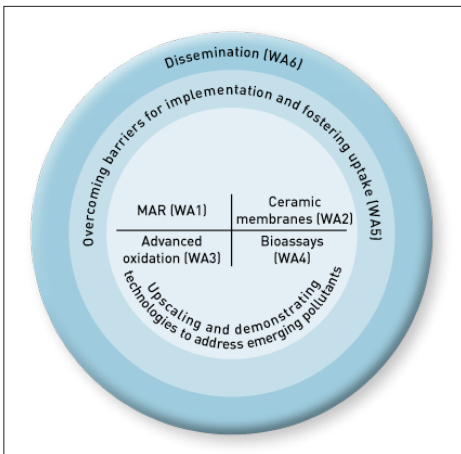
In Europe, efforts to address emerging pollutants in drinking and wastewater are already in progress. Using applied research and demonstration sites across Europe, the DEMEAU project is demonstrating new, collaborative approaches for advancing the

uptake of knowledge, prototypes, practices and technologies that enable the water sector to tackle emerging pollutants more effectively. The project consists of a network of partners from research, water utilities and SMEs that are exploring five promising water treatment technologies: Managed Aquifer Recharge (MAR), Hybrid Ceramic Membrane Filtration (HCMF), Automated Neural Net Control Systems (ANCS), Advanced Oxidation Techniques (AOT), and Bioassays.

## New collaborative approaches

Using action research, the DEMEAU project provides new, improved approaches for developing and testing relevant water treatment technologies as a way to innovatively and effectively address the gaps and opportunities for tackling emerging pollutants. Bridging the gap between research and industry, DEMEAU facilitates close collaboration and feedback among the research community, SMEs and water utilities by lowering the economic and shared risks associated with innovation and trial of such new, promising technologies.

To fuel innovation and knowledge exchange, the project actively explores synergies among drinking and wastewater treatment technologies. This integrated approach has been critical to the overall success and uptake of the five technologies explored in the project. On the one hand, researchers have been able to receive inspiration and critical feedback from SMEs, while SMEs



A visualization of the approach.

and utilities have been able to broaden their markets by pioneering the water sector.

## Technologies for emerging pollutants

### Managed Aquifer Recharge (MAR)

Managed Aquifer Recharge (MAR) is a versatile technology that provides drinking water supply, process water for industry, for irrigation and for sustaining groundwater dependent ecosystems. MAR uses natural aquifer treatment processes, such as mechanical filtration, sorption and biodegradation, at the subsurface level. These natural treatment processes do not require additional chemicals, offering a more sustainable alternative to traditional treatment processes.

MAR has been shown to provide a variety of benefits, including water storage and improved water quality. However, the implementation of MAR is often hampered by uncertainty relating to economic and environmental profiles. To address this,



Copyright: Cetaqua Caption: MAR infiltration system in Sant Vicenç dels Horts (Barcelona, Spain).

life cycle assessments (LCA) and life cycle costing (LCC) tools, based on a set of indicators selected for environmental impacts and costs, are being applied to MAR sites for comparison against other competitive water treatment technologies. From the assessments, it has been found that natural, infiltration pond systems are a low-cost and low-energy option for groundwater recharge, provided that a suitable long-term strategy to prevent clogging is implemented. Such ponds can be upgraded or combined with advanced oxidation processes to enhance their capacity for removal of organic micropollutants.

### Hybrid Ceramic Membrane Filtration (HCMF)

Polymeric membranes are widely used

in water treatment to remove pathogens, particles and organics from surface, ground, and process and filter backwash water. However, ceramic membranes are much more resilient, outperforming polymeric membranes even under extreme conditions (e.g. temperature, pH and chemicals).

LCC assessments based on case studies also show that HCMF have lower operational costs than polymeric membranes, though implementation costs were higher for HCMF. In order to improve cost effectiveness, several alterations to the ceramic membrane modules have already been tested and successfully applied within the DEMEAU project. For example, by combining several membranes into one vessel, fewer valves, and therefore steel, are needed. In addition, an improved bottom

plate has helped to enhance its durability, making the technology more resilient during backwashing, particularly in the long-term.

### Automated Neural Net Control Systems (ANCS)

Automated Neural Net Control Systems (ANCS) are computer-based, process optimisation systems that use tailored mathematical algorithms, with applications in drinking water processing and supply, urban drainage systems, and activated sludge reactors in wastewater treatment plants. In the drinking water industry, ANCS technology is usually applied as an add-on to optimize membrane filtration, and thus is widely applicable. Within DEMEAU, marked improvements in filtration and enhancements in process productivity (of



about 4 to 15%) has made ANCS particularly lucrative as an add-on for existing membrane filtration plants in Europe to increase their increasing environmental and economic sustainability.

However, several barriers to widespread uptake still exist for ANCS. Life cycle assessments have revealed that a certain degree of complexity is necessary in order for ANCS to be cost-effective. Consequently, larger plants are more cost-effective than smaller plants. Similarly, as maintenance is a necessary aspect of the technology, ANCS is more cost-effective at larger scales. As a result, understanding the extent and costs of maintenance required for the plant is an important aspect to account for prior to

implementation.

### Advanced Oxidation Techniques (AOT)

Oxidation techniques have a long tradition for use in disinfecting drinking and wastewater, however, its benefits for use in removing emerging pollutants have only recently come to light. Results from pilot plants and the first full-scale application using post-ozonation produced removal rates greater than 80% for many emerging pollutants.

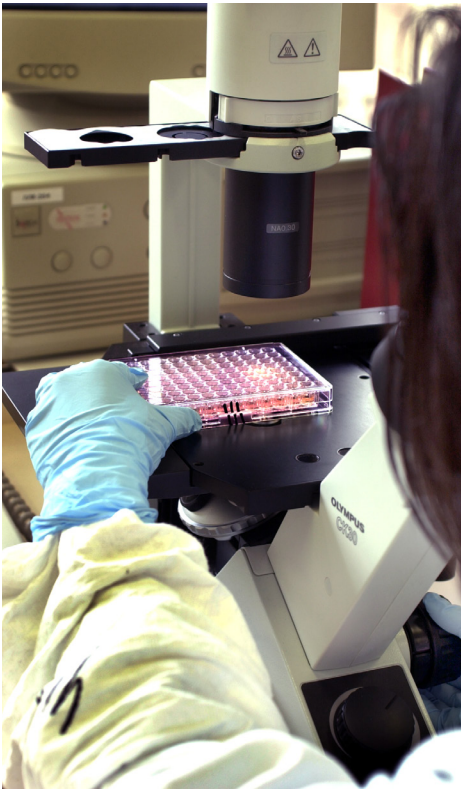
Within DEMEAU, researchers, utilities and SMEs are testing a combination of various oxidation processes (including O<sub>3</sub>, O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub>, UV/H<sub>2</sub>O<sub>2</sub>) as well as different post-treatment applications, such as sand filtration

or biological activated carbon filtration.

Due to the collaborative character of DEMEAU, the project is actively facilitating a safe environment for utilities and SMEs to experiment and apply this innovative technology in a full-scale drinking water plant. The results have been promising: one oxidation reactor developed by a Dutch SME projects significant energy reductions. In fact, the SME estimates 30-40% less energy consumption with its oxidation reactor as compared to conventional reactors using UV/H<sub>2</sub>O<sub>2</sub> processes.

### Bioassays

Current mainstream water monitoring strategies rely exclusively on chemical analysis. However, chemical analysis only



Copyright: BDS Caption: In the lab using Bioassay techniques.

identifies specific, targeted compounds with no information on the biological effects of the pollutants. Bioassays address this gap in monitoring strategies, and hold the potential to serve as an additional, complementary technology to chemical analysis.

Because bioassays measure the biological effects of single compounds present in water samples, they are particularly useful for application in assessing the harmful effects of complex mixtures of unknown pollutants. As a result, bioassays have the potential to widen the scope of water quality monitoring, and can be tailored to and adjusted for testing a range of water sources, from general toxicity tests to very specific biological activities.

Though some scientists and end-users view bioassays as a potential replacement of more costly techniques, currently, regulatory acceptance of bioassays is slow. Demonstration and validation studies are being carried out in an effort to bring

bioassays toward regulatory acceptance.

The studies found that in order to facilitate the operational use of these tools for decision-makers, knowledge dissemination is essential.

### Conclusions and recommendations

Ultimately, transparent sharing of research results, increased communication, and more trans- and interdisciplinary exchange and collaboration between researchers, utilities and SMEs have been shown to provide the greatest potential for successful knowledge transfer and uptake of new technologies. Despite these findings, key barriers to, as well as opportunities for, need further investigation moving forward.

Firstly, for promising water treatment technologies to effectively tackle emerging pollutants, regulatory standards have to be defined for emerging contaminants at the national- and EU-level, such as for example, laws that establish long-term target values for water quality of waste water treatment plant effluent, surface water, and drinking water. In addition, increasing regulatory pressures will motivate water utilities to implement innovative solutions-oriented technologies, while also providing an incentive for technology developers to generate innovations.

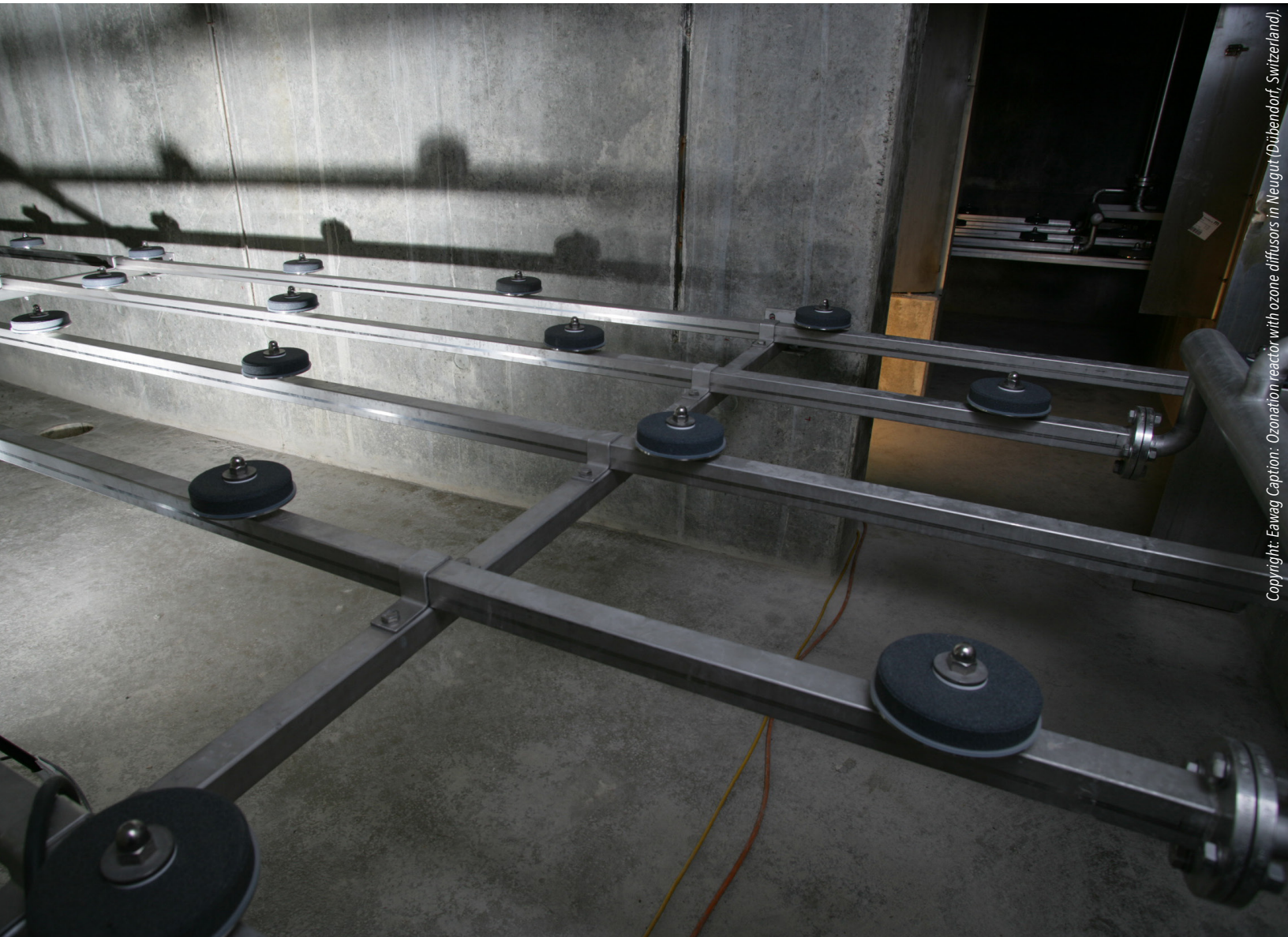
Secondly, movement towards better integration of regulators and policy makers into the innovation cycle is also needed. Without targeted input and timely feedback from policy makers and regulators, technological advancements will always follow rather than lead the innovation curve. Informing the general public is one way to raise public awareness on the topic and create pressures that can result in direct policy action. In this regard, LCA and LCC results have a great potential to convey complex research messages to the non-scientific community.

Thirdly, as already highlighted, there are economic barriers and associated risks. As mentioned previously, SMEs and water utilities often cannot bear the burden posed by such economic barriers. Because innovation in the water sector is often fraught with uncertainty, it requires a very specific environment for actors to be willing to engage and also be successful.

Large-scale projects such as DEMEAU, that provide the economic security and stability to innovate, have demonstrated the potential to facilitate environments for collaborative technological advancements in water treatment. Not only do such projects facilitate synergistic, cross-sector knowledge sharing, but also they provide the testing grounds for trying promising technologies before they are fully launched on the market.

### Acknowledgments

The DEMEAU project is supported by the supported by the European Seventh Framework Programme (EU-FP7) under grant agreement No. 308330. DEMEAU follows a solution-oriented approach using applied research and demonstration sites to explore five promising technologies. News on the project and detailed contact information for the partners involved are available on the project website [www.demeau-fp7.eu](http://www.demeau-fp7.eu).



Copyright: Eawag Caption: Ozonation reactor with ozone diffusers in Neugut (Dübendorf, Switzerland).