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PROJECT PERIODIC REPORT

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Name, title and organisation of the scientific representative of the project's coordinator[1]:

KWR, Theo van den Hoven

Tel: +31 30 60 69 511

Fax: +31 30 60 61 165

E-mail: Theo.van.den.hoven@kwrwater.nl

Project website[2] address: http://demeau-fp7.eu/

[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

Final publishable summary report

Executive Summary (max 1 page)

DEMEAU has promoted the uptake of knowledge, prototypes and practices from previous EU research in order to enable the water sector to face emerging pollutants (EPs). The project focused on four groups of technologies, being Managed Aquifer Recharge (MAR); Hybrid Ceramic Membrane Filtration (HCMF), advanced oxidation processes and bioassays.

All groups of technologies got a push to the market. Both ceramic membranes for drinking water production and ozonation as polishing step for wastewater treatment reached the stage of full-scale implementation. Special mentioning deserves the full-scale ozonation reactor at the wastewater treatment plant in Neugut (Switzerland), which is running successfully since March 2014. This is the first plant in Switzerland with an additional ozonation step and serves as a reference for the about 100 plants to be upgraded in the next twenty years.
The project developed and demonstrated an innovative and energy efficient (30-40% energy saving) UV reactor to inactivate EPs. The reactor will be implemented full scale in the coming period.
Project outcomes related to MAR include new design concepts (such as pre-treatment with a reactive organic layer or with combined ozone/hydrogen peroxide/UV oxidation), a European approach for MAR authorization and a supportive toolbox for operators and decision makers.
DEMEAU selected and validated a set of bioassays and derived trigger values for them above which human and ecosystem health risks might occur. This boosted the implementation of bioassays in chemical monitoring programmes of water utilities as well as in policy frameworks (i.e. the upcoming EU legislation on Water Reuse) and in standardization (DIN/ISO, OECD).

To support wider implementation of the addressed technologies, we established Unique Selling Propositions on the basis of LCA and LCC assessments. To enable these assessments, we developed characterization factors for the selected EPs. These factors add to the database of LCA frameworks to assess the impact of water treatment technologies on the environment and public health.

We raised awareness of the project through dissemination events at the water utilities, workshops and conferences and through the website, social and printed media. A video animation of the project (https://www.youtube.com/watch?v=v8iihsQYOos) attracted a lot of attention.

Summary description of work context and objectives (max 4 pages)

The overall objective of DEMEAU is to promote the uptake of knowledge, prototypes and practices from previous EU research enabling the water and wastewater sector to face emerging pollutants (EPs). After reviewing previous European research projects we have selected technologies and outcomes grouped as follows.

- Managed Aquifer Recharge (MAR);
- Hybrid ceramic membrane filtration, combining ceramic membranes with processes such as coagulation, pre-coats of powdered activated carbon or ion exchange pre-treatment;
- Hybrid advanced oxidation processes;
- Bioassays.

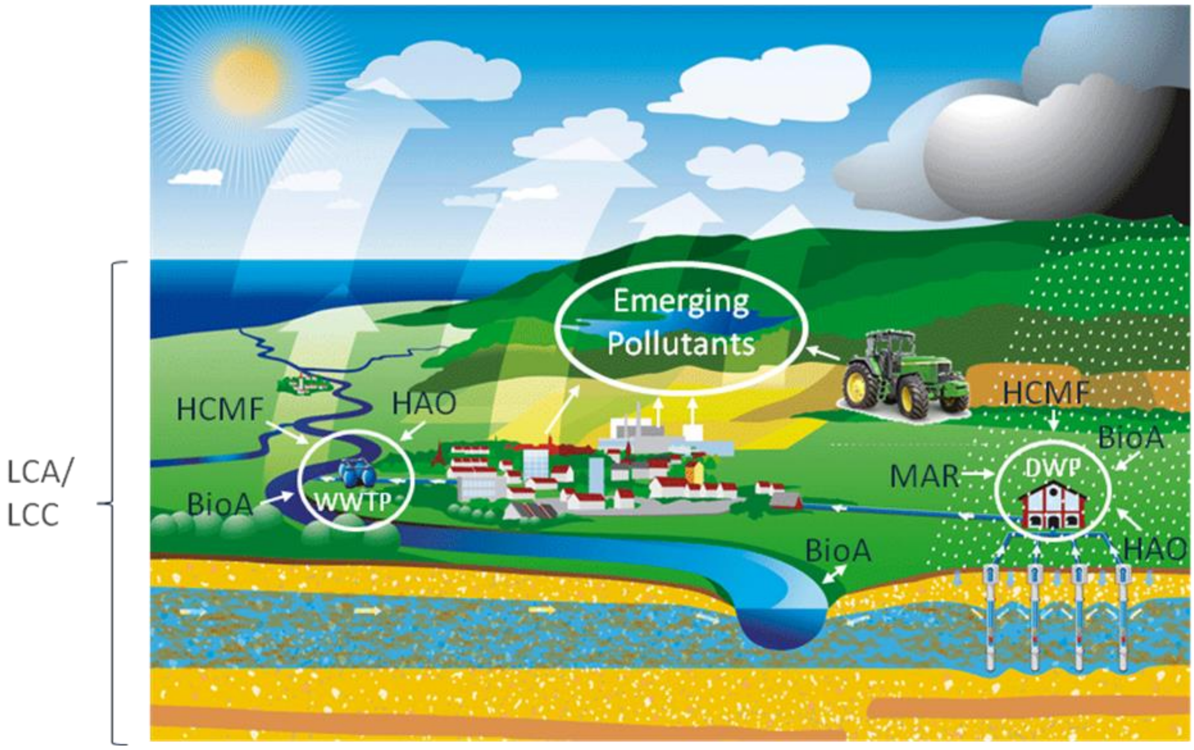
Important considerations in the selection were the following ones.

- Relevance for the water sector at a global level, apparent a.o. from the broad interest of water utilities. MAR enables storage of water in periods of good resource quality and it offers natural degradation of pollutants. Hybrid ceramic membranes are capable of removing a broad spectrum of pollutants. Oxidation processes are good candidates to treat surface water and municipal wastewater effluents, which are a main source of emerging pollutants. They also offer flexible and low-cost solutions to treatment processes for drinking water production. Modern bioassays provide cost-effective means to generate a tight monitoring tool for water quality, including emerging and unknown pollutants;
- Proof of principle available from previous projects;
- Proven and broad interest from SME's (market potential);
- Added value to existing technologies and practices.

DEMEAU is organised around each of the four selected technology areas.

In addition an important objective of DEMEAU is to address barriers and promoters for implementation, being performance assessment against conventional technologies, standardization and policies.

The figure below demonstrates how the different technologies in DEMEAU are interconnected.



Interconnection of the DEMEAU technologies and methods. MAR – Managed Aquifer Recharge; HCMF – Hybrid Ceramic Membrane Filtration; HAO – (Hybrid) Advanced Oxidation, BioA – Bioassays, LCA/LCC – Life Cycle Assessment / Life Cycle Cost; WWTP – Waste Water Treatment Plant; DWP – Drinking Water Plant.

Common to all DEMEAU technologies is that a lot of expertise and experience is available for each technology at the laboratory, pilot or even full scale, but they are not yet widely implemented in water utilities for various reasons. While the barriers to utilisation for MAR are the authorisation procedures and public perception, for bioassays regulation trigger values still need to be defined at the policy level. Other barriers include the lack of communication and information flow between research experts and the utilities that are looking to update their treatment plants. Additionally, there are also often legal and/or regulatory barriers, economic barriers, and barriers associated with maintenance. LCA (Life Cycle Assessment) and LCC (Life Cycle Costing) should help to overcome these barriers by proving the effectiveness and cost-benefit of the technologies.

Through its cooperation with water utilities, which act as launching customer and demonstration sites, DEMEAU aims to show the effectiveness and feasibility of these technologies and encourage their wider application.

WA1 Managed Aquifer Recharge (MAR)

This Work is to demonstrate the benefits of MAR and to provide a toolbox with applicable methods for data interpretation and modelling for its authorization as well as recommendations for optimal design and operation in compliance with the European Community Directives, especially within the frame of water-reuse.

MAR has been investigated in a variety of R&D projects since many years and many installations in Europe have been in operation for decades. However, at current stage a certain reluctance to install new sites can be observed even though they are mentioned in the EU Water Framework Directive (WFD) as possible supplementary measure to achieve good quantitative and qualitative groundwater status. This is mainly due to the fact that certain organic trace substances have been observed to persist in the subsurface and the site-specifity of the performance.

More specific, WA 1 was to cover two main aspects:

- demonstrating the effect of existing MAR sites in Europe onto groundwater quality and quantity,
- recommendations to support site authorization at new sites in compliance with the EU environmental legislation (WFD, GWD) including definition of pre-requisites and the development of a toolbox.

WA2 Hybrid ceramic membrane filtration in water treatment

Ceramic membranes do offer several advantages over state-of-the-art membranes such as better mechanical and chemical stability, better performance and a longer lifetime resulting in lower energy consumption, less waste and a more sustainable membrane operation. In the recent EU-project TECHNEAU the benefits of (hybrid) ceramic membrane filtration and improvement of the water quality using ceramic membranes was proven on laboratory and pilot-scale for different applications. Until recently the application of ceramic membranes, however, was hampered by a relatively high investment cost. Because of recent innovations, such as the new ceramic membrane filtration system design Ceramac®, the development of hybrid ceramic membrane systems and developments in automatic process control and integrity monitoring, the cost of ceramic membrane filtration can be reduced dramatically. The CeraMac® reactor largely reduces the number of membranes in a pressure vessel. In combination with a better mechanical and chemical stability and longer lifetime, this makes ceramic membranes a cost-effective alternative for polymeric membranes.

This work area is to demonstrate the benefits of (hybrid) ceramic membrane filtration with ceramic membrane systems on a large scale, including the improvement of the water quality. Furthermore, this Work Area will demonstrate the technical and economic feasibility and integrity of hybrid ceramic membrane systems (HCMF) in general and the Ceramac® technology in particular on demonstration and full-scale level.

Also this WA is to demonstrate a new automatic process control system based on artificial neural networks (ANCS), which results in lower investment and operational costs of membrane based processes. Another objective is to demonstrate and validate the integrity of ceramic membrane systems, using Laser-induced Breakdown Detection (LIBD).

WA 3 Advanced treatment (UV-H_2O_2, O_3-H_2O_2, O_3-biological filter) of drinking water and waste water

This Work Area will demonstrate the potential of (hybrid advanced) oxidation technologies for water and waste water application in full scale. Next to the recent EU-projects (TECHNEAU, THREE, NEPTUNE, RECLAIM WATER) waste water and drinking water oxidation will be studied jointly to benefit from the knowledge in each sector, the removal processes and the influence of the source water composition on the efficiency. Appropriate online control of the technologies to assure constant high water quality with minimal energy consumption is an important task to improve the long-term stability and robustness of the processes, a prerequisite for implementation. We will demonstrate the up-scaling, controlling, and validation of (advanced) oxidation technologies for drinking and waste water treatment together with partner utilities at different sites.

We will conduct applied research on the removal processes in different advanced treatment processes to close research gaps hampering the technology transfer to practice. A major barrier is the uncertainty related to the formation of oxidation by-products (OBPs) from matrix components and transformation products (TPs) from micropollutants. The minimization of OBP formation and the mitigation of TPs by a combination of different oxidation processes or by post-treatment will be studied and evaluated by theoretical concepts (including kinetics and mechanisms), chemical analysis and bioassays (together with WP6). The experiences and results thus obtained will be used to develop a decision tool for the implementation of oxidation technologies.

WA 4 Implementation of novel rapid and quantitative bioassays for water quality monitoring

This WA builds on earlier outcomes of EU projects in developing innovative biological screening tools for integrative, quantitative biological effect-based analysis of complex mixtures of pollutants in water. The development of new molecular screening tools is expanding rapidly. We aim to generate a system of powerful quantitative *in vitro* bioassays to effectively measure a wide range of major classes of toxicants (i.e. acutely toxic compounds, endocrine disruptors and genotoxic agents) in the water cycle. Since, these molecular screening tools may not yet be at a stage to capture all relevant pollutants, simple in vivo tools using preferably non-vertebrate organisms or early life stages will be considered, avoiding the use of higher vertebrates as experimental animals, and increased costs and lower throughput generally associated with these methods.

These tools hold great promise in being introduced and integrated in current monitoring strategies using mainly chemical analytics, and expectedly are highly complementary to modern chemical-analytical methods: while bioassays are particularly suitable to assess hazards even of complex mixtures of pollutants with limited possibilities of chemical identification, chemical analytics typically focuses on identification of compounds irrespective of their biological effect. In combination a much more powerful and cost effective system of chemical water quality can be designed, which offers important societal and economic benefits.

However, these technological innovations also face barriers including current legislation which needs adaptations to allow the use of these novel technologies, while it may also challenge existing interests of stakeholders. Therefore, consensus building, standardisation and demonstration studies at launching facilities is essential. In doing so, this WA will provide a generic roadmap to the implementation of innovative bioassays in the water sector, and remove existing barriers for implementation.

This WA aims on the selection and validation of the minimal panel of bioassays for cost-effective comprehensive toxicity screening from a broad range of available novel bioassays for the evaluation of water and wastewater quality. In addition, integration of automated sample workup with automated in vitro toxicity screening will be pursued aiming to facilitate implementation. The validation tasks aim at bioassay-based toxicity screening of water samples and compliance with legislation. Since most of the proposed activities in DEMEAU have already been carried out for *in vivo* bioassays, we will focus primarily on *in vitro* methods as being developed by consortium SMEs.

Importantly, this WA will focus on the technical implementation of the selected and validated rapid toxicity screening panel at a selection of water utilities. It will address regulatory and other barriers, aiming at removal of such barriers. This WP will also serve as a platform to test technologies as tested and developed in other work activities (MAR in WA1, HCMF in WA2 and advanced oxidation in WA3).

WA 5 Overcoming barriers and fostering the uptake of the technologies

This WA addresses performance testing of the technologies demonstrated in this project. Also this WA will address institutional and regulatory barriers for the uptake of these and other innovative technologies in the water sector. A first objective is a comprehensive and holistic assessment of the sustainability profiles of promising new water technologies identified in WA 1-4 to quantify potential benefits in environmental and economic terms to foster uptake and implementation of emerging technologies by the water sector and identifying key application areas based on a unique selling proposition (USP) for each of the technologies. In particular, the following issues will be addressed:

- Assessment of environmental footprints via Life Cycle Assessment (LCA)
- Enhancing LCA impact assessment for toxicity of micro-pollutants and water footprint
- Assessment of economics via Life Cycle Costing (LCC)
- Development of guidelines for consistent sustainability assessment of water technologies

A second objective is to foster implementation of the promising new water technologies identified in WA1-4 to maximize impact. Identifying and stressing the USPs of each technology is addressed and is a crucial prerequisite but not sufficient for a successful market penetration.

In order to assure a swift uptake and achieve high implementation rates the following additional issues need to be addressed for these new technologies:

- Implementation barriers: for the identified key application areas obstacles and difficulties for an uptake of these innovative technologies in the water sector have to be identified and assessed. Especially available and required capacities, organisational, institutional and regulatory barriers have to be carefully taken into account.
- Recommendations for impact: For each new technology demonstrated in WP1-4 specific recommendations have to be formulated for their most promising application areas.

WA 6 Dissemination

The objective of this WA is to ensure an effective dissemination of project results to all relevant stakeholders, most importantly utilities, policy makers, standardisation bodies, but also the general public. The ultimate goal is to facilitate the market deployment and exploitation of the technologies.

In addition to utilizing standard channels for dissemination (website, project brochure, scientific journals and events, movies/animation, technology promotion brochures), a central means for liaison with potential end-users will be provided by technology demonstration events at the associated utilities. Furthermore, strategies for overcoming barriers to market deployment will be actively addressed in the framework of tailored workshops.

Description of main S & T results/foregrounds (max 25 pages)

At the start of the project we organized several workshops to further specify tasks, to build the teams and to agree on cross cutting issue, such as a list of emerging pollutants (EPS) as a common basis for the research and piloting activities in all Work Areas.

DEMEAU list of emerging pollutants (EPs)

Substance	Group
Benzotriazole	anti-corrosive agent
Bezafibrate	lipid modifying agent
Carbamazepine	antiepileptic
Diclofenac	antiinflammatory / antirheumatic
Iopromide	X-ray contrast media
Metoprolol	beta blocking agent
Phenazone (Antipyrine)	analgesic / antipyretic
Primidone	antiepileptic (barbiturate)
Sulfamethoxazole	sulfonamide antibacterial
Trimethoprim	Antibacterial

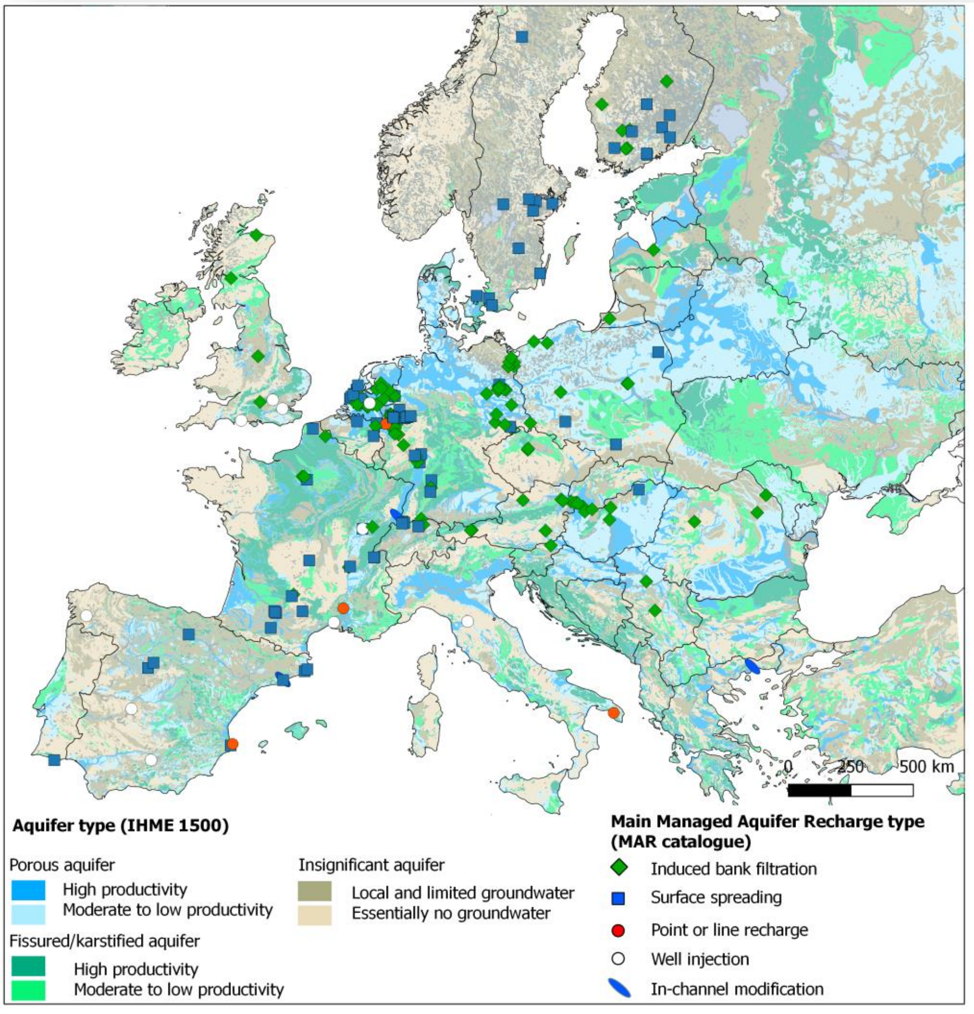
We selected these EPs as they are commonly found in water resources, they represent a broad spectrum of chemical and physical properties including good to bad elimination by oxidation. Also the available at consortium partner labs was a criterion.

These compounds are investigated at all sites. Depending on the site, the water matrix the treatment process and the availability in the analytical labs, we included additional compounds for each study separately. For the lab studies on ozonation transformation products, we did not choose the ten DEMEAU compounds because for most of them the reactivity and transformation products have already been studied. Therefore, we choose compounds that are specifically interesting for this study, for example compounds that have reactive sites for the attack of ozone.

In the starting phase we also invested in connections to the utilities associated to DEMEAU. These utilities include Waternet (the Netherlands), Berliner Wasserbetriebe (Germany), PWN Waterleidingbedrijf Noord-Holland (the Netherlands), Sociedad General de Aguas de Barcelona (Spain), WAG Wassergewinnungs- und aufbereitungsgesellschaft Nordeifel mbH (Germany), Waterworks Zurich (Switzerland), Zweckverband ARA Neugut (Switzerland), Dunea (the Netherlands) and Water company Limburg (the Netherlands).

WA1 Managed Aquifer Recharge (MAR)

To learn from existing MAR sites, we produced a unique catalogue with information on location, operation, hydrogeology and water quality of 270 European MAR sites with 40 parameters for each site. The catalogue shows an increase of MAR in Europe over the past decades with bank filtration used in the majority of sites, followed by spreading methods like infiltration ponds. The catalogue is useful for operators and planners to categorize their site and relate it to existing ones. It shows a huge potential for MAR in the Mediterranean Region. The further usage of the compiled data beyond the life time of the project was secured by establishing contacts to the International Groundwater Resources Assessment Centre (IGRAC) in The Netherlands. The data from the European MAR catalogue will be incorporated into a global MAR inventory currently developed by the IGRAC.



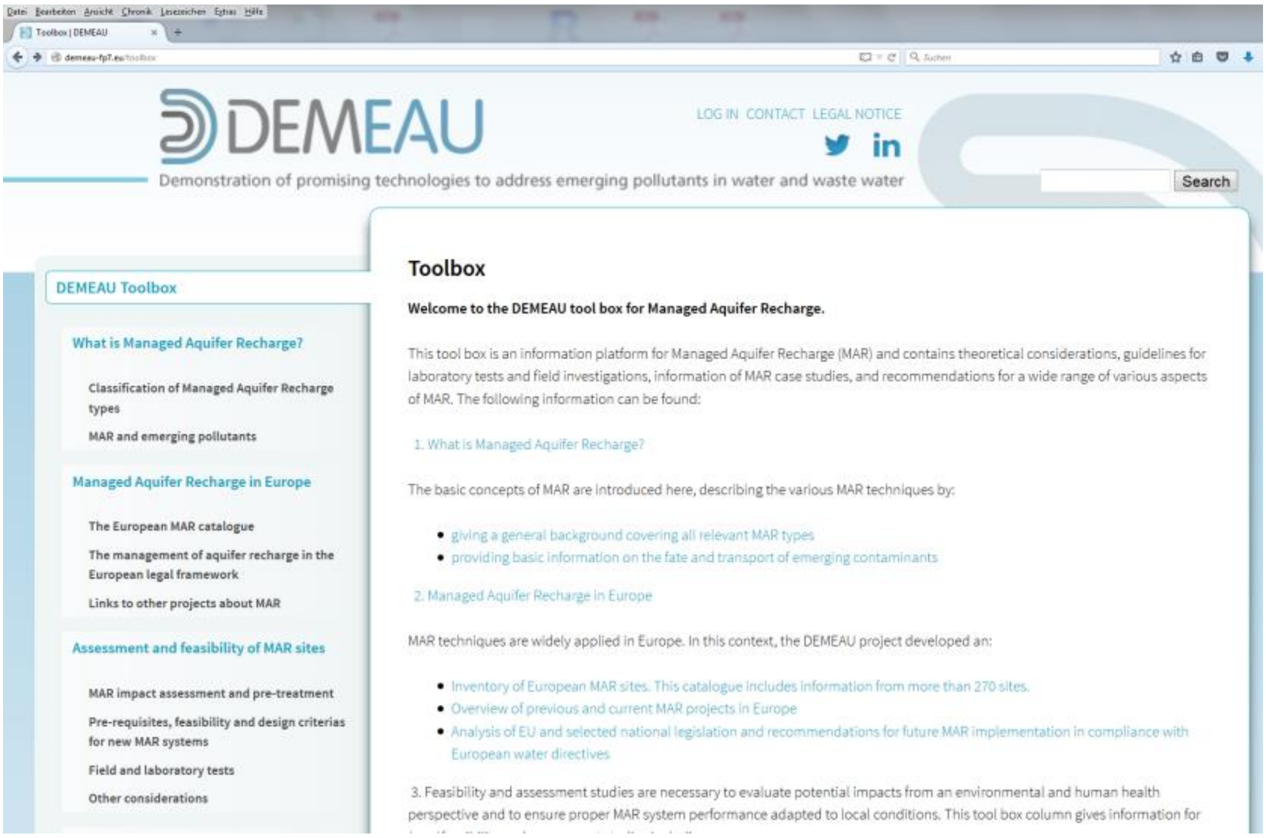
Catalogue of MAR sites with data from 120 induced Bank Filtration sites, 86 Surface Spreading sites and 12 Well Injection sites.

A comprehensive bibliographic review of removal rates of 12 EPs in different MAR-sites shows that redox status and residence time are key parameters. These parameters are included in a decision matrix for operators and researchers to determine the persistence of trace organics in the subsurface

To promote the application of MAR systems and to support operators and authorities to design and operate new MAR systems that will comply with the European Water Directives while minimizing energy consumption and costs, we developed and validated various supportive tools. This includes the following tools.

- Protocol for soil-column experiments assessing fate and transport of trace organics
- Soil-column study protocol to assess the fate of emerging pollutants under MAR conditions
- Hydraulic characterisation of managed aquifer recharge sites by tracer techniques
- Approaches to assess the long-term impact on ambient groundwater
- Risk Assessment methodologies
- Design criteria, including pre-treatment options
- Data handling tools

Together with the key parameters determining the removal of emerging pollutants in MAR systems, we collected these tools in the 'DEMEAU MAR toolbox' which is easily accessible on a web page (http://demeau-fp7.eu/toolbox). The toolbox contains also illustrative case studies.



Screenshot of the DEMEAU tool box for Managed Aquifer Recharge.

With the knowledge of source water and intended end-use, the most appropriate pre-treatment methods and their removal efficiencies for contaminants of main concern as well as removal efficiencies in the MAR systems can be assessed by using a the DEMEAU MAR toolbox. We assessed possibilities to design and operate a MAR system with minimal environmental impact at two MAR sites using LCA and LCC.

We developed recommendations for the implementation of MAR in compliance with EU legislation including possible points of compliance for different MAR techniques.

WA2 Hybrid ceramic membrane filtration in water treatment

DEMEAU contributed to the design and validation of the construction of the top and bottom plate of the Ceramac® reactor, which is an essential part of the reactor as these plates have to resist large pressures during the high flow and very short backwash cycles. We applied CFD and FEM modelling to select production techniques. Tests of nearly 800 backwashes showed that the reactor is stable and ready for implementation in the full scale water production plant in Andijk (the Netherlands). The full scale is currently being tested before being operated 24/7

To remove EPs from water, ceramic ultrafiltration membranes have to be combined with other treatment steps into Hybrid Ceramic Membrane Systems (HCMF). In the original plans the benefits and feasibility of HCMF was to be demonstrated on pilot-scale in the HAMBURG WATER Cycle® project “Jenfelder Au” of the Hamburger Stadtentwässerung HSE. After the start of DEMEAU, the commissioning of this eco-sanitation project was postponed which forced us to look for an alternative demo-scale project, which we found in the municipal WWTP effluent from ARA Birs (Basel-Landschaft, Switzerland) and Almelo (The Netherlands).

Top view of the plate and frame system of the HCMF demosites in Basel (left) and Almelo (right).

In Basel we demonstrated hybrid ceramic membrane processes with submerged membranes both for operating conditions and their efficiency for micropollutant removal. We studied combinations of ultrafiltration membranes with powdered activated carbon (PAC) and iron flocculants. Most of the target micro pollutants were removed from the municipal wastewater by the tested PAC-UF process with 60 to 95% efficiency. Especially the non-polar compounds (benzotriazole, carbamazepine and diclofenac) were removed with 80 to 95 % efficiency. Negligible removal of the target compounds was observed during the reference phase, i.e. without PAC addition into the system. Lower fouling was observed during the operational phase with PAC addition. In comparison to the reference operation the fouling rate after the stabilization of PAC concentration decreased from 3-4 kPa/d to 2-2.5 kPa/d. The enhancement of PAC separation by coagulation by iron addition failed, possibly due to high mixing gradients in the compartments of the HCMF units, which did not provide proper conditions for flocculation.
In Almelo we demonstrated a PAC-HCMF pilot plant for removal of EPs through short and long term tests. The removal of EPS was studied at three PAC dosages (15, 30 and 60 mg PAC/L) and at two permeate fluxes (60 and 100 L/m2.h) in short term tests. Long term experiments were conducted to investigate the stability of the hybrid PAC-HCMF process. These tests aimed at studying the effect of PAC dosing on Trans Membrane Pressure development at different permeate fluxes during a continuous pilot operation. PAC dosage of 30 mg/L was used in these experiments and permeate fluxed of 60, 80, 100 and 120 L/m^2.h were investigated. For the CALUX

bioassay measurements extra samples were taken during the experiment with 60 mg PAC/L dosing. In general, higher PAC doses lead to increasing removal of the selected EPs. Depending on the solutes and PAC dose (tested 0-15-30-60 mg PAC/L) up to 90 % removal could be achieved. The highest removal (70-90 %) was achieved with 60 mg PAC/L. With a relative low dose of 15 mg PAC/L showed only 0-20 % removal while with 30 mg PAC/L about 20-70 % could be achieved. A stable flux of 100 $L/m^2.h$ was achieved as the highest possible with this pilot. There is no significant effect measured of the PAC dosing for the stability HCMF process. Chemical cleaning of the membranes was adequate to maintain a stable PAC-HCMF process. No significant relation was found between removal percentages and physicochemical properties of the EPs, such as charge, logKOW or logDpH 7,4. Bioassays showed that HCMF was capable to remove up to 90 % of the activity. In conclusion, the demonstrations on municipal WWTP effluent in Basel and Almelo showed that HCMF is a stable process and able to remove the EPs with 60-95% effectiveness. Up to 90% of the bioassays triggering compounds could be removed.

Automatic Neural Net Control systems (ANCS) are able to optimize flux, filtration time and/or chemical cleaning frequency of a membrane filtration plant with respect to water production demand, chemical or energy demand and effluent water quality. Lowering investment costs by process optimization is of great interest for (ceramic) membrane plants as their ability to compete with other treatment processes strongly depends upon the cost factor. We demonstrated the potential and benefits of ANCS at a pilot of the backwash treatment system of UF plant in Roetgen near Aachen (Germany). The system was “trained” under various process parameters to identify the optimal choice of operational parameters for the control of the UF backwash process. Application of ANCS at the large scale plant was planned but due to project delay and problems with data connection, implementation on the full scale UF system in Roetgen was not possible. Instead, extra offline optimization trials were carried out. Data from the large scale plant were pre-processed to calculate characteristic filtration cycle parameters. With those data we validated ANCS data of the plant data. Results show the benefit of productivity optimization. Possible savings amount to about 30%.

The demonstration of the nanoparticles analyser based on Laser-Induced Breakdown Detection (LIBD) to determine nanoparticle removal and on-line integrity of membranes encountered problems with the stability of the laser system. This resulted in a major delay in activities. In the end we wrote a test protocol and conducted tests on a lab-scale UF pilot with polymeric virgin and compromised (handmade leak) UF membranes. The trials showed that LIBD has a sufficient repeatability and reproducibility to measure nanoparticles as low as 103 part./mL and as small as 20 nm. With a limit of detection around 103 part./mL, the lack of analysis software limited the quantification of the concentrations around 106 part./mL. Calculation of the log removal between the feed and the permeate was in most cases not possible because of the screening effect (bigger particles hide the smaller ones) and the quantification limit around 106 part./mL. Consequently, the analyser is more efficient to apply to the filtrate of membrane processes for industrial online monitoring. This was proven during both on a lab scale and pilot scale experiment. LIBD proved its ability to detect membrane leaks of nanometer sizes (< 40nm).

To enable application under rough field conditions and by laymen, the related SME adjusted the design of the LIBD analyser and successfully tested this on pilot scale at a water treatment plant.

WA 3 Advanced treatment (UV-H_2O_2, O_3-H_2O_2, O_3-biological filter) of drinking water and waste water

DEMEAU investigated the effectiveness of the treatment technology for chemical and ecotoxicological water quality at WWTP Neugut in Dübendorf (Switzerland). This WWTP is the first plant to run with an additional ozonation step and serves as an example for the upgrade of other WWTPs. With the adoption of the new water protection act in Switzerland in 2014 to minimise the occurrence of EPs in natural water bodies, around 100 WWTPs need to be upgraded with an advanced treatment step.

Different doses of ozone were applied to elucidate the optimal conditions to eliminate the 12 substances currently proposed in Switzerland. For this WWTP, an ozone dose of 2.0 - 3.3 mg/L (0.55 g ozone / g DOC) is recommended to eliminate these 12 plus another 40 analysed substances to more than 80% overall across the entire plant. Two toxic by-products, bromate and N-nitrosodimethylamine (NDMA), are known carcinogenic compounds that can be formed with ozone. They were analysed according to a modular testing framework to evaluate the treatability of wastewater with ozone. The concentrations of bromate and NDMA expected in the receiving water body after dilution were below the drinking water standard of the World Health Organization. The efficiency of ozonation and various post treatments to reduce ecotoxicological effects still occurring in the conventionally (biologically) treated wastewater was assessed with various bioassays. The investigations revealed that the wastewater treatment with ozone resulted in significantly reduced ecotoxicological effects. Biological post-treatments partially led to further decreases in the effects. In a few assays partially higher effects after ozonation occurred, which could be removed by suitable post-treatments with biological activity. In general, a biological post-treatment, e.g. a sand filtration, is recommended after ozonation, as it eliminates easily degradable compounds like NDMA. Overall, a significant improvement in the water quality of the WWTP effluent was achieved with ozonation plus biologically active post-treatment.

We tested different strategies for dosing ozone at WWTP Neugut. As a result, the ozone production and dosing is today controlled by the water flow with a down-regulation at rain events, which proved to be a robust and reliable dosage strategy that minimizes both, energy consumption and formation of undesired by-products. The UV absorbance gives further information on the water composition and can be used to optimise the ozone dosage. We also evaluated the investments and additional operating costs for the ozone reactor at WWTP Neugut. The total costs of operation including amortization are adding up to about CHF 0.06/m3, corresponding to a theoretical increase of current costs by 10%. However, thanks to optimizations at other ends at the WWTP Neugut, the costs do not increase for the end user.

We conducted experiments with ozone and ozone/H_2O_2 treatment in the pilot plant for drinking water treatment at the Water Supply Zurich (Switzerland). In addition to the original plans, we tested a novel AOP system (PROMIX) which was provided by XYLEM free of charge. In both O_3/H_2O_2 advanced oxidation processes, a minimal elimination of 87% for all spiked compounds was achieved at the highest ozone and peroxide doses (3 and 9 mg/L, respectively). In this condition, bromate formation was still lower than 3 µg/L (below the drinking water guideline value of 10 µg/L) due to the low concentration of bromide in the influent water (about. 15-17 µg/L).

The team conducted pilot scale treatment with UV/H_2O_2 at two drinking water production plants in the Netherlands (Bergambacht and Heel). We tested a model to predict the conversion of a broad range of organic EPs in a UV/H_2O_2 process with low pressure UV lamps, which was applied to optimize UV reactors of partner SME Van Remmen. We observed that the model predictions were very accurate (for most pollutants <10%), that very high conversion could be obtained, and that the optimized UV reactors resulted in a 30-40% reduced energy demand of the process. Furthermore it was shown that the effect of pre-treatment of the water, reducing the DOC content and increasing UV-T values, can improve reactor performance by 30-70%, depending on matrix composition and type of pollutant. It was also shown that application of a LP UV system at Heel does not result in the formation of mutagenic by-products. We found that the photolysis of nitrate, in combination with the presence of NOM, may result in the formation of possible mutagenic by-products. In order to prevent this, at nitrate concentrations >10 mg/L, photolysis of nitrate may be prevented by applying LP instead of MP UV lamps, or possibly to remove nitrate and/or NOM.

Sound decisions on the removal of EPs by oxidation technologies have to address the prevention of toxic by-products formation from the source water matrix and the assessment of the potential for toxic transformation products formation from EPs. In this field, research gaps had to be filled with additional lab and field experiments. We determined ozonation rate constants for selected compounds occurring in high concentrations in the WWTP effluents, while compiling the kinetics of ozone reactions of other compounds from literature. Also we measured photolysis rate constants for a selection of compounds for LP and MP UV/H_2O_2 processes in different water matrices. The compilation of kinetics and mechanisms for the transformation of organic substances and how the EPs elimination during oxidative water treatment can be predicted are presented in a report.

Collimated Beam experiments to determine the process parameters affecting the formation of potentially mutagenic by-products resulting from UV/H_2O_2 treatment showed that minimizing photolysis of nitrate and NOM content helps to lower or even prevent the formation of mutagenic by-products. Pilot experiments at the drinking water production plant Heel confirmed these results.

We set up an experimental method for the detection and identification of ozone transformation products and investigated three compounds in detail including several ozonation transformation products. This brought us a step further in understanding the mechanism of ozone reactions with EPs, which is relevant for the implementation of ozonation technologies.

To assist decision makers in the implementation of oxidation technologies for elimination of EPs we developed tools both for wastewater and drinking water treatment. For wastewater treatment, this is a modular laboratory decision tool which helps to decide if treatment of a specific wastewater with ozone is recommended by assessing several parameters (matrix effects on ozone stability, elimination efficiency for EPs, oxidation by-products, bioassay activity). For drinking water treatment, it describes under which circumstances the treatment with ozone, O_3/H_2O_2, or UV/H_2O_2 may be the treatment of choice. For this evaluation, the concentration of bromide in the raw water plays a crucial role, since ozone reacts with bromide to form the by-product bromate, a suspected carcinogenic compound. The addition of H_2O_2 to ozone is mitigating the formation of bromate. In treatment with UV/H_2O_2, no bromate is formed, however, the process is more energy demanding which increases the costs.

WA 4 Implementation of novel rapid and quantitative bioassays for water quality monitoring
As a first step to the implementation of innovative bioassays in the water sector we have selected a panel of bioassays to assess the effect of EPs for further validation. The selection took place in consistency with views of DIN/ISO and included as criteria performance characteristics, validation status, costs and service availability. In total we have evaluated more than a hundred bioassays with a focus on human health safety and modes of action relevant for the Water Framework Directive compounds. The bioassays included a CALUX® human cell-based bioassay panel of DEMEAU partner BDS, but also its main competitors. Using outcomes of validation tests on the DEMEAU technologies, we selected the key assays that were most informative and suitable for comprehensive water quality monitoring while still being practical and cost-effective.

Toxicity endpoints	Escher et al	DEMEAU cases	WFD compounds screen	DEMEAU bioassay(s)
Xenobiotic metabolism	X	X	X	PAH CALUX PXR CALUX

Endocrine disruption/developmental toxicity	**X**	**X**	**X**	**ER CALUX antiAR CALUX GR CALUX**
Genotoxicity	**X**	**X**	**X**	**P53 CALUX**
Cytotoxicity		**X**	**X**	**Cytotox CALUX**
Adaptive stress response	**X**	**X**		**Nrf2 CALUX**
Lipid metabolism		**X**		**PPAR CALUX**
Ecotoxicity assays		**X**		**Bacterial/algal inhibition assays**

DEMEAU core bioassay panel. All CALUX assays that scored positive (X) in the WFD compound screen are included. The NRF2 and PPAR assays are facultative and responsive to chemicals in surface water that are unrelated to the regulated ones, while the ecotoxicity assays can be included when focussing on environmental risk assessment.

Since bioassays are preferably used as a pre-screen in safety assessment, we also assessed if compounds listed in the WFD are recognized by the bioassay panel. The assay panel was automated and high throughput activity assessment with the entire CALUX panel in DEMEAU revealed about 70% of those chemicals were active, again suggesting that this list may not represent always compounds of highest concern. Our results showed that hazard identification and risk assessment of such hugely complex chemical mixtures thereby cannot rely solely on lists of prioritized chemicals, and warrants inclusion of biological methods which nowadays can be reliable and quantitative.

We paid ample attention to regulatory acceptance. DEMEAU partners are actively involved in a DIN/ISO working groups for the standardization of bioassays. One of those groups (ISO/TC 147/SC 5 N) is developing an ISO protocol for the assessment of estrogenic activity in (waste)water using *in vitro* tools (CALUX, Yeast estrogen screen), and carries out blinded validation/ring test studies. Further validation of ER-CALUX an AR-CALUX assays in a broader context is undertaken to generate OECD guidelines.

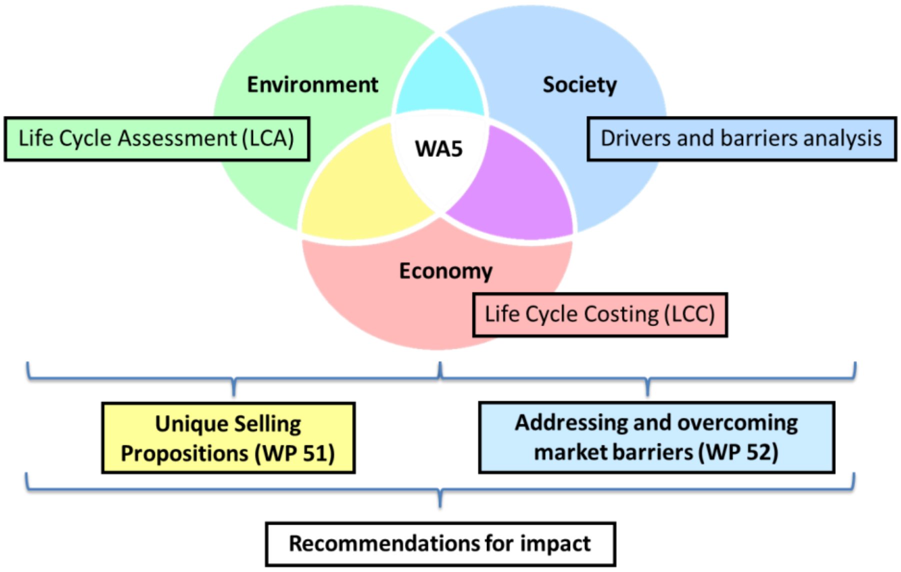
A very important step in the regulatory acceptance of bioassay data was the establishment by DEMEAU of so-called trigger values which define a level above which human and/or ecosystem health risks cannot be waived and additional examination of specific activity is warranted.

We have screened the DEMEAU technologies with the selected bioassays. Screening of various types of MAR sources (groundwater, surface water and WWTP effluent) revealed the importance of endocrine - oxidative stress and photosynthesis inhibition pathways. We found clear differences between samples that can help to guide optimization of the performance of the MAR site. Screening of a HCMF (PAC-UF) system for the removal of EPs from municipal wastewater showed high removal rates of hormonal effects, bacteria luminescence inhibition and photosynthesis inhibition in algae as induced by the spiked chemicals. Wastewater treatment with ozone resulted in significantly reduced activity in the majority of bioassays as compared to effects measured in the conventionally (biologically) treated waste water. In a few assays higher activities after ozonation occurred, which could be removed by suitable post-treatments.

To promote the implementation of bioassays at water utilities, we developed a water quality testing framework with associate partner Waternet. Also we organised a training workshop and started follow up projects at specific utilities.

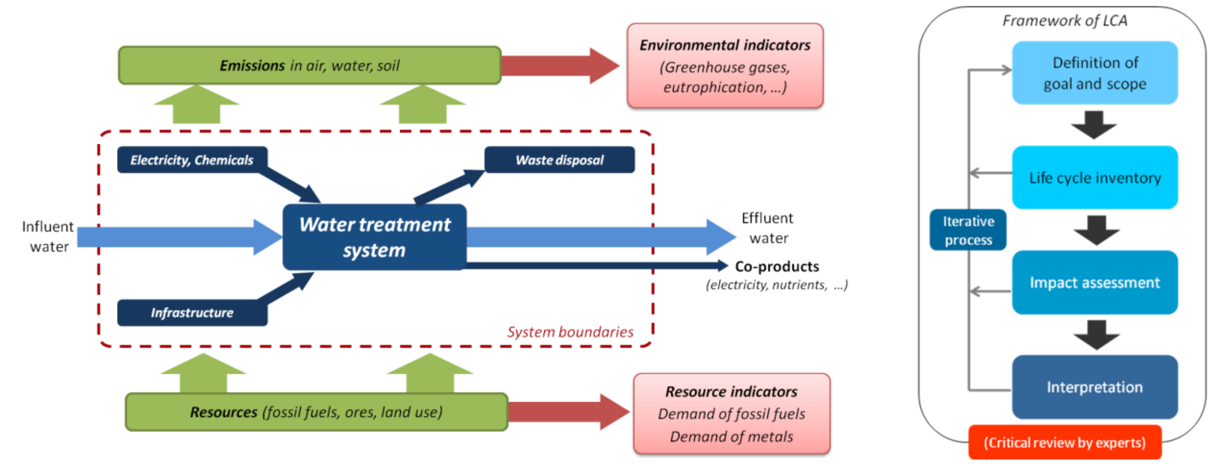
WA 5 Overcoming barriers and fostering the uptake of the technologies

Work area 5 aimed at assessing environmental, economic and social aspects of all technology groups studied in DEMEAU. Main technological application areas in combination with environmental and economic characteristics helped to define ‘unique selling propositions’ (USPs) for each technology. In combination with an understanding of market drivers and barriers derived from stakeholder feedback on real implementation of the technologies, we formulated recommendations for impacts. A conceptual approach was agreed upon during the beginning of the DEMEAU project and further concretized by applying different assessment tools to concrete case studies from all technology work areas of DEMEAU: i.e. Environmental Life Cycle Assessment (LCA), economic Life Cycle Costing (LCC) and social drivers and barriers analyses.



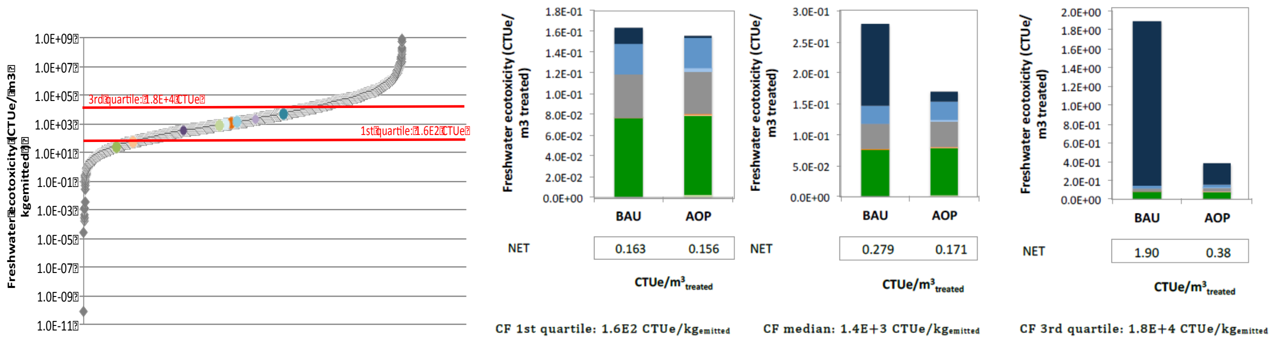
Sustainability components, respective analysis tools (Life Cycle Analysis, Life Cycle Costing and drivers and barriers analysis) and their integration in DEMEAU.

In consultation with all WA-leaders and stakeholders, we selected case studies to be analysed on their sustainability profile provided data for the LCA and LCC analyses were available. We reported USPs along with detailed outcomes and discussion of LCA and LCC results of DEMEAU case studies. Experiences gained over the course of the DEMEAU project from the combined application of aforementioned tools in five case studies helped in the formulation of ‘final guidelines for sustainability assessment of water technologies’. The first sections of the guidelines provide ‘hands-on’ recommendations to prepare and carry-out the sustainability assessments in the individual case studies. This is a crucial step because all analyses depend on a transparent data flow between the sustainability assessment team and the case studies and encompasses (based on our experience) the following four steps: (1) the selection of case studies; (2) definition of the technical systems, their system boundaries (figure below, left panel) and future scenarios such as implementation of an additional micropollutant removal stage; (3) exchanging and validating input data; and (4) validation and quality control (figure below, right panel). The guidelines thereafter detail the application of LCA, LCC and drivers and barriers analysis for water technologies and their integration into ‘recommendations for impact.’



DEMEAU guidelines for sustainability assessment of water technologies. Left panel: typical system boundaries of an LCA for a water treatment system; right panel: framework of LCA according to ISO 14040/44 (source: DEMEAU deliverable 51.1 'Unique selling propositions')

One of the challenges we encountered with regard to LCA application was the limited number of possibly prevalent micropollutants actually monitored and measured at the different case study sites and the lack of specific LCA characterization factors for assessing their potential environmental impact. By applying the USEtox® consensus model for toxicity assessment in LCA, we calculated new characterization factors for the predefined list of DEMEAU EPs at the beginning of the DEMEAU project to be measured at all sites. Nevertheless, this proved a challenge because accounting for a limited number of compounds necessarily leads to an underestimation of the total (eco)toxicological improvement potential in the water sample. Assumptions on the overall toxicity of the micropollutants in WWTP effluents can be quite decisive, as seen in the figure below where an extrapolation approach was developed to show the potential range of total ecotoxicity score of a WWTP effluent sample..



Left panel: range of freshwater ecotoxicity LCA characterization factors of DEMEAU target compounds (coloured dots) in comparison to all available LCA characterization factors in the USEtox® database with 1st and 3rd quartile; right panel: freshwater (eco)toxicity of effluent emitted from WWTP Neugut under business-as-usual (BAU) scenario and with ozonation assuming a mean toxicity of the micropollutants in the wastewater to be at the 1st, median or 3rd quartile (source: DEMEAU deliverable 51.1 'Unique selling propositions')

The social drivers and barriers analysis conducted for the same case studies as LCA and LCC provided insights into enabling or constraining factors for market uptake. We identified capacity gaps beyond the actual implementation of the technologies encompassing four different levels: (i) contextual, such as policies and regulations; (ii) inter-organisational, such as relationships, agreements and consultative networks among stakeholders; (iii) intra-organisational, such as organizational culture, procedures and resources within organisations; and (iv) individual such as relevant knowledge, skills and motivation of involved individuals. Initially, a drivers and barriers analysis was conducted using online surveys among stakeholders from the selected case studies. Result helped to identify at which level within the innovation process different stakeholders were most active and revealed perceived drivers and barriers for the wider application of the technologies. Subsequent in-depth drivers and barriers assessment workshops and interviews helped to confront different stakeholder groups with these drivers, barriers and capacity gaps and to define possible ways to overcome barriers. An example output table of such a workshop is provided in the table below.

Example results table from an stakeholder workshop conducted for MAR in Spain (source: DEMEAU deliverable 52.2 'Recommendations for impact')

	BARRIERS	REQUIRED FROM SCIENTIFIC COMMUNITY	REQUIRED FROM ADMINISTRATION	REQUIRED FROM OPERATORS
		• Establishment of MAR communities, with special attention to the science-policy interface: exchange of knowledge, local options and consequences • Cooperate on realistic guidelines and regulations that consider the health and environmental effects in a measurable way • Willingness to communicate with each other, openness, transparancy		
TECHNOLOGICAL	• Well clogging • Lack of maintenance protocols • Quality of infiltration water • Effects on ecotoxicology of groundwater are unknown	• Model clogging effects and find solutions • Translate experiences from other countries to local projects • Stop solving problems that already have been solved somewhere else • Determine the boundary condtions under which MAR is an effective solution.	• Make existing technological questions explicit	• Make plants/playgrounds available for pilots and tests
REGULATORY	• Regulators still see too many risks • Regulation are inflexible • Conservative attitude of regulators • Regulation does not (yet) include the variety of water qualities (incl recycled water) • Lack of health and environmental parameters • Complex communication among various administrative levels	• Define health and environmental parameters to be able to make MAR practices measurable • Listing priority substances to monitor. • Dissemmination to and coordination with regulators	• Aim for regulations that are locally adaptable • Inlcude measurable parameters (also of emerging pollutants) in regulations that allow measurement of the effects on water quality (instead of being strict on the inflow water) • Consider water quality on basin level • Don't come up with new regulations, but improve existing ones • Improve communication among adm. levels • Adapt EU regulations to local circumstances	• Be transparent: show results, provide test data, real costs, reasons for failure, etc. to look jointly for solutions • Participate in discussions (especially local discussions regarding specific solutions) • Don't just 'assume' that regulations are and will always be a barrier.
FINANCIAL	• MAR competes with other water related solutions • High costs for pre-treatment of (recycled) water for well injection • Open question of who pays the bill • Viability of solution is questioned	• Conduct and communicate Lifecycle Costing and Lifecyle assessments to clarify the 'choices' and longer term effects	• Aim for public funding on a longer term (avoid limited subdidies) • Integrate costs of water reclamation in water bill (to allow for higher investments) • Consider also the (partly qualitative) savings done by reclaiming water • Extending exploitation period (for operators), redistribution of costs • Not "coffee for all" (refers to autonomous regions)	• Contribute financially to development and maintenance of technology and regulations (is already done by some) • Invest in tertiary treatment (which enables infiltration of cleaner water)
SOIAL	• Conservative attitude of consumers • Lack of dissemination on local level	• Communicate findings (in understandable language) outside scientific community	• Start public dialogue about MAR, including various stakeholders	

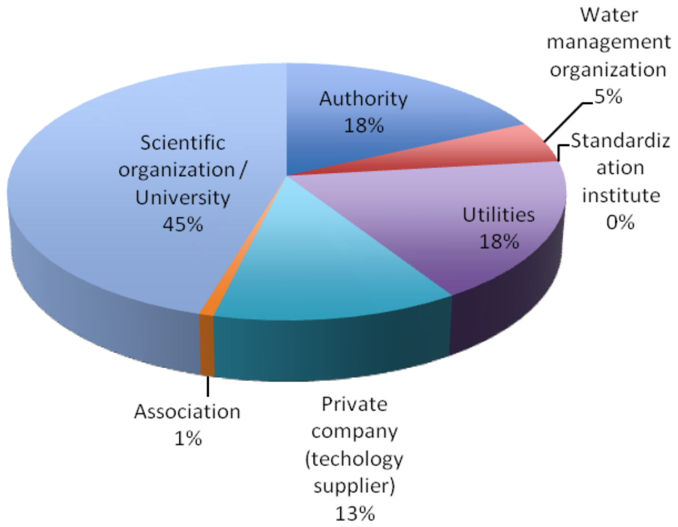
Along with the range of benefits and costs of the new technologies against business-as-usual scenarios in wastewater and drinking water treatment derived from LCA and LCC analyses, we then prepared recommendations for impact for all technologies studied in DEMEAU to foster their market uptake and increase their future impact within the water sector. We prepared the recommendations as self-standing capacity building documents for each technology group in DEMEAU. These could ideally be used in conjunction with the technology brochures developed in WA6.

WA 6 Dissemination

We planned the dissemination activities of DEMEAU in the beginning of the project on the basis of an assessment of our target groups and outlined the activities accordingly in the dissemination strategy. DEMEAU's target groups comprise water utilities as the end users of the technologies, policy makers, scientists and technology developers as well as the general public. In order to highlight the synergies of DEMEAU's work areas and thus the technologies, we developed a storyline that helped to prepare dissemination messages used for a variety of means and activities.

We developed different dissemination means for different target groups. For awareness raising, we produced a video animation, newsletters, a leaflet and technology brochures. The short video animation, 'Dare to drink? Emerging pollutants in our water,' provides a visual of the storyline, and targets policy makers and the general public. It illustrates what emerging pollutants are, how they enter water sources and what role individuals can take in improving the quality of their drink water. By September 2015 it has over 1,200 views, and has reached a wide breath of audiences.

To target utilities, we organised so called utility events to present the respective technology at the demonstration site and to forward the results of the DEMEAU activities. In conjunction with the utility events we organised workshops that targeted at all stakeholders relevant for the implementation of the technology, ranging from authorities, to utility operators, to laboratories. We organised utility events for MAR in Scheveningen, Berlin and Barcelona, for HCMF in Andijk and Roetgen, for oxidation technologies in Neugut and Zürich and for bioassays in Paris.In general, the demography of participants at utility events and linked workshops was diverse as shown in the figure below. The scientific community was generally best represented at such events, also due to the fact that the project staff consists to a majority of scientists. Representatives of authorities, utilities, and the private sector (primarily technology suppliers) were represented in relatively even shares. Very small proportions of participants were from water management organisations and associations. We see this mix of representatives from each target group as a positive outcome of the project's outreach.

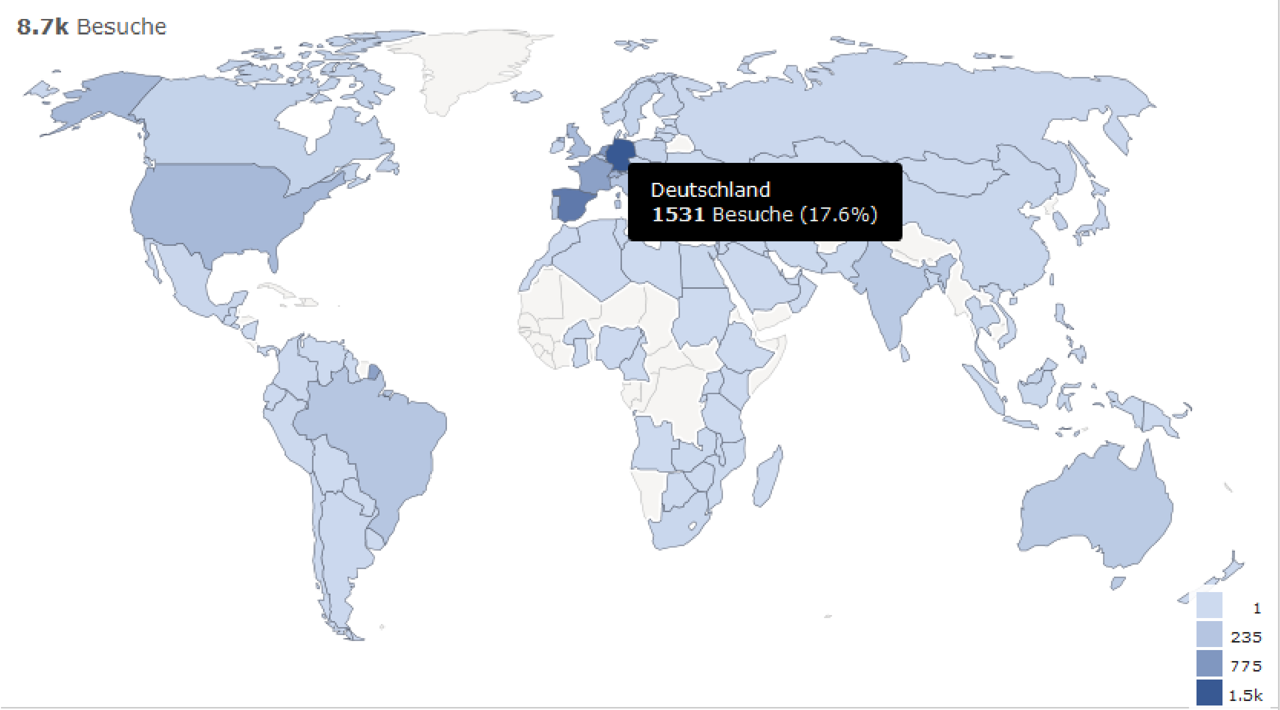


Participants of DEMEAU utility events and workshops according to target groups.

To influence policy for fostering uptake, we used external events to reach out to policy makers, e.g. the WssTP annual conference in Brussels 2015, the FP7 Resource Efficiency Cluster Events and DIN/ISO working groups for standardisation of bioassays. Workshops facilitated stakeholder participation and utility events together with contributions to European working groups such as the Catalan Water Partnership helped to reach out to technology clients..

In order to reach the scientific community, DEMEAU staff participated in conferences and presented the research.

Most importantly to mention as digital communication channels are the project's website, social media and online networks. The website was launched on December 06, 2012 and showed a steady and large increase in website traffic. From the date of launching till the end of the project on August 31, 2015, there have been 35,409 cumulative visitors to the site. The DEMEAU website has been effective at attracting a large number of visitors, developing a wide network that spans across the entire globe from nearly every continent. The figure below visualises the full distribution of visitors for the website. Germany housed the highest number of visitors to the website (17.8%).



Distribution of visitors on the DEMEAU website according to country. Germany hosts the majority (17.8%) of website visitors.

The DEMEAU Twitter account drew initially upon the Twitter users among the network of the project consortium and garnered 300 followers over the course of the project. The account was also followed by a wide network of users in Twitter, including WssTP and WaterNewsEurope. These users have themselves large followership and provide important information to their audience.

Example tweets of DEMEAU colleagues to promote the project.

We used Twitter to announce a wide variety of activities, including utility events, workshops, press releases for major project deliverables, interesting news articles, and retweets from other relevant tweeters across the drinking and wastewater sector. Because the Twitter account and the website are linked, both channels helped to boost the other's presence. For example, the release of the video animation was announced on Twitter, and helped to increase traffic on the website as well as increase the number of views of the animation.

The newsletters, released in every year of the project, provided an overview of the milestones of the project. We emailed the newsletters to the wider DEMEAU network and distributed it at external dissemination events e.g. at the WssTP annual conference in Brussels and at the World Water Week in Stockholm. The first newsletter focused on introducing the project and providing an overview of the status of the research among the technologies. The second newsletter provided preliminary findings among the technologies, and also provided a special piece of the DEMEAU storyline to facilitate continuity as the project progressed. The third and final newsletter served to communicate the larger milestones of the project and also provide insights into any major conclusions.

DEMEAU also produced several articles. One article published in the German American Water Technology magazine served as a final dissemination product for the project. In project partners published or will publish scientific articles. We produced Technology Brochures for Bioassays, ANCS and MAR and distributed them during the DEMEAU events, through the website and also through the project partners at other dissemination possibilities.

The final dissemination event was split into four packages: (i) a final consortium meeting on 17, 18 June in Dubendorf open to the public, (ii) a presentation at the WssTP Water Innovation Europe conference on 24 June in Brussels , (iii) a booth at this conference to reach out to water managers and representatives of the water sector and (iiii) a presentation at the resource efficiency cluster on 16 September in Brussels.

Potential impact and main dissemination activities and exploitable results (max 10 pages)

As described in the DOW and referring to the FP7 Work Programme, the expected impact of the project was *'To exploit at the maximum the potential of existing technologies and previous results studies in order to increase their chances to innovate (technological and non-technological innovation)'*.

DEMEAU has successfully exploited the results of previous European research projects in the field of water technologies (e.g. TECHNEAU, RECLAIM WATER, NEPTUNE, PuriFast) to address the challenge of emerging pollutants in the water cycle. We addressed both technological and non-technological barriers.

We have focused on four groups of technologies: Managed Aquifer Recharge (MAR), Hybrid Ceramic Membrane Filtration, Advanced oxidation processes and bioassays. Apart from the technological aspects we have addressed barriers and promoters for their implementation.

All groups of DEMEAU technologies got a push to the market. To summarize, ceramic membranes for drinking water production and ozonation as post treatment for waste water reached the stage of full scale implementation. An innovative and energy efficient UV reactor demonstrated its value on pilot scale and will be implemented full scale in the coming period. A European approach for MAR authorization and a supportive toolbox for operators and decision makers is available to boost the application of MAR systems. Bioassays are increasingly used for pre-screening in water quality monitoring programmes. The selection and validation of a set of bioassays in DEMEAU together with the derivation of trigger values for them helped to boost the implementation of bioassays. DEMEAU set steps towards adoption in regulatory schemes (DIN/ISO, OECD), but full implementation requires longer timeframes and more validation and standardization efforts. This work will be continued in international follow up projects and activities such as within the framework of the Global Water Research Coalition and in DIN/ISO working groups for the standardization of bioassays.

Of course these achievements are not the sole benefit of DEMEAU, as most of our activities were embedded in other projects and initiatives. But DEMEAU certainly contributed to the progress in all technology areas addressed in the project.

More specific, DEMEAU has achieved the following impact.

For MAR systems.

- The project has delivered the first up-to-date and full characterization of MAR sites in Europe (European MAR catalogue). Apart from demonstrating the capabilities of MAR systems when it comes to the removal of emerging pollutants, this catalogue is an excellent basis to promote MAR systems in Europe and beyond. The 'DEMEAU MAR tool box' gives easy access to supportive instruments for water utilities and authorities who consider the application of MAR systems. Outcomes are taken on board in follow up projects such as the EU funded projects MarSol and SubSol.

For Hybrid Ceramic Membrane Filtration (HCMF)

- DEMEAU has demonstrated the potential of ceramic membranes to remove EPs from contaminated resources. The revolutionary CeraMac® concept with nearly 200 membranes in one pressure vessel substantially lower the investment costs and makes ceramic membranes an attractive alternative for conventionally applied polymeric membranes. DEMEAU contributed to the design and testing of the top and bottom plate of the reactor, which is implemented in the full scale drinking water production plant in Andijk (the Netherlands). This plant is currently being tested before being operated 24/7. We showed that, combined with other treatment processes ceramic membranes into HCMF systems, this technology is able to substantially remove EPs from WWTP effluent.

- The use of ANCS in the water industry is a topic of research for many years already, but application at a full scale plant is realised for coagulation and distribution systems only. DEMEAU showed the potential of this technology to operate full scale membrane plants more cost-effectively.
- The LIBD technology as a system to monitor integrity of membrane based treatment systems showed their potential to detect leaks at nano-scale level, even under disturbing practical conditions at treatment plants. This holds promises for their market application, although further testing is required.

For advanced oxidation technologies.

- DEMEAU contributed to the up-scaling, controlling and validation of oxidation technologies at waste water treatment plants. We showed that these technologies do provide solutions which guarantee energy efficiency, robust controlling, efficient elimination of EPs, optimal mitigation of transformation products and minimal formation of oxidation by-products.
  Special mentioning deserves the full-scale ozonation reactor at the WWTP in Neugut. This reactor was taken into operation in March 2014 and is running successfully since then. This is the first plant in Switzerland to run with an additional ozonation step and serves as an example for the upgrade of other WWTPs. With the adoption of the new water protection act in Switzerland in 2014 to minimise the occurrence of EPs in natural water bodies, around 100 WWTPs need to be upgraded with an advanced treatment step. This shows the relevance and potential impact of the DEMEAU contribution to the Neugut plant.
- DEMEAU delivered an innovative UV/H_2O_2 reactor for the removal of EPs from drinking water resources based on CFD modelling and kinetic data of the conversion of EPs. Testing at drinking water production plants confirmed the model predictions on the conversion effectiveness of EPs. Even importantly, they showed that the newly developed reactors require 30-40% less energy than regular UV reactors. The latter is an essential feature to boost the application of the new UV reactor.
- The project produced a decision tool for the implementation of oxidation technologies to eliminate EPs. It helps to decide if treatment of a specific wastewater with ozone is recommended, and under which circumstances the treatment of drinking water with ozone, O_3/H_2O_2, or UV/H_2O_2 may be the treatment of choice.

For bioassays

- A validated, cost-effective and practical panel of bioassays for pre-screening in water quality monitoring programmes is now available, including trigger values for some assays above which further monitoring and action is warranted to prevent adverse health or environmental impacts.
- In the Netherlands, Switzerland and France, but also elsewhere (US, China, Brazil, Canada) water utilities are increasingly using bioassays, including the ones developed by DEMEAU partners. Important progress towards enhancing bioassay acceptance such as the establishment of trigger values, the analysis of WFD compounds, validation and test submission to regulatory authorities and demonstration studies for confidence building contributed to the increased application of bioassays.
- The project set steps towards regulatory acceptance of bioassays in DIN/ISO working groups and started further validation of some assays to generate OECD guidelines.

The DEMEAU team had to work inter- and transdisciplinary by combining environmental, economic and social approaches applied for water technologies in order to derive recommendations for their sustainable implementation in the water sector. Beside the purely technical aspects the communication between all involved stakeholders from several case studies was crucial. Learnings from this process and the application of relevant tools for water technologies were used to develop ‘Final guidelines for sustainability assessment of water technologies’ .

We developed new characterization factors for Life Cycle Assessments (LCA) with the international consensus model USEtox® for target compounds identified at the beginning of the DEMEAU project as well as an approach to transparently highlight assumptions and their influence on the valuation of the environmental performance of water technologies. This adds to the instruments to assess water technologies.

Drivers and barriers analyses during the DEMEAU project through online interviews, telephone interviews and stakeholder workshops helped to first identify enabling and constraining factors for market uptake. The confrontation of different stakeholders with identified barriers during workshops and interviews helped to gather different perspectives how to overcome barriers and make best use of existing drivers. This information together with target application areas and environmental and economic benefits and impacts built the basis for the formulation of technology and stakeholder specific recommendations for impacts.

Although not a primary focus, DEMEAU also contributed to the peer reviewed scientific knowledge with publications on supportive research for all demonstrated technologies.

Through social media and the video animation we reached out to the public at large to create awareness of the threat that micro pollutants such as medicines and personal care products in our water resources water might pose for public health and the environment. We communicated what consumers can do to prevent pollution and that, through innovation, the water sector still manages to keep health and environmental risks associated with pollutants in drinking water and waste water treatment effluents in almost all cases below critical levels.