European Commission

Micropollutants in the water systems

A contribution to the Zero Pollution Action Plan from the Research & Innovation perspective

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Report

Research and Innovation

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European Commission
Directorate-General for Research and Innovation
Directorate B — Healthy Planet
Unit B.1 — Circular Economy & Biobased Systems

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Micropollutants in the water systems

A contribution to the Zero Pollution Action Plan from the Research & Innovation perspective

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Directorate-General for Research and Innovation
Healthy Planet

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Abbreviations

Abbreviation	Definition
ARB	Antibiotic resistant bacteria
ARGs	Antibiotic resistant genes
BPD	Business Plan Development (Horizon Results Booster service)
BSG	Benefit of Specific Groups
CAP	EU Common Agricultural Policy
CECs	Contaminants of emerging concern
CP	Collaborative Projects
CSA	Coordination and Support Actions
DBPs	Disinfection by-products
DG	Directorate-General
DSS	Decision support system
EEA	European Environment Agency
EFSA	European Food Safety Agency
ERC	European Research Council
FP7	Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013)
GTM	Go To Market (Horizon Results Booster service)
H2020	Horizon 2020– the Framework Programme for Research and Innovation (2014-2020) (Horizon 2020)
IA	Innovative Actions
JRC	Joint Research Centre
MSCA	Marie Skłodowska-Curie Actions
NGO	Non-governmental organisation

PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PCT	Patent Cooperation Treaty
PDES	Portfolio Dissemination and Exploitation Strategy (Horizon Results Booster service)
PFAS	Per- and polyfluorinated alkyl substances
POPs	Persistent organic pollutants
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals
RIA	Research & Innovation Actions
WFD	Water Framework Directive
WssTP	Water Supply and Sanitation Technology Platform (currently Water Europe)

1 Executive summary

This report presents the results of a portfolio analysis of 83 projects funded under the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013) (FP7) and Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020) (H2020), which focus on micropollutants in water systems. The report provides an overview and a detailed assessment of advances made in R&I on micropollutants in three pre-defined Themes: 1) Measuring and monitoring; 2) Evaluating and assessing; and 3) Prevention and remediation.

The total cost of the project portfolio amounts €389,4 million, of which €297 million worth of EU support. For the purposes of this study, a common classification for the FP7 and Horizon 2020 research programmes has been provided. According to this classification, the ENV programmes' group has the largest number of projects in the portfolio (28 out of 83) and accounts for 44,8% of the total EU contribution. The FOOD, NMP and SME programmes' groups share the second place in terms of number of projects. In terms of distribution of projects across the three pre-defined Themes, Theme 3 - Prevention and remediation has the largest number of projects and accounts for nearly 60% of total EU contribution in the portfolio. There was a total of 1.110 participations in the projects, most of them from EU Member States. Germany, Spain, the Netherlands, the UK and Italy are the countries with the most participating institutions. The Associated Countries are represented most notably by Switzerland, Israel and Norway.

The methodology used for this study includes desk research, comparative analysis and expert assessment. The group of projects has been selected using a list of keywords related to micropollutants. At a later stage, projects below EUR 1 million budget and MSCA related to fellowship training and infrastructures were withdrawn from the sample, as well as H2020 projects starting after 2019. Desk research was performed on the information provided in the project portfolio, the CORDIS database and project websites. Based on implemented activities, outputs and results, every project has been associated with a specific type of pollutant, source of pollution and achieved or expected impact(s). The report also provides an overview of what projects have produced in terms of deliverables and publications.

In all three Themes, the majority of projects apply a multifunctional approach, as they usually address several types of pollutants rather than being focused on just one specific category. Pesticides and pharmaceuticals are the main types of pollutants addressed throughout the portfolio. In addition, Theme 1 also has a strong focus on microorganisms, while in Themes 2 and 3 a significant number of projects are aimed at endocrine disruptors and persistent organic pollutants (POPs). The mapping reveals that most projects do not focus on specific sources of pollution. Throughout the whole portfolio, the prevailing sources of pollution are land-based ones, as compared to sea-based sources. Agriculture stands out as the main source of pollution covered by projects in Theme 1. In Theme 2 and Theme 3, wastewater is the most widely covered source of pollution, followed by industry effluents.

All projects in the portfolio are associated with multiple impacts. However, there is a predominant technological impact related to the development of sensors, measurement and monitoring devices (Theme 1) and technologies aimed at reducing micropollutants in aquatic

systems (Theme 3). Projects under Theme 2 have primarily environmental impact, as they focus on evaluating and assessing the environmental behaviour and effects of micropollutants on ecosystems. The most common economic impacts in the portfolio are related to creating business opportunities and employment growth, while social impact is usually observed in projects that have implications for human health. Around 37% of projects have a policy impact, as they have either facilitated the revision of certain EU policies and regulations or have produced recommendations targeted at decision-making bodies.

Several recommendations can be made to facilitate synergies and coordination between stakeholders within the EU R&I Programmes, institutions, Member States and Associated Countries. R&I projects, which share a common theme or address similar issues, could be grouped in clusters in a publicly available database. In this way, projects could either collaborate and form partnerships, or build on previously accumulated knowledge and further enhance and upscale solutions. Collaborative platforms could be established for experts and stakeholders interested in specific challenges related to micropollutants in water systems. Such platforms would allow for knowledge spillovers and solutions being replicated or adapted to different contexts. In addition, the engagement of stakeholders in the processes of prevention and remediation through multi-actor platforms and co-creation techniques is recommended, as it greatly enhances the credibility of solutions.

Based on the review of projects in the portfolio, several gaps in terms of knowledge and innovation on micropollutants in water systems have been identified. Certain types of pollutants have been addressed by a relatively small number of projects and therefore, additional in-depth research is needed for them. These include: antibiotic resistant bacteria (ARB) and antibiotic resistant genes (ARGs), biocides, and microplastics, nonetheless it should be noted that actions have been taken since 2019 (under H2020-WP2020 and HE-WP 2021) for which results are still not available.

The key messages for decision-makers and policy recommendations identified in the portfolio projects could be classified in three groups. The first group concerns improvements of the Water Framework Directive (WFD) that would reduce the misinterpretations of its objectives and allow for the policy shift required. The second group of recommendation is focused on coherence between relevant EU directives and regulations and better harmonisation between EU and national legislation in specific areas of water management. The last group of recommendations is focused on the EU Common Agricultural Policy (CAP) and its implications for the protection of drinking water resources.

Several best practices in dissemination and exploitation have been identified in the portfolio in terms of their compliance with three criteria: 1) dissemination activities are adapted to different types of audience; 2) external opportunities are utilised to maximise the uptake of research; and 3) continuity is ensured beyond project completion, i.e., arrangements are made to ensure that information on project results will not be lost once the project comes to an end.

To stimulate exploitation, it is recommended that projects conduct market surveys among stakeholders to collect ideas on the potential for commercialisation of future products and their expected market volumes. Workshops with end-users could also be useful for receiving feedback and fine-tuning solutions. Projects should explore all possibilities for demonstration of developed

solutions to relevant stakeholders. To further facilitate exploitation, the EC could consider introducing regular updates in the CORDIS database related to the actual commercialisation of results after project completion. These could include information on market uptake, spin-offs, use of results by other projects (including other funding Programmes like Life+, ERDF), etc.

2 Introduction

This report presents the results of a portfolio analysis of 83 projects funded under the Seventh Framework Programme (FP7) and Horizon 2020, which focus on micropollutants in water systems. The report provides an overview of EU-funded science on micropollutants. Its findings could be used as inputs for the contribution of DG RTD to the Zero Pollution Action Plan, as well as the EU Strategic Approach to Pharmaceuticals in the Environment (PiE), and the current revision and evaluation of relevant Directives in the water sector. In addition, the report suggests possible approaches to establish synergies and coordination mechanisms for R&I programming with other stakeholders within the EU Programmes, Institutions, Member States and associated countries, as well as best practices for dissemination and exploitation of innovative solutions.

The report is organised as follows. Section 3 presents a brief overview of the existing policy initiatives related to micropollutants in water systems and a description of the pre-defined Themes and the related assigned projects. Section 4 describes the project portfolio and outlines the methodology for assessing project relevance in relation to types of pollutants, sources of pollution and impacts. This section also presents the actual results achieved by projects in terms of enhanced knowledge and innovative solutions. Synergies and coordination mechanisms, as well as best practices in dissemination and exploitation, are presented in Section 5. Section 6 presents the overall findings, conclusions and policy recommendations resulting from the portfolio analysis. Annexes with additional information on the project portfolio complement the report.

3 Policy initiatives and themes

3.1 Policy initiatives

A comprehensive mapping of policy priorities and challenges related to micropollutants in water systems has been carried out. This encompassed strategic and policy documents, legislative documents, and action plans. Depending on whether or not they introduce legally binding measures, the documents fall under several categories, presented below:

1. Legally binding instruments:
    - EU Water Framework Directive[1]
    - Urban Waste Water Directive
    - Nitrates Directive
    - Marine Strategy Framework Directive (currently under review)
    - Single-use Plastics Directive
    - EU REACH Regulation
    - Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (currently under review[2])
2. Policy initiatives:
    - European Green Deal for the European Union
    - EU Biodiversity Strategy for 2030
    - Chemical Strategy for Sustainability Towards a Toxic-Free Environment
    - Towards Zero Pollution in Air, Water and Soil – EU Action Plan (including Staff working documents SWD (2021)140 and SWD (2021)141).
    - European Strategy for Plastics in a Circular Economy.

It should be noted that most of the legally binding documents listed above address water quality in general. There are no specific provisions laid down on micropollutants and further work is needed to address emerging concerns in the current revision of the policy legislation packages. However, all these documents have been taken into consideration for a comprehensive overview of the wider challenges related to pollution in water systems.

[1] Including results of the conducted fitness check of the directive.
[2] Industrial emissions – EU rules updated (public consultation currently open).

3.2 Policy themes

This section introduces the three pre-defined Themes, to which projects in the portfolio have been assigned, with further details on what each Theme encompasses:

- **Theme 1. Measuring and monitoring**: projects under this Theme focus on developing analytical techniques for groups of substances, including techniques for sampling, detection, quantification and monitoring of micropollutants.
- **Theme 2. Evaluating and assessing**: projects under this Theme are aimed at evaluating and assessing the environmental behaviour and effects of micropollutants, including risk assessment and management of their effects on human health and ecosystems.
- **Theme 3. Prevention and remediation**: projects under this Theme focus on developing strategies and technologies to reduce micropollutants in aquatic ecosystems.

4 Analysis of the portfolio of projects

4.1 Description of the portfolio

The project portfolio analysed in this report includes 83 projects, 52 of which funded under the Seventh Framework Programme (FP7), and 31 supported under Horizon 2020. The total cost of the portfolio amounts €389,4 million, of which €297 million worth of EU support.

Most projects under Horizon 2020 are funded through Innovation Actions (IA) and Research & Innovation Actions (RIA), accounting for the largest share of EU contribution under Horizon 2020. There are fewer projects in the portfolio supported by the SME Instrument (Phase 2[3]) and Marie Skłodowska-Curie Actions (MSCA). Grants of the European Research Council (ERC) account for the smallest share of Horizon 2020 projects in the portfolio.

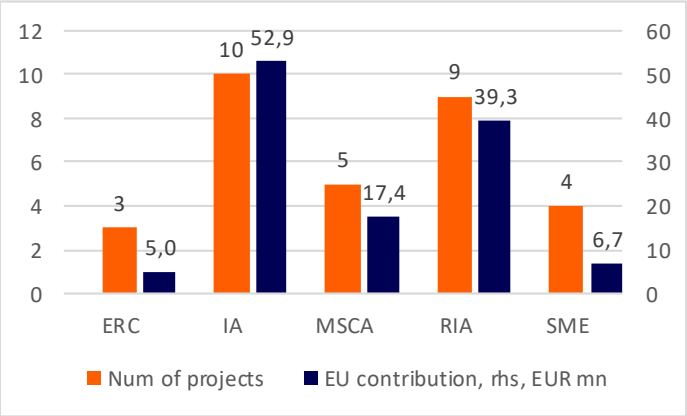

Figure 1. Number of Horizon 2020 projects and EU contribution by type of action

In terms of project funding schemes, most projects under FP7 are supported by the Collaborative Projects funding scheme (CP). Considerably fewer projects are supported by the Benefit of Specific Groups (BSG)[4] funding scheme, the European Research Council (ERC) scheme, the Coordination and Support actions (CSA) funding scheme, and the MC actions.

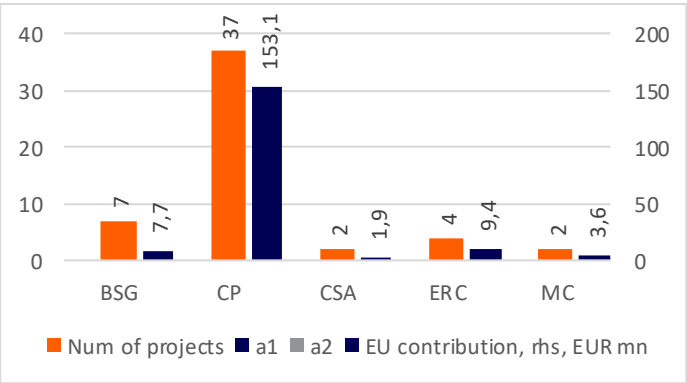

Figure 2. Number of FP7 projects and EU contribution by project funding scheme

[3] Phase 1 projects funded through the SME Instrument are not included in the project portfolio, as they are below the budget threshold of EUR 1 million.

[4] Under the FP7 Research Programme, the BSG funding scheme refers to projects where research is carried out for the benefit of specific groups, in particular SMEs.

Figures 3 and 4 below present the number of Horizon 2020 projects by Work Programme part and the number of FP7 projects by Research Theme, and their respective EU contribution. Under Horizon 2020, Societal Challenge 5 accounts for the largest EU contribution (effectively larger than indicated in Figure 3, as the two identified Circular Economy Focus Area projects are funded by the SC5 budget), and under FP7, the largest EU contribution is observed under the Environment programme.

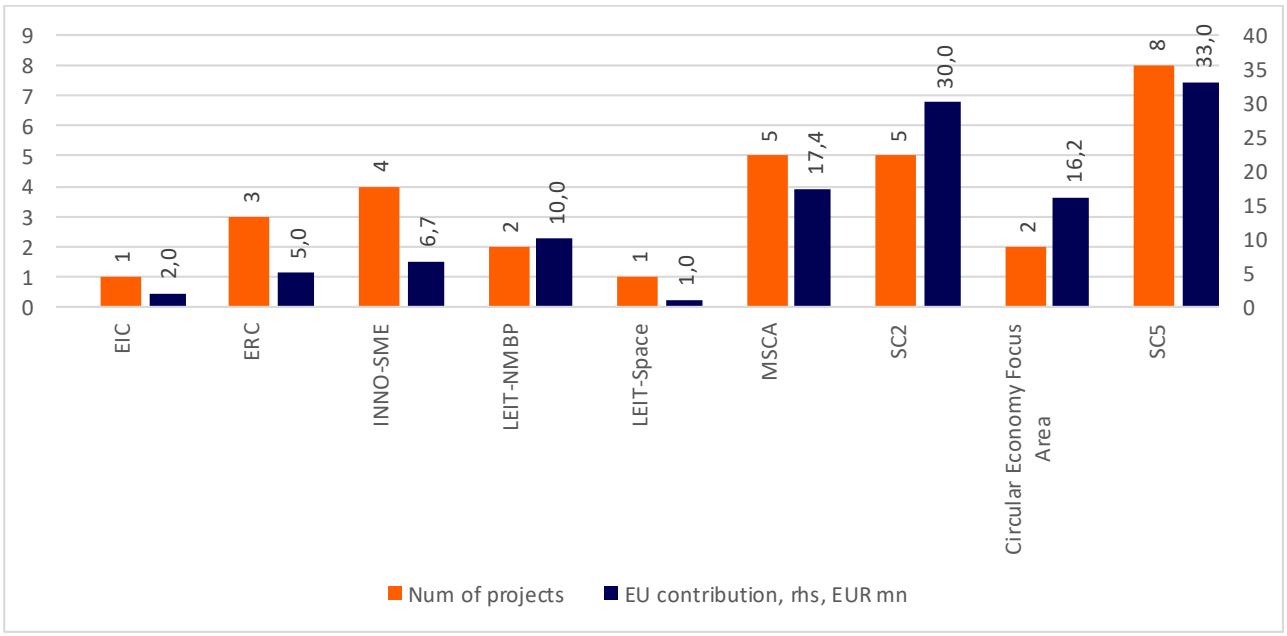

Figure 3. Number of Horizon 2020 projects and EU contribution by Work Programme parts

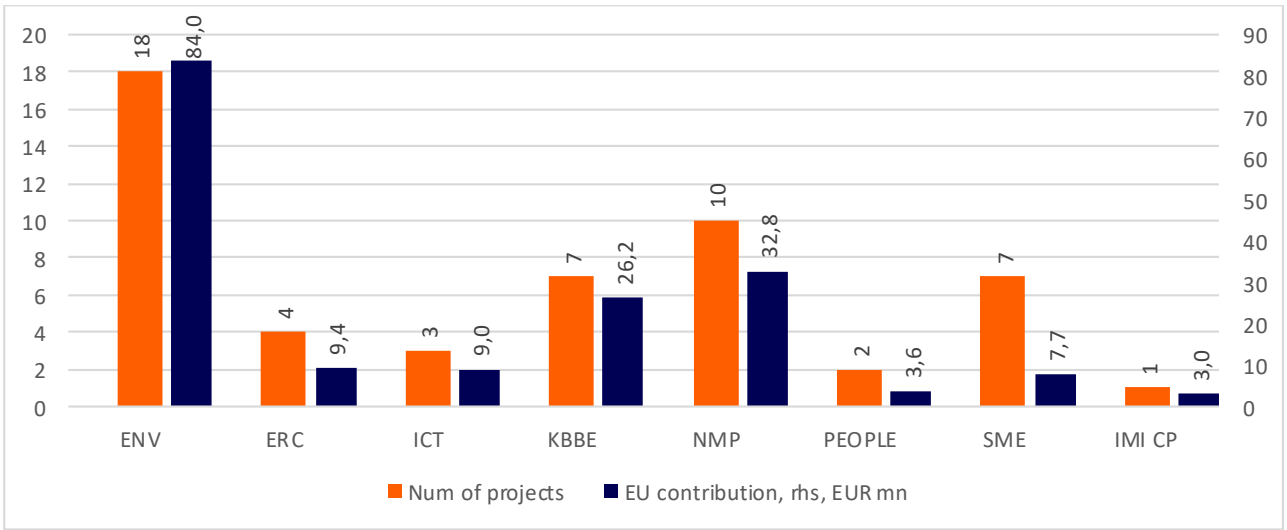

Figure 4. Number of FP7 projects and EU contribution by Research Theme

For the purposes of this study, a common classification for the FP7 and Horizon 2020 research programmes has been provided. This classification is composed by 9 thematic groups comprising projects from the following Work Programmes budget parts:

- **ENV**: FP7 *Cooperation programme* – Theme 6 *"Environment (including climate change)" & H2020 Societal Challenge 5 "Climate action, environment, resource efficiency and raw materials"*
- **ERC**: FP7 *Ideas programme – European Research Council programme & H2020 PART I – Excellent Science – European Research Council (ERC)*
- **FOOD**: FP7 *Cooperation programme* – Theme 2 *"Food, Agriculture and Fisheries, and Biotechnology" & H2020 Societal Challenge 2 "Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research, and the Bioeconomy"*
- **HEALTH**: FP7 *Cooperation programme* – Theme 1 *"Health" (Innovative Medicines Initiative – Joint Undertaking) (no projects from the H2020 framework Programme)*
- **ICT**: FP7 *Cooperation programme* – Theme 3 *"ICT – Information and Communications Technologies" (no projects from the H2020 framework Programme)*
- **MSCA**: FP7 *People programme & H2020 PART I – Excellent Science – Marie Skłodowska-Curie Actions*
- **NMP**: FP7 *Cooperation programme* – Theme 4 *"Nanosciences, Nanotechnologies, Materials and New Production Technologies - NMP" & H2020 PART II Industrial Leadership – "Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing"*
- **SME**: FP7 *Capacities programme – Part 2 "Research for the Benefit of SMEs" & H2020 PART II Innovation in SMEs*
- **SPACE**: *H2020 PART II Industrial Leadership – Space (no projects from the FP7 framework Programme).*

According to this classification, the ENV programmes' group has the largest number of projects in the portfolio (28 out of 83) and accounts for 44,8% of the total EU contribution. The FOOD, NMP and SME programmes' groups share the second place in terms of number of projects, as each one is represented by 12 projects. In terms of budget, the second place corresponds to the FOOD programmes' group, which have received nearly 19% of the total EU contribution.

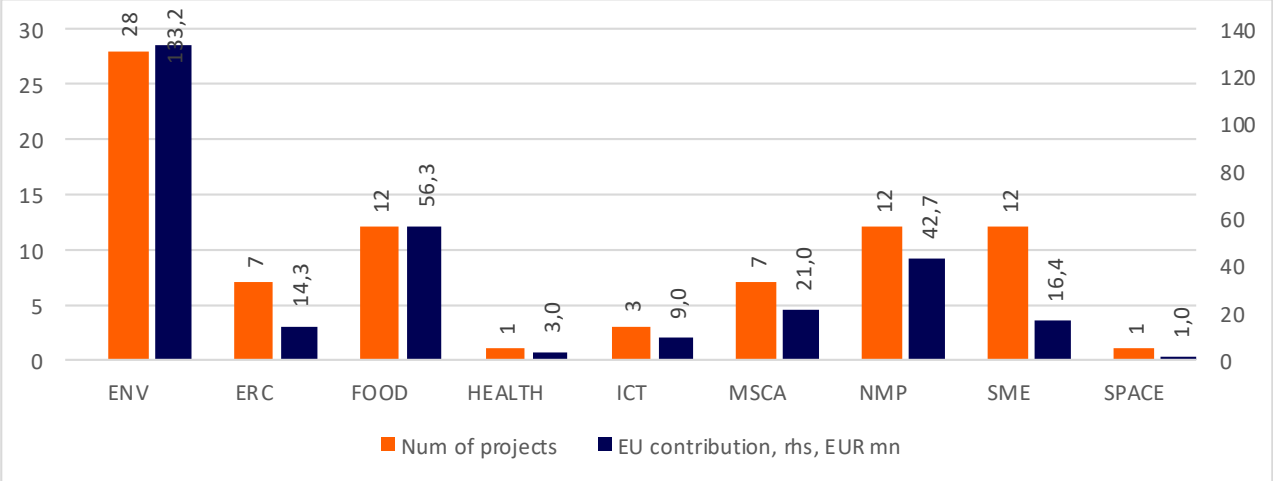

Figure 5. Total number of projects and EU contribution by programme group (as per classification provided)

There was a total of 1.110 participations from 789 institutions. Most participations are from EU Member States (926). Germany, Spain, the Netherlands, the UK[5] and Italy are the countries with the most participating institutions. The Associated Countries (ACs) are represented by 67 organisations, with Switzerland, Israel and Norway taking the lead. The rest of third countries are represented most notably by Asia (35 participants from India and 13 from China). Figure 6 below shows the number of participants from EU Member States and the EU contribution received by them. Similarly, figure 7 presents participants from Associated Countries and third countries and the respective amount of EU contribution received.

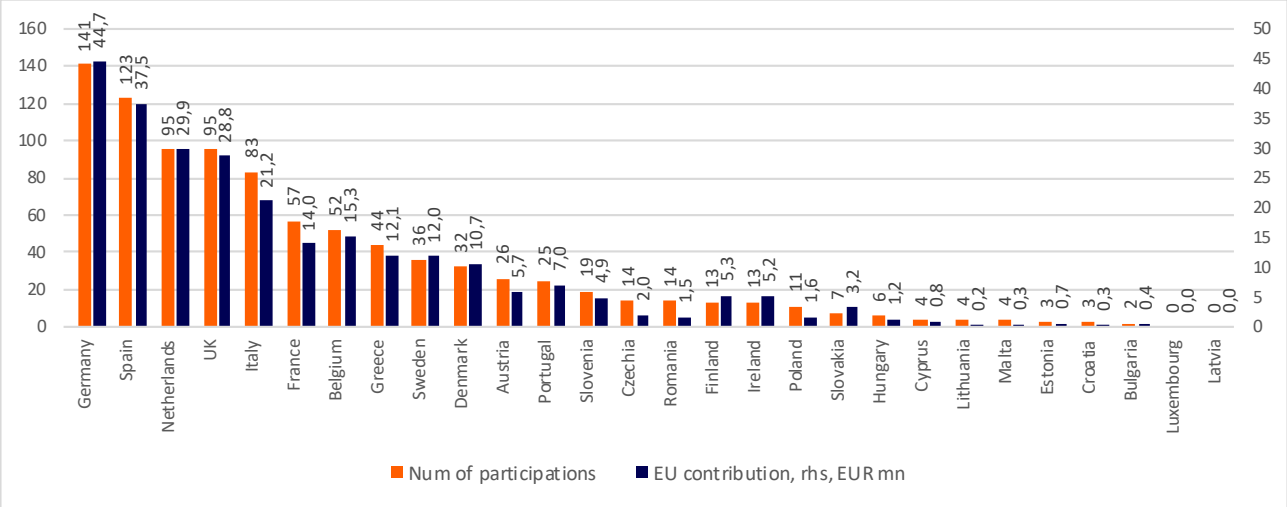

Figure 6. Number of participants and EU contribution received by EU Member States

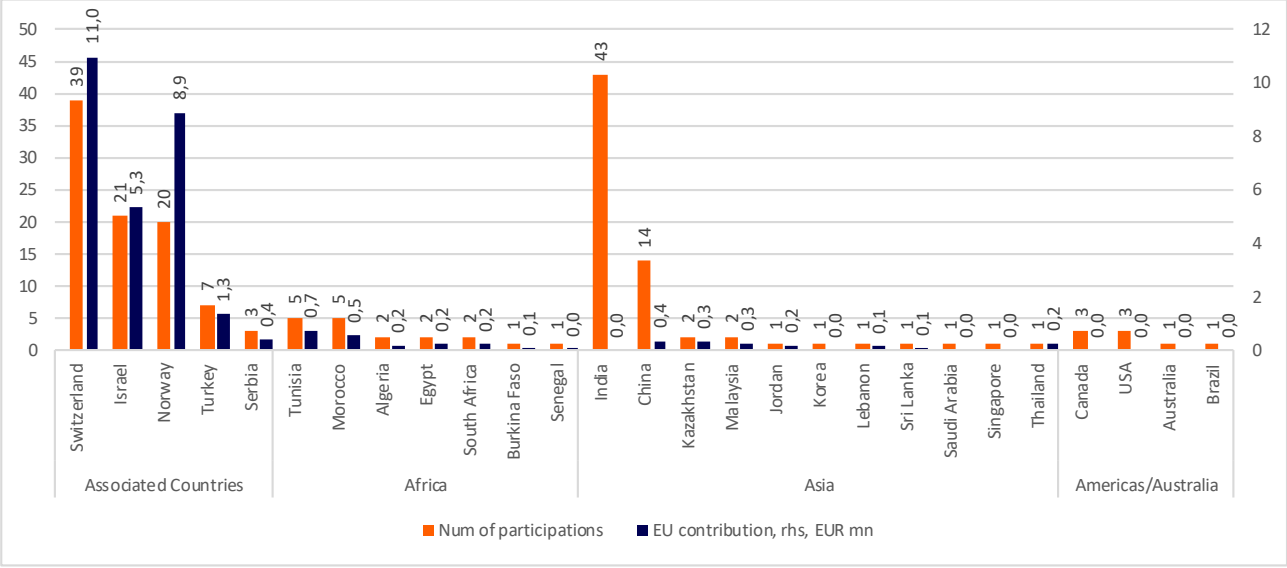

Figure 7. Number of participants and EU contribution received by Associated Countries and third countries[6]

[5] The UK is counted as a Member State within this report as most of the projects included in the portfolio started before 2020. A total of 72 British organisations participated in projects included in the portfolio. In 8 of these cases, UK entities acted as Coordinator.

[6] Tunisia was an Associated Country under H2020 (3 participations in 2 projects), but not under FP7 (2 participations in one single project)

In terms of distribution of projects across the three pre-defined Themes, Theme 3. Prevention and remediation has the largest number of projects (51 out of 83) and accounts for nearly 60% of total EU contribution in the portfolio. Theme 1. Measuring and monitoring and Theme 2. Evaluating and assessing were assigned to 16 projects each[7], and have an almost equal share of the total EU contribution in the portfolio.

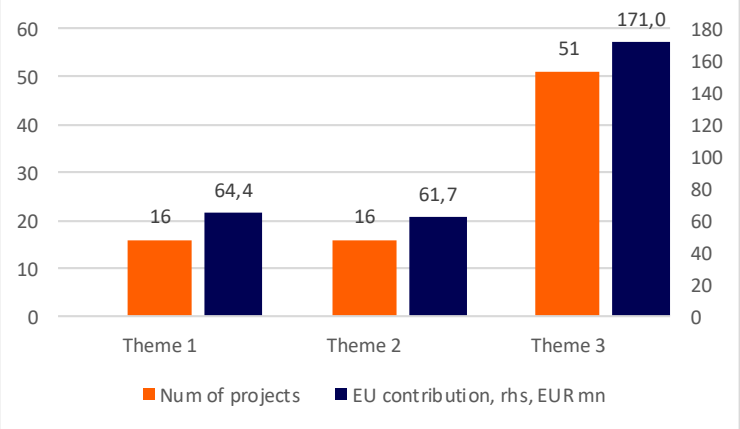

Figure 8. Number of projects and EU contribution per pre-defined Theme

[7] There are two cross-cutting projects in the portfolio (WATERDISS2.0 and PAVITR), which were initially assigned to more than one pre-defined Theme. For the purposes of Figure 8 above, both projects were assigned to a main/predominant Theme (Theme 3). In the qualitative analysis and Annex 2 below, these projects are analysed separately for each Theme attributed to them. Hence, the analysis of Theme 1, Theme 2 and Theme 3 covers 18, 17 and 51 projects respectively.

4.2 Methodology applied

The methodology used for this study includes desk research, comparative analysis and expert assessment.

The group of projects has been selected using firstly the following search keywords in their abstracts and keywords fields: micropollutant, nanopollutant, microplastic, pharmaceutical, pesticide, diffuse pollution, emerging concern, emerging pollutant, disruptor, CEC. At a later stage, projects below EUR 1 million budget and MSCA related to fellowship training and infrastructures were withdrawn from the list. H2020 projects with starting date posterior to 2019 have not been included in the portfolio either, as they were considered not to have advanced enough in their results. The third stage consisted of reading each abstract to decide whether or not the project was in line with the scope of the portfolio subject and their classification into one of the three pre-defined Themes.

Desk research was performed on the information provided in the project portfolio (see annex for details), the CORDIS database, project websites and other publicly available information regarding selected projects. The relevance of each project to specific types and sources of pollutants has been assessed by reviewing implemented activities, outputs and results. Based on the project description, as available in the CORDIS database, every project has been associated with a specific type of pollutant, source of pollution and achieved or expected impact(s). Some projects have been associated with more than one type of pollutant or source, and with multiple impacts.

The various types of pollutants addressed by the projects in the portfolio have been grouped in 11 categories, described in more detail below.

- **Pesticides** (plant protection products) – various types of synthetic and organic compounds (e.g., herbicides, insecticides) used mainly in agriculture. However, these substances could enter and contaminate water systems from diffuse sources, among which agriculture, industrial facilities, wastewater discharge, forestry and atmospheric deposition.

- **Biocides** – this category includes various disinfectants, antiseptics and preservatives, as well as disinfection by-products (DBPs).

- **Pharmaceuticals** – synthetic and organic compounds used for medical purposes, as well as in personal care and cosmetic products, which can enter and contaminate waters from diffuse and point sources. This category also includes antibiotics, antibiotic resistant bacteria (ARB) and antibiotic resistant genes (ARGs), which are among the major contaminants of emerging concern (CECs).

- **Heavy metals** – metallic chemical elements that have a relatively high density and are toxic or poisonous at low concentrations. Examples of heavy metals include mercury, cadmium, copper and lead. Heavy metals in water systems are usually introduced via industry effluents, pollution by ships and oil, atmospheric deposition and riverine inputs.

- **Nutrients** – the category refers to inputs from fertilisers and other nitrogen- and phosphorus-rich substances. These substances originate from both point and diffuse sources, including agriculture, aquaculture and atmospheric deposition.

- **Endocrine disruptors** – harmful substances that alter the functions of the endocrine system and consequently cause adverse health effects and reproduction rates. The category refers to some synthetically produced pharmaceuticals that are intended to be highly hormonally active (e.g., contraceptive pills), and man-made chemicals and by-products released into the environment. These include some pesticides (e.g., DDT and other chlorinated compounds), chemicals in some consumer and medical products (e.g., some plastic additives) and a number of industrial chemicals (e.g., polychlorinated biphenols (PCBs), dioxins).

- **Persistent Organic Pollutants (POPs)** – toxic substances composed of organic (carbon-based) chemical compounds and mixtures. The most commonly encountered POPs are organochlorine pesticides such as DDT, industrial chemicals, polychlorinated biphenyls (PCBs), as well as unintentional by-products of many industrial processes, especially polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF), commonly known as dioxins.

- **Per- and polyfluorinated alkyl substances (PFAS)** – diverse group of human-made chemicals that accumulate over time in the environment, animals and humans. The main sources of PFAS pollution are industrial production facilities, textile, paper and painting/ printing facilities, some consumer products, and emissions from industrial wastewater.

- **Microorganisms** – microscopic organisms in water systems such as cyanobacteria and microalgae, and the harmful toxins produced by them. The category also refers to projects tackling biofouling, biofilm accumulation and bacteria adhesion on solid surfaces such as ships' hulls or mechanical components immersed in saltwater.

- **Microplastics** – the term refers to small particles of plastic pollution of size 1 µm – 5mm. In comparison, nanoplastics are particles of size <1µm. Micro and nanoplastics can originate from primary industrial sources or from the degradation of macroplastics (particle size: >5mm). Micro and nanoplastics can have negative effects on human health and biota (e.g., by causing inflammation, oxidative stress and disruption of hormone signalling).

- **Contaminants of emerging concern (CECs)** – the category refers to projects, which address the wider group of contaminants of emerging concern (also called emerging or novel pollutants), rather than focusing on a specific substance from this group.

A partial overlap is observed between three of the above listed categories of pollutants: pesticides, POPs and endocrine disruptors. For example, the most commonly encountered POPs are pesticides such as DDT, polychlorinated biphenyls (PCB) and dioxins, which also act as endocrine disruptors.

It should be noted that projects addressing some types of CECs are assigned to other categories if they are explicitly mentioned in the project descriptions. For example, projects aimed at

prevention and remediation of antibiotics and related challenges such as ARB and ARG are assigned to the pharmaceuticals category.

The sources of pollution addressed by projects in the portfolio have been grouped in two large categories (land-based and sea-based sources), which comprise several sub-categories described in more detail below:

Pollution from land-based sources:

- **Wastewater** encompasses challenges related to wastewater infrastructure, including ineffective collection, treatment, and recycling systems that may result in inadequately treated sewage, storm overflows of sewage and septic systems, run-offs, etc. This sub-category also includes pollution caused by sewage sludge, i.e., the residual material resulting from wastewater treatment.
- **Agriculture** refers to pollution associated with agricultural activities, including plant protection products, pesticides, fertilisers and other nutrient enrichment substances, and organic matter.
- **Industry** includes pollution caused by industrial production facilities, industrial effluents, chemical or oil spills, and non-synthetic substances.

Pollution from sea-based sources:

- **Pollution by ships** covers all types of waste discharges by ships, as listed in the Port Reception Facilities Directive (e.g., oil discharges, noxious liquid substances, sewage, garbage, and passively fished waste). The category also refers to pollution caused by antifouling paints and their components applied to the hulls of vessels.
- **Pollution by aquaculture** refers to challenges generated by aquaculture production (e.g., fish farming, shrimp farming, oyster farming, mariculture, and algaculture), including freshwater aquaculture. The category also refers to nutrient enrichment, pharmaceutical products, as well as abandoned cage nets and other aquaculture equipment.

For the purposes of the impact assessment applied in the qualitative analysis of projects in the portfolio, five types of impacts have been identified:

- **Social impact** – relevant to projects that have implications for human life, health and assets. In addition, social impacts could also be identified in projects with specific societal involvement or educational activities targeted at specific groups (e.g., children, youth) or the general public.
- **Economic impact** – relevant to projects that have market readiness, i.e., pre-market deliverables produced, and are likely to have a real-life contribution. These might also be projects aimed at creating business opportunities, including such with labour market/employment growth implications. Economic impacts might also be observed with regard to industrial leadership and increased productivity in agriculture, forestry and

aquaculture. In addition, the economic benefits of taking action on prevention vs. remediation are taken into consideration.

- **Technological impact** – relevant to projects that have produced some technological innovation such as various tools, measurement models, early warning systems, prototypes, patents, industrial designs, decision support systems (DSS) and modelling scenarios. These might also be projects related to data mapping and classification of different pollutants.

- **Policy impact** – relevant to projects that have some implications for policy makers and decision-making bodies. These might be projects that have produced specific guidelines, concrete measures and recommendations targeted at national, local or regional authorities, EU institutions, Member States, and associated countries.

- **Environmental impact** – relevant to projects aimed at improving the status of water bodies in quantitative and qualitative terms. These could be projects focusing on protecting water levels in aquifers and lakes, preserving environmental flows, avoiding loss of biodiversity and degradation of landscape quality, enabling a sustainable use of resources, and facilitating ecosystem service approaches and hydromorphological processes.

After associating each project with a specific type of pollutant, source of pollution and achieved or expected impact(s), project deliverables and publications have been assessed and classified in several categories. The information on the deliverables and publications per project is collected from CORDIS and project websites (if available). Each type of deliverable and publication has been counted only once, regardless of the number of deliverables of the same type (for example, if there are three peer-reviewed publications produced under a project, they are counted as one deliverable of this type). The categories used for the mapping process are listed below:

Deliverables:

- **Demonstration event** – the category encompasses trade shows, workshops and conferences where new products and services are displayed, demonstrated and discussed. Demonstration events are focused on or involve business, future investors, academic and research communities.

- **Toolbox/ model** – this category refers to the logical description of a system or a process that can be used for calculations, simulation or forecasting. Different types of methodologies and technologies are also included in this category.

- **Patent** – the category refers to a type of intellectual property that gives its owners the legal right to exclude others from making, using, or selling an invention for a limited period of years in exchange for publishing and enabling public disclosure of the invention.

- **Pilot** – the category refers to projects that include a pilot-scale study/ pilot-scale research or testing of a product in a pilot plant. A pilot study is a small-scale preliminary study conducted to evaluate feasibility, time, cost, scaling factors, unpredicted results, and further develop a process, etc. to properly design and implement a full-scale commercial process. A pilot plant is a pre-commercial production system that employs new production technology and/ or produces small volumes of new technology-based products.

- **Prototype** – the category refers to original models constructed to include all the technical characteristics and performances of a new product. The design, construction and testing of prototypes normally falls within the scope of R&I activities.
- **Business plan/ Market research** – the category refers to all deliverables that will help identify and/or estimate the market demand for a product, including the financial viability of its introduction to the market.
- **Early warning system** – a mechanism for detecting, characterizing and providing notification of a source water contamination event (spill event) in order to mitigate the impact of contamination.
- **Decision support system (DSS)** – a computerized system that gathers and analyses data, synthesizing it to produce comprehensive information reports.

Publications:

- **Scientific publication** – the category refers to publications in scientific journals presenting a new invention or progress in the field of water pollution research.
- **Peer-reviewed article** – the category refers to publications in scientific journals, which have been peer-reviewed, i.e. evaluated by other scholars before being accepted for publication.
- **Policy brief** – a concise summary of a particular issue, the policy options to deal with it and recommendations on most effective solutions or regulatory aspects. It is basically addressed to policymakers and decision-making bodies at national, local or regional level, as well as at EU institutions.
- **Guidelines** – the category refers to recommendations on good practices, approaches and solutions which are not limited to policymakers, but rather target a wider range of stakeholders, including practitioners, river basin managers, drinking water companies, industry actors, and NGOs.
- **Conference proceedings** – a collection of academic papers published in the context of an academic conference or workshop. Conference proceedings typically contain the contributions made by researchers at the conference.

4.3 Qualitative analysis

This section presents a qualitative assessment of the portfolio projects, covering four elements of analysis.

4.3.1 Types of pollutants

Portfolio projects are mapped and analysed in terms of their relevance to the 11 categories of pollutants listed in Section 4.2: pesticides, biocides, pharmaceuticals, heavy metals, nutrients, endocrine disruptors, POPs, PFAS, microorganisms, microplastics and contaminants of emerging concern. Specific focus is placed on projects related to microplastics, which are further analysed in terms of sources of pollution and solutions provided.

The subdivision of projects in the portfolio across the three themes mentioned above (Theme 1. Measuring and monitoring, Theme 2. Evaluating and assessing, and Theme 3. Prevention and remediation) is maintained when relating to different pollutants types. In all three themes, the majority of projects apply a multifunctional approach, as they usually address several types of pollutants rather than being focused on just one specific category.

One cross-cutting project (WATERDISS2.0) is assigned to all three themes in the portfolio and, as it aims at dissemination of various water-related FP6 and FP7 projects, it does not address a specific type of pollutant. WATERDISS2.0 produced some tools on knowledge brokering, as well as recommendations and guidelines for future dissemination of EU research outputs, which are presented in greater detail in section 5.2 below.

Another cross-cutting project (PAVITR) is assigned to Themes 1 and 3, as it developed sensors for monitoring of emerging and traditional contaminants, as well as advance technologies for wastewater treatment in India.

a. Theme 1. Measuring and monitoring

In Theme 1, a total of 18 projects focused on developing analytical techniques for sampling, detection, quantification and monitoring of micropollutants are included in the portfolio. Pesticides, pharmaceuticals and microorganisms in water systems are the main types of pollutants addressed by projects in Theme 1 (see Table 1 below). Measuring and monitoring of heavy metals and POPs are also among the frequently addressed challenges in the portfolio. Other pollutants, such as biocides, nutrients, endocrine disruptors, and PFAS are addressed by a limited number of projects in Theme 1. One project in the portfolio is aimed at detecting microplastics in marine waters.

Pesticides, also known as plant protection products, are the most common type of pollutants in Theme 1, addressed by 11 out of 18 projects. The main application of five of these projects is within the food and agri-industries, as they are related to pesticide residue detection in the food industry (FOODSCAN), or identification of trace quantities of pesticides in food and drinking water (ARROWS). Some projects have a very narrow focus on specific pesticides such as organophosphate and carbamate pesticides, 2-methyl-4-chlorophenoxyalcanoic and phenoxyalcanoic herbicides (FOODSCAN), diazines, ureas and triazines (BEEP-C-EN).

Pharmaceuticals (addressed by 7 projects) constitute the second largest category of pollutants in Theme 1, together with microorganisms (also addressed by 7 projects). While some projects cover pharmaceuticals in general, others are specifically targeted at antibiotics (BIOFOS), sulphonamides (SMS) and specific veterinary pharmaceuticals such as coccidiostats (CONffIDENCE). Some of the projects aimed at measuring and monitoring pollution from microorganisms refer to cyanobacteria (CyanoLakes, MARS), toxic microalgae species (SMS) and biotoxins such as alkaloids, marine toxins, mycotoxins (CONffIDENCE).

Heavy metals are usually targeted as a wider group of pollutants in Theme 1, but some projects provide tailored solutions for detection of specific types of heavy metals. For example, the biosensors produced by BEEP-C-EN rely on different enzymes, proteins and microorganisms, which are sensitive to mercury, arsenic, chromium and lead.

Persistent organic pollutants (POPs) are addressed by four projects in Theme 1, one of which is specifically focused on this category of contaminants. NanoScreen has produced a portable nano-optical sensing device for pre-screening of POPs in food products and water.

One project in Theme 1 partially covers microplastics pollution in marine waters, although this is not its main focus. ODYSSEA developed a platform that fully integrates networks of observing and forecasting systems across the Mediterranean basin, addressing both the open sea and the coastal zone. The project fills in high-priority gaps in data collection through multiple approaches that include deploying novel *in-situ* microplastics sensors at sea.

Table 1. Type of pollutants addressed by projects in Theme 1 - ***Measuring and monitoring***

Funding programme	Project	Pesticides	Biocides	Pharmaceuticals	Heavy metals	Nutrients	Endocrine disruptors	POPs	PFAS	Microorganisms	Microplastics	CECs	Not specified
FP7	ARROWS	√											
FP7	BEEP-C-EN	√			√			√					
FP7	BIOFOS	√		√	√								
FP7	CONffIDENCE	√		√	√			√	√	√			
FP7	FOODSCAN	√											
FP7	FOODSNIFFER	√								√			
FP7	PHOTOSENS		√	√									
FP7	SEA-on-a-CHIP	√		√			√						
FP7	SMS	√	√	√						√			
FP7	BRAAVOO			√	√		√			√			
FP7	WaterDiss2.0												√
FP7	MARS	√				√				√			
H2020	NanoScreen							√					
H2020	ODYSSEA										√		
H2020	CoPs	√				√							
H2020	INTCATCH	√								√			
H2020	CyanoLakes									√			
H2020	PAVITR			√	√			√	√			√	
Total		**11**	**2**	**7**	**5**	**2**	**2**	**4**	**2**	**7**	**1**	**1**	**1**

b. Theme 2. Evaluating and assessing

The portfolio under Theme 2 includes a total of 17 projects focused on evaluating and assessing the environmental behaviour and effects of micropollutants, including related risks to human health and ecosystems. Pharmaceuticals, pesticides, endocrine disruptors and POPs are the main types of pollutants addressed by projects in this Theme (see Table 2 below). Other pollutants, such as heavy metals, PFAS, microorganisms and biocides are addressed by a limited number of projects in Theme 2. One project in the portfolio is related to evaluating and assessing the effects of microplastics.

Pharmaceuticals are the most common type of pollutants covered by Theme 2, addressed by 8 out of 17 projects. More specifically, the portfolio shows that advances have been made in evaluating and assessing the effects of several groups of pharmaceuticals. Some projects examine the harmful effects of cytostatic pharmaceuticals (CytoThreat) and the wider group of cancer treatment drugs (PHARMAS) on human health, aquatic organisms and other wild animals. Other projects focus on assessing the effects of antibiotics, antibiotic resistant bacteria and antibiotic resistance genes (ANSWER), which are among the major contaminants of emerging concern.

Pesticides constitute the second largest category of pollutants in Theme 2, which is addressed by seven projects. For example, the BROWSE project examines the effects of plant protection products on operators, workers, residents and bystanders exposed to them. Some projects assess the effects of pesticides on groundwater resources and groundwater dependent ecosystems (GENESIS) while others focus on risks to river basins and aquatic ecosystems (SOLUTIONS).

Endocrine disruptors are addressed by four projects under Theme 2. Their effects have been assessed with regard to selected species representative of different environmental systems such as Daphnia magna, Zebrafish adults and embryos, roots and aerial parts of rice plants, yeast and cell cultures (CHEMAGEBE). Similarly, human health risk assessment has been performed regarding exposure to toxic chemicals and potential consequences, including endocrine disruption (CHEMO-RISK).

POPs are addressed by four projects under Theme 2. For example, GLOBAQUA evaluated the effects of POPs on aquatic ecosystems and revealed that brominated flame retardants (a specific type of POPs) are major contributors to sediment pollution in river basins.

One project in Theme 2 focuses on assessing the sources and impacts of microplastics in freshwater systems. LimnoPlast has analysed major urban areas as hotspots of plastic pollution and developed innovative technological solutions to remove microplastics from municipal and industrial wastewater. For example, one of the proposed solutions is based on bio-degradable and environmentally sound polymers.

Table 2. Type of pollutants addressed by projects in Theme 2 - ***Evaluating and assessing***

Funding programme	Project	Pesticides	Biocides	Pharmaceuticals	Heavy metals	Nutrients	Endocrine disruptors	POPs	PFAS	Microorganisms	Microplastics	CECs	Not specified
FP7	ATHENE							√					
FP7	BROWSE	√											
FP7	CyroThreat			√									
FP7	ENNSATOX			√									
FP7	GENESIS	√			√			√					
FP7	iPIE			√									
FP7	MicroDegrade	√											
FP7	PHARMAS			√			√						
FP7	SOLUTIONS	√					√	√	√			√	
FP7	TOX-TRAIN	√	√		√								
FP7	CHEMAGEBE			√	√		√						
FP7	GLOBAQUA	√		√				√					
FP7	WaterDiss2.0												√
H2020	ANSWER			√						√			
H2020	ECORISK2050	√		√									
H2020	LimnoPlast										√		
H2020	CHEMO-RISK						√			√			
Total		**7**	**1**	**8**	**3**	**0**	**4**	**4**	**1**	**2**	**1**	**1**	**1**

c. Theme 3. Prevention and remediation

Theme 3 accounts for the largest share of the portfolio, with 51 projects (61,4% of the total number) focusing on developing strategies and technologies to reduce micropollutants in water systems. POPs, pesticides, pharmaceuticals and endocrine disruptors are the main types of pollutants addressed by projects in Theme 3 (see Table 3). Remediation of heavy metals and nutrients are also among the frequently addressed challenges in the portfolio. Other pollutants, such as PFAS and microorganisms are addressed by a limited number of projects in Theme 3. Four projects are targeted at the wider group of contaminants of emerging concern (CECs), without specifying a distinct pollutant, and three projects are aimed at cleaning microplastics in water systems.

Various types of POPs are addressed by 20 projects in Theme 3. For example, NAMETECH aims at removing chlorinated compounds, while OXFLOC and PHASEPLIT have developed technologies to degrade and remove organic pollutants from industrial wastewaters. ROUTES, on the other hand, aims at management of organic pollutants in sewage sludge. The VORTEX project targets at hydrocarbon and hydrocarbon-like polymers contained in plastics released in oceans.

Pesticides and nutrients are usually addressed in parallel under Theme 3, mainly by projects tackling diffuse pollution of nitrogen and plant protection products used in agriculture. Pesticides and nutrients also have a central place in projects aimed at protecting drinking water resources like FAIRWAY and WATERPROTECT. Other projects focus specifically on recovery and utilization of nutrients and their components, including phosphorus (P-REX and RUN4LIFE).

A wide range of pharmaceuticals is addressed by 17 projects under Theme 3, covering prescription drugs, veterinary drugs, antibiotics, cancer treatment drugs, etc. The majority of projects addressing pharmaceuticals provide filtration solutions for wastewater treatment facilities such as the PFS project. Some projects address pharmaceuticals and endocrine disruptors in parallel and provide solutions for remediation of drinking waters (CHITOCLEAN) and wastewaters originating from drug manufacturing sites, households, hospitals and animal farms (ENDETECH).

Heavy metals are addressed by 14 projects in Theme 3. While some projects provide solutions for reducing heavy metals generated by metallurgical industries (CERAMPOL), others are focused on immobilization of toxic metals in groundwater aquifers, drinking water wells and riverbank filtration sites (REGROUND). The latter is specifically focused on arsenic, barium, cadmium, chromium, copper, lead, mercury, and zinc.

There are three projects in Theme 3 that aim at reducing microplastics in water systems. CLAIM has developed devices for prevention and *in situ* management of microplastics in the Mediterranean and Baltic Sea. The proposed cleaning technologies and approaches prevent microplastics from entering the sea at two main source points, i.e., wastewater treatment plants and river mouths. GOJELLY has developed an innovative microplastics filter made by jellyfish mucus. VORTEX has developed an approach for microbial degradation of plastics in the ocean and in this way has contributed to reducing microplastics originating from fragmentation of macroplastics.

Table 3. Type of pollutants addressed by projects in Theme 3 - ***Prevention and remediation***

Funding programme	Project	Pesticides	Biocides	Pharmaceuticals	Heavy metals	Nutrients	Endocrine disruptors	POPs	PFAS	Microorganisms	Microplastics	CECs	Not specified
FP7	AFFRIM									√			
FP7	AquaCell							√	√				
FP7	AQUAREHAB	√				√	√						
FP7	BIOTREAT	√		√				√					
FP7	CERAMPOL			√	√								
FP7	ChitoClean	√		√			√						
FP7	Clean Water	√					√			√			
FP7	DEMEAU											√	
FP7	ENDETECH			√			√						
FP7	ManureEcoMine			√	√	√							
FP7	Nametech	√			√		√	√					
FP7	NANOPUR			√			√						
FP7	NanoSelect	√			√	√							
FP7	OxFloc							√					
FP7	PHASEPLIT			√				√	√				
FP7	Routes				√	√	√	√					
FP7	WaSClean	√			√			√	√				
FP7	WATERMIM	√		√			√						
FP7	WATERPLASMA			√				√	√				
FP7	AquaFit4use	√					√		√				
FP7	LbLBRANE				√					√			
FP7	LIMPID			√			√	√					
FP7	MINOTAURUS							√					
FP7	MONACAT	√		√		√	√	√					
FP7	NATIOMEM							√		√			

Funding programme	Project	Pesticides	Biocides	Pharmaceuticals	Heavy metals	Nutrients	Endocrine disruptors	POPs	PFAS	Microorganisms	Microplastics	CECs	Not specified
FP7	P-REX					√							
FP7	WATERBIOTEC							√		√			
FP7	WaterDiss2.0												√
FP7	MARSOL	√		√			√		√				
H2020	Eco-UV	√		√	√					√			
H2020	FAirWAY	√				√							
H2020	WATERPROTECT	√				√							
H2020	RUN4LIFE					√							
H2020	AQUAlity											√	
H2020	CLAIM										√		
H2020	GoJelly										√		
H2020	PFS			√			√	√					
H2020	CGM	√		√	√				√				
H2020	VORTEX							√			√		
H2020	ELECTRA				√	√		√					
H2020	PANI WATER	√		√						√			
H2020	INDIA-H2O	√				√							
H2020	GREENER				√								
H2020	REWATERGY											√	
H2020	REGROUND				√								
H2020	AquaNES							√					
H2020	ELECTRON4WATER	√					√	√		√			
H2020	ALGAMATER				√					√			
H2020	NexTGen												√
H2020	PAVITR			√	√			√	√			√	
H2020	Saraswati 2.0					√		√					
Total		**18**	**0**	**17**	**14**	**12**	**14**	**20**	**8**	**9**	**3**	**4**	**2**

4.3.2 Sources of pollution

Portfolio projects are mapped and analysed in terms of their relevance to different sources of pollution. A differentiation has been made between land-based sources (e.g., agriculture, wastewater and industrial emissions) and sea-based sources (e.g., pollution by ships and aquaculture). Table 4 below shows the different sources of pollution, as covered by projects under each of the three pre-defined Themes.

Table 4. Number of projects addressing different sources of pollution per Theme[8]

Theme	Land-based sources			Sea-based sources		Not specified
	Agriculture	Wastewater	Industry	Aquaculture	Ships	
Theme 1	7	5	5	4	2	4
Theme 2	5	10	7	-	-	3
Theme 3	13	39	19	1	-	7
Total	**25**	**54**	**31**	**5**	**2**	**14**

The mapping of the portfolio reveals that most projects focus on a specific type of pollutant (or a mix of pollutants) rather than on specific sources of pollution. Throughout the whole portfolio, the prevailing sources of pollution are land-based ones, as compared to sea-based sources, which are covered by a limited number of projects. And yet, some variations are observed in terms of land-based sources covered by each theme. Agriculture stands out as the main source of pollution covered by projects in Theme 1. In Theme 2 and Theme 3, wastewater is the most widely covered source of pollution, followed by industry effluents.

Pollution from **wastewater** accounts for the largest share in the portfolio, as it is addressed by 65% of all projects. This is not surprising considering the wide range of pollutants that enter water bodies through sewerage systems, including pharmaceuticals, heavy metals, POPs, and others. This category is most widely covered by projects in Theme 3, which shows that research has been concentrated on strategies for removing or modifying pollutants in wastewater treatment. Some projects in Theme 3 focus on sewage sludge management (ROUTES, P-REX) and sludge reuse (NEXTGEN). Other projects like AQUANES and DEMEAU tackle wastewater pollution through advanced oxidation technologies. Projects in Theme 3 also respond to specific wastewater challenges characteristic of different parts of the world, including India (SARASWATI 2.0, PAVITR) and Africa (WATERBIOTECH).

Pollution from **industry** is addressed by 37,3% of the projects in the portfolio. This category, too, is most widely covered by projects in Theme 3, which shows that R&I activities have been concentrated on remediation of industrial effluents rather than measuring or evaluating effects associated therewith. Projects in this category are usually associated with pollution caused by heavy metals, PFAS, POPs, and endocrine disruptors. A number of projects in Theme 3 focus specifically on solutions for industrial wastewaters. For example, AQUACELL applied the Microbial

[8] See Annex 2 for details.

Fuel Cells (MFCs) technology for the treatment of industrial wastewater, which allows for efficient electricity generation, minimal sludge formation and operation on a small scale adaptable to specific end-user requirements. OXFLOC has developed a system of industrial effluents treatment, which combines particle removal and adsorption with advanced oxidation. ALGAMATER, on the other hand, has applied microalgae technology to deliver a cost-effective system for the treatment of toxic industrial wastewater. CGM offered a solution for capturing and recycling micropollutants released by industrial processes in the textile and manufacturing industries. Other projects like CERAMPOL developed solutions related to wastewater generated by metallurgic sites, pharmaceutical industries and hospitals.

Pollution from **agriculture** is addressed by 30,1% of the projects in the portfolio, which are mostly concentrated in Theme 3 and Theme 1. Projects in this category are usually associated with pollution caused by pesticides and nutrients. In Theme 3, projects like FAIRWAY and WATERPROTECT demonstrate the implications of agriculture for drinking water quality and promote practices for reducing diffuse pollution among farms. In Theme 1, a number of projects, tackling pollution from agriculture, have a specific focus on and direct application in the food industry (BIOFOS, FOODSCAN, FOODSNIFFER) and are by extrapolation applicable to drinking water as well.

As regards **sea-based sources**, a total of five projects address pollution originating from aquaculture. SEA-ON-A-CHIP stands out in this category, as it has a twofold application in aquaculture: the sensor platform developed provides for the rapid assessment of compounds produced by the aquaculture industry that affect environment and human health while allowing for the monitoring of compounds affecting aquaculture production (toxic bioaccumulative compounds, including endocrine disruptors). Projects like SMS and BRAAVOO combine measures targeted at pollution caused by both aquaculture and ships. For example, SMS has enabled *in situ* monitoring of marine waters for hazardous compounds, like tributyltin, which is an antifouling agent in paints applied to vessels, and diuron, the most widely used herbicide to control algal blooms. Similarly, BRAAVOO has facilitated the detection of various harmful substances in marine waters such as alkanes and polycyclic aromatic hydrocarbons (PAHs), which are usually caused by oil pollution from shipping.

4.3.3 Assessment of impacts. Prevention and remediation techniques[9]

This element of the qualitative analysis focuses on the types of impact achieved by projects in the portfolio. Five types of impact have been outlined for the purposes of the assessment: social, economic, technological, policy and environmental impacts. This section also highlights specific prevention and remediation techniques (used in projects within Theme 3) with perceived policy relevance and upscaling potential.

a. Theme 1. Measuring and monitoring

In Theme 1, there is a predominant **technological impact** observed in 16 out of 18 projects altogether, as they focus on the development of sensors, measurement and monitoring

[9] See Annex 2 for details.

technologies, prototype development, analysis and rapid assessment that prevent early contamination of waters and detection of toxins which will lead to better management of water system pollutants. A strong technological impact is observed in projects, which have produced innovative bio-assessment tools, early warning systems and online technologies that go beyond the state-of-the-art. For example, BEEP-C-EN has designed a biosensor industrial platform for pollutant detection in water. The project contributes to the advances in biosensor technology applications such as the detection of herbicides, organophosphorus pesticides and toxic phenolic compounds. Another example of a project that has a scientific and technological impact is NANOSCREEN, which produced a portable nano-optical sensing chip for pre-screening purposes that detects POPs contamination in food and water.

Also in Theme 1, 14 out of the 18 projects show an **economic impact.** Some projects have led to increased efficiency and reduced final cost of sensing and monitoring technologies. FOODSCAN developed a novel biosensor platform that detects pesticide residue in foods and wine (therefore, it could also be applicable to drinking water) and has a reduced final cost per sample. The project outputs contribute to increased efficiency in food safety control, which is a vital economic activity. Other examples of economic impact observed in Theme 1 are related to labour market implications and employment growth. For example, by developing a multi-parameter sensor platform for environmental and pharmaceutical sensing that detects harmful chemicals, the PHOTOSENS project enables not only a technological advantage but also boosts the labour market with the creation of high-tech jobs (boost the labour market as based on high-tech job creation) in Europe. Project SMS affects positively some socio-economic aspects related to maritime activities such as the fish industry. In addition, it is expected that increased confidence in marine water quality would raise citizen satisfaction and lead to increased revenues from recreational activities in coastal areas.

When looking at **social impact** in Theme 1**,** again 13 out of the 18 projects set out societal implications on human life, assets and wellbeing. The majority of projects with social impact have the potential to influence positively drinking water quality, wastewater treatment and human health in general. For example, the CoPs project developed a sensor network solution to reduce the risk of tap water contamination by sustained monitoring of its key parameters. By transferring real-time data on the level of on- the- site contamination, early alerts can be made, and diseases caused by bacteria and toxins prevented, leading to improvement of citizens' life. In the PAVITR project, the social pillar is presented through solutions for water challenges on both regional and local scales in India. The project's novel technology for sanitation of water systems contributes to clean water provision and better living conditions for people.

The third most recognised impact covered by 11 out of the 18 projects in Theme 1, is the **environmental impact** with regard to protecting ecosystems and improving the status of water bodies in quantitative and qualitative terms. For instance, BRAAVOO has developed a device using biological sensors in order to detect a wide range of toxins from antibiotics to heavy metals in the ocean. The project provided an improved approach to monitoring the chemical, physical and biological quality of the oceans, having thus, an environmental impact on the water and its ecosystem by reducing the effect of emerging chemical pollutants. Similarly, the SMS project has developed an automated networked system that allows *in situ* monitoring of marine water pollution and a variety of chemicals in coastal areas. The technology gives rise to real-time data

collection, smooth communication and effective water filtration that benefit the coastal environment and generally improve environmental safety. INTCATCH has contributed to improving water quality and the health of water basins' ecosystems by developing a "smart boats" technology that uses multi-parameter sensors for measuring a variety of pollutants from oil to chemicals in rivers and lakes.

Under Theme 1, there are 6 of altogether 18 projects that have an **impact on policies**. ODYSSEA has provided knowledge base to support policy decisions towards sustainable growth of the EU Mediterranean marine and maritime economy. Further, bridging the gap between scientists, authorities and practitioners in order to provide policy makers with the most relevant outcomes is the major goal of WATERDISS2.0. This project collected data on over 60 water research projects (funded by FP6 and FP7 programmes) and produced a recommendation report on improving the uptake of research results in the water sector. There is a recognized impact on policymaking seen in the INTCATCH project that has given a valuable input for the development of effective policies and actions for water pollution prevention.

b. Theme 2. Evaluating and assessing

In Theme 2, the majority of the projects (15 out of 17) have an **environmental impact,** as the emphasis is laid on evaluating and assessing the environmental behaviour and effects of micropollutants on human health and ecosystems. CYTOTHREAT, for example, focuses on the assessment of risks associated with cytostatic drugs. Their release is detrimental to both humans and the environment, as they might cause diseases such as cancer and reduced fertility, as well as systematic ecological effects. SOLUTIONS provided tools for the impact and risk assessment of complex mixtures of emerging pollutants, their metabolites and transformation products in river basins. ENNSATOOX brings insight into the biological activity of particular nanoparticles found in cosmetics and pharmaceuticals and hence, has a positive environmental impact on the preservation of aquatic ecosystems.

In Theme 2, 14 out of the 17 projects reported a **technological impact**. For example, the TOX-TRAIN project has developed a user-friendly toolbox that can be used to characterize human toxicological and eco-toxicological impacts related to emissions released over the life cycle of products and technologies. Therefore, the project demonstrates a technological impact via its toxicity assessment tool. Similarly, innovations that boost a high-tech impact through prototype tool development can also be seen in PHARMAS and ENNSATOX.

Social impact is observed in 11 out of 17 projects under Theme 2. For instance, by developing a children's book and an educational programme, ANSWER has a vital social impact on the younger generation by giving them the opportunity to learn more on the topic of water pollution from an early age. Also, the BROWSE project has conducted a risk assessment on the effects of plant protection products on human health, thus contributing to the protection of health of agricultural workers, residents, and vulnerable groups such as infants, pregnant women and children.

In Theme 2, there are 9 out of the 17 projects that outline **policy implications**. At the time of project completion, BROWSE contributed to the revision of data requirements set by the

Directive 91/414/EEC concerning the placing of plant protection products on the market[10] and to the Thematic Strategy on the Sustainable Use of Pesticides. The project itself was designed to contribute to the implementation of both the Authorisation Regulation (1107/2009) and the Sustainable Use Directive (2009/128/EC). The results of the CYTOTHREAT project on the analysis of cytostatic pharmaceuticals effects on humans and the environment could be used by the EC for risk assessment and contribute to policymaking (incl. EMA guidelines on environmental risk assessment). Moreover, by analysing the sources and impacts of microplastics in freshwater, LIMNOPLAST transfers the knowledge and outcomes to European decision makers.

Under Theme 2, only 6 out of 17 projects altogether have produced an **economic impact**. The BIOTREAT project estimates efficient water management in terms of costs and benefits from the use of a particular resource. It also takes into consideration ecosystem services that bring about economic prosperity value such as mass tourism. The project has bridged the gap between laboratory studies and full-scale application and one of its findings accounts for the development of an environmental and economic assessment for bio treatment of micropollutants in drinking water resources.

c. Theme 3. Prevention and remediation

In Theme 3, the projects have primarily **technological impact**, in line with the Theme's rationale**.** 43 out of 51 projects are aimed at prevention and remediation by placing special emphasis on developing strategies and technologies to reduce micropollutants in aquatic systems. A variety of prototype systems have been developed in order to filter, pre-filter and purify water systems within ECO-UV, CERAMPOL, BIOTREAT, CHITOCLEAN, MINOTAURUS and MONACAT. Some projects apply prevention techniques using multi-actor participatory approaches. For example, WATERPROTECT contributes to protecting drinking water resources by enabling actors to monitor, finance and effectively implement management practices. Seven case studies have been presented under the WATERPROTECT project, focusing on various actors implementing good practices related to land management, farming, product stewardship and point source pollution prevention, to ensure safe drinking water supply. These case studies cover different climatic conditions, various farming systems, legal frameworks, larger and smaller water collection areas across the EU.

Other remediation techniques are specifically focused on drinking water purification from chemicals and toxins. CHITOCLEAN, for instance, has developed an innovative approach for purification of polluted drinking waters based on chitin-based biosorbents. Natural materials made from carcasses of shrimps and crabs are to be physically and chemically enhanced to be suitable for the use in drinking water purification applications. The advantages of the Enhanced Chitin-based Materials technique are related to improved stability, adaptability to different forms of filters and maximal adsorption rates and capacities.

[10] No longer in force. Repealed by Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.

A significant number of projects have an equal share of **environmental and social impact,** 40 out of the 51 projects under Theme 3.

The WATERBIOTECH project provided sustainable water supply to African farmers who use untreated wastewater for irrigation. The novel biotechnology contributed to a variety of public health improvements and safe use of clean water, thus preventing waterborne and diarrhoeal diseases. At the same time, WATERBIOTECH demonstrates also an environmental impact by preventing the untreated polluted water from being discharged into rivers and lakes and thus contaminating them with pathogenic microorganisms.

Under Theme 3, 36 out of 51 projects altogether demonstrate **an economic impact.** For example, LIMPID points out that ecosystem services that benefit from the purification of water systems have the potential to accelerate tourism in the region and boost the economy. By creating job opportunities, realising cost-savings for small communities and providing a more efficient use of financial resources for water treatment, WATERBIOTECH has delivered a positive impact on the African local economies. The project also brings economic benefits to African households and businesses, as recycled wastewater has the potential to save domestic water usage and thus reduce water bills.

In Theme 3, **policy implications** have been reported about 16 out of a total of 51 projects. In the P-REX project for example, a policy brief and an integrated guidance document containing the research findings have been produced for the purpose of supporting decision and policy makers and their work on Europe's circular economy. The delivered outputs could be used in a variety of fields such as public health, regional policy, research and innovation, agriculture and the internal market. The project itself is about developing ways such as sustainable sewage sludge management in order to recover phosphorous from municipal wastewater which can be used in agriculture.

4.3.4 Overview of deliverables and publications

This section of the qualitative analysis provides an overview of what projects have produced in terms of scientific publications, review papers, policy briefs, patents, guidelines and solutions. Project outputs are presented in line with the CORDIS classification of deliverables (e.g., demonstrators, pilots, prototypes, reports, etc.) and publications (e.g., peer reviewed articles, conference proceedings). Table 5 below presents the number of projects associated with different deliverables and publications in each pre-defined theme. A more detailed overview of the main achievements of each project in terms of enhanced knowledge and innovation is presented in Section 4.4 of the report.

A significant number of projects (nearly 76%) plan to or have been involved in demonstration events, either as participants, co-organisers together with other FP7 or Horizon 2020 projects, or as hosts themselves. For instance, DEMEAU has organised a number of demonstration events specifically targeted at water utilities. CYTOTHREAT, GLOBAQUA and ENDETECH have co-organised a workshop on pharmaceutical residues, which is a topic of common interest for all three projects.

Toolboxes and models, including various methodologies and technologies, account for the most common deliverable produced by nearly 88% of all projects. For example, in Theme 2, TOX-TRAIN has produced a toolbox to assess toxicological impacts related to the life cycle of technologies. The toolbox developed (USEtox) allows for the quantification of chemical emissions for a number of compound groups, including ionic and amphiphilic substances, persistent bio-accumulating chemicals or metabolites, pesticides and biocides, fragrances, and metals. The IPIE project, on the other hand, has developed models for predicting eco-toxicological responses to active pharmaceutical ingredients.

Pre-market outputs such as pilots and prototypes are also quite common in the portfolio, especially in projects under Theme 3. This shows that a considerable number of projects have tested solutions on a pilot-scale and hence, delivered outputs with a high degree of maturity and market readiness. For example, MINOTAURUS has developed a prototype of an optotrode system assessing enzyme activity in bioremediation processes. Under ROUTES, process units on both lab and pilot scales have been developed and optimized for the production of biopolymers.

The large number of projects developing business plans and engaging in market research shows that participants have dedicated efforts to explore the market potential of project results and facilitate the business uptake of new solutions. For example, CLAIM has developed new business models to enhance the economic feasibility for upscaling the innovative cleaning technologies for microplastics in the Mediterranean and Baltic seas.

Early warning systems have been delivered by a limited number of projects, mostly under Theme 1, which is not surprising as real-time systems for detection and monitoring of pollutants are of special interest to this theme. For instance, SEA-ON-A-CHIP developed early warning systems detecting chemical contamination of estuarine and coastal areas. Decision support systems have been delivered by nine projects, most of which are under Theme 3.

Nearly all projects (91,6%) have produced multiple scientific publications and the number of projects with peer-reviewed articles, as listed in CORDIS, is also very high. A total of 34 projects have produced conference proceedings, which further facilitate knowledge transfer and dissemination of R&I results in specific thematic fields related to micropollutants in water systems. Some projects have produced guidelines targeted at practitioners and other stakeholders (river basin managers, drinking water companies, industry actors, and NGOs). The publications targeted at policymakers and EU institutions are fewer, as a limited number of projects have produced policy briefs.

Details on the specific type of pollutants, sources of pollution, impacts, deliverables and publications associated with each project are to be found in Annex 2.

Table 5. Number of projects associated with different deliverables and publications per theme[11]

Theme	Deliverables								Publications				
	Demonstration event	Toolbox/ model	Patent	Pilot	Prototype	Business plan/ market research	Early warning system	Decision support system	Scientific publication	Peer-reviewed article	Policy brief	Guidelines	Conference proceedings
Theme 1	12	15	3	4	8	6	5	1	16	12	2	5	9
Theme 2	14	16	1	4	3	2	1	1	16	11	5	5	6
Theme 3	37	42	10	29	24	23	-	7	44	30	6	7	19
Total	**63**	**73**	**14**	**37**	**35**	**31**	**6**	**9**	**76**	**53**	**13**	**17**	**34**

[11] See Annex 2 for details.

4.4 Actual results per project

This section provides a description of the actual results of each project and highlights the main achievements in terms of enhanced knowledge (progress beyond the state-of-the-art) and innovation (new solutions reaching the market). The section also identifies the development stage reached at the end of each project with regard to the commercial applicability of results, wherever such information was available.

Actual results and development stage per project are presented in three tables, maintaining the subdivision across the pre-defined Themes.

Table 6. Actual results per project in Theme 1 – Measuring and monitoring

FP	Project	Actual results	Development stage
FP7	ARROWS	Micro-analytical technology for detecting toxic substances in food, drinking water and tissues. A chip-scale capillary electrophoresis/liquid chromatography mass spectrometer (CE/LC-MS), which has the functionality of a laboratory-scale, high-end system.	The prototype version of the mosaicking software is developed in MATLAB programming language and tested on an underwater monocular sequence.
FP7	BEEP-C-EN	A platform of biosensors able to detect herbicides, organophosphorus pesticides and toxic phenolic compounds in water samples. The biosensors are suitable for in-situ control of water pollution and could be used by socio-economic entities in the fields of environment and agri-industry.	The biosensor prototypes were built and tested over a three-month period. The devices were robust, affordable, accurate, and ready for commercial application, more work needed in terms of design and packaging.
FP7	BIOFOS	A reusable biosensor system based on optical interference and lab-on-a-chip (LoC) technology for detection of food contamination (also applicable to drinking water). A device for detection of antibiotics, mycotoxins, pesticides and copper, which offers a faster, low-cost and portable solution for monitoring of food (and water) quality.	Two PCT patents were filed and they give the credential for a potential exploitation of the project results. Patent application by CSEM and PCT patent application on laser surface functionalization by ICCS/NTUA have been among the project outcomes.
FP7	CONffIDENCE	Inexpensive screening tool for detection of a range of food and feed contaminants including organic pollutants, pesticides, antibiotics, coccidiostats, inorganic arsenic, methylmercury, alkaloids, marine biotoxins and mycotoxins. The outcomes will have a far-reaching impact on consumers' health.	Prototype multiplex dipsticks were designed and assembled in order to reach detection limits compatible with the EU legislation in force or expected for Fusarium toxins. The resulting immunoassay protocol is rapid, inexpensive, easy-to-use, and is commercially available and delivered by Unisensor (a partner in the project).
FP7	FOODSCAN	A novel and automated biosensor platform for pesticide residue detection and traces of pesticides that is based on the Bioelectric Recognition Assay (BERA) technology for rapid, portable, cheap, user-friendly, and sensitive detection. An electronic interface for facilitating ease of use during real-time analysis of foods is built as well.	The pre-production prototype developed during this project is a BERA sensor aimed at the detection of micropollution. The early prototype can detect a number of organophosphate and carbamate pesticides, several classes of herbicide and a number of wine & cork contaminants. The final prototype was specified and built to fully operational capacity.

FP	Project	Actual results	Development stage
FP7	FOODSNIFFER	A field-deployable and simple-to-use food and water testing device technology that integrates three major innovations: (i) a transducer, an all-silicon fully integrated optoelectronic platform capable of synchronous highly sensitive label-free multi-analytic detection. (ii) innovative wafer-scale microfluidics and filtration systems. (iii) a low-power reader controlled by a smartphone through a custom-produced application. It is suitable for lab-quality molecular analysis of the entire food chain by targeting several food contaminants such as pesticide residues, mycotoxins and allergens in selected food categories.	A prototype bench-top measuring apparatus developed which will be used in the preliminary evaluation of the analytical performance of the FOODSNIFFER system.
FP7	PHOTOSENS	A low cost, nano-structured, large-area multi-parameter sensor platform that uses Photonic Crystal (PC) and Surface Enhanced Raman Scattering (SERS) methodologies for environmental and pharmaceutical applications. Its innovation also lies in the development of a new roll-to-toll nanoimprinting manufacturing methods.	PHOTOSENS tools available at Nanocomp for roll-to-roll UV imprinting and post processing of optical micro- and nanostructures and printed SERS structures were introduced.
FP7	SEA-on-a-CHIP	An early warning system that provides a rapid real-time analysis of marine waters (assessment of eight common contaminants from five groups of compounds) that affect aquaculture production in multi-stressor conditions. The device is a compact, autonomous multi analytic immune-sensor with impedimetric transduction integrated into an automated microfluidics system.	3 prototypes have been constructed each time with advanced capabilities, able to sense a higher number of compounds with a reduced volume, weight and energetic consumption. Each step allowed obtaining a more advanced prototype of autonomous biosensor platform. The final prototype was tested in the IPMA aquaculture facilities with successful results.
FP7	SMS	A real-time in situ monitoring device that can detect traces of marine water pollutants in coastal areas and send back alerts. It has the ability to monitor a variety of algal species and related toxins as well as pharmaceuticals and chemical compounds such as biocides, pesticides, herbicides and flame retardants.	A colorimetric assay based on the protein phosphatase-2A inhibition for Okadaic Acid detection has been developed and automated in a prototype produced by Systea. The prototype device features a vast number of communication technologies, able to establish network connection even in the most remote places. However, the results obtained by Systea were not satisfactory.
FP7	BRAAVOO	An innovative in situ device to detect a wide range of toxins such as antibiotics, toxins from algal blooms, endocrine-disrupting chemicals from paints, oil-derived compounds, and toxic heavy metals in the ocean. Three types of sensors were incorporated: 1) immunosensors that use antibodies to detect specific biological molecules, 2) bacterial biosensors, and 3) a system to detect toxins using the light-dependent reactions occurring in algae.	A prototype guidance, navigation and control (GNC) system was developed. The prototype uses 10 batteries and is capable of autonomously taking a sample, dispatching this over the sensors and measuring its output. The project data buoy prototype has been deployed in Loug Derg and on several occasions after that in bays or lakes around Ireland.

FP	Project	Actual results	Development stage
FP7	WaterDiss2.0	The project addressed the gap between research results and policy implementation by developing a bridge. It linked the scientists and their relevant water research results to policymakers, authorities, and practitioners. Further, it collected data on how over 60 water research projects under FP6 and FP7 approached knowledge sharing of their findings and outputs. It also identified obstacles and good practices in information sharing activities.	The analysis of the impacts and activities carried on during the WaterDiss2.0 project led for part to the design of new knowledge brokerage tools and generated recommendations and observations.
FP7	MARS	The project supported managers and policy makers in the practical policy implementation, effective River Basin Management Plans development, and when shaping future environmental policy. It focused on the Water Framework Directive implementation by understanding how stressors interfere and influence ecological status and ecosystem services.	MARS products were presented and discussed at Water Framework Directive - Common Implementation Strategy (WFD-CIS) working groups such as ECOSTAT, FLOODS and GROUNDWATER. In addition, MARS launched the Freshwater Information Platform, through which the results of several projects are stored and disseminated.
H2020	NanoScreen	A sensitive, affordable, rapid, in situ nano-optical sensing chip (PickMolTM) for pre-screening purpose that detects food and water contamination by POPs	The patented PickMolTM technology was validated by certified laboratory and can be tailored for any organic molecule, which means its large potential for application also in other fields like pharmaceutical & chemical industry, security and sport (doping control).
H2020	ODYSSEA	An interoperable, cost-effective platform that fully integrates networks of observing and forecasting systems across the Mediterranean basin (both the open sea and the coastal zone).	To facilitate the use of existing monitoring data, ODYSSEA conducted a legal study on the permissibility, conditions and limitations of using various data sources, among which the Copernicus Marine Environment Monitoring Service (CMEMS), EMODnet, SeaDataNet, MonGOOS, and others. One of the main deliverables of ODYSSEA is the 'Recommendations and proposals for new regulatory regimes' report.
H2020	CoPs	In-situ monitoring sensor platform that rapidly detects specific water pollutants (such as pesticides and nitrates in fresh waters) and transmits real-time data on contaminant levels as well as movements in natural water systems before they can reach water infrastructures and consumers.	The team intends to deploy beta version prototypes for large-scale testing in relevant environments.

FP	Project	Actual results	Development stage
H2020	INTCATCH	Cost-effective, user friendly "smart boats" that measure and detect pollutants such as Escherichia coli and pesticides in European lakes and rivers. The real time collected data is transferred to a cloud and can be processed by decision-support software in order to help both the communities and the authorities in tackling the water pollution.	A pilot scale system, supplied by the project partner Salsnes Filter from Norway, to treat CSOs was installed at Villa Bagatta on Lake Garda with integrated real-time monitoring systems using the same sensors and communications as those on the INTCATCH boats.
H2020	CyanoLakes	The project detects and monitor cyanobacteria blooms in lakes and coastal seas. Due to its quick and simple access to appropriate Earth observation (EO) based products, it improves the timeliness and coverage of the water quality status. It also serves the authorities, organisations, researchers, and commercial actors who need the data in order to tackle cyanobacterial harmful algal 'blooms'.	CyanoAlert service tools, including a web-based viewer, subscription and app, which constitutes the core of the service on the end-user side were developed.
H2020	PAVITR	A cost-effective wastewater technology, which can be scaled up for government entities and investors. The technology will fight water pollutants (i.e. emerging, traditional contaminants), will address drinking water challenges, ensure the provision of safe water reuse, rejuvenate river water quality, and restore degraded ecosystems in India.	The consortium adapted an already ambitious set of prototypes (14 in total). All the prototypes have been assigned to an implementation partner in India and the technologies are connected to motivated stakeholders, who are contributing to their success.

Table 7. Actual results per project in Theme 2 – Evaluating and assessing

FP	Project	Actual results	Development Stage
FP7	ATHENE	The project designed a biological wastewater treatment by elucidating the responsible enzymatic reactions of mixed microbial populations. It allowed finding technical solutions that harness the biological processes for an enhanced biodegradation and detoxification. The project is relevant to organics in the aquatic environment and in drinking water.	A set of methodologies was developed to elucidate microbial transformation of micropollutants occurring in wastewater treatment under anaerobic conditions (e.g., iron-reducing, sulfate-reducing) and under aerobic conditions (e.g., cascaded reactors, suspended vs. biofilm systems, substrate limitations).
FP7	Browse	An easy-to-use software that offers improved models for assessing exposure of operators, workers, residents and bystanders to pesticides. In addition, a new e-training platform which gives users a wide range of training materials on sustainable use of pesticides was built.	A protocol for data collection was also developed to ensure consistency of the sampling procedures across countries. The protocol was communicated to Greek and Italian partners and Newcastle visited the partner institutions in the two countries to train the interviewers and discuss the sampling guidelines.
FP7	CytoThreat	The project addressed the needs of the European society for assessing the risks associated with the release of pharmaceuticals into environment (i.e., cytostatic pharmaceuticals, their metabolites and transformation products) in both wastewater treatment systems and the environment.	The developed analytical methods were applied to assess the occurrence of cytostatics (including transformation products) in waste and surface water samples from Spain and Slovenia.
FP7	ENNSATOX	Cost effective tools and methods that examine the short and long-term risks of nanoparticle exposure on aquatic life as well as the impact of certain classes of nanoparticles (silicon-, zinc- and titanium-based) on the environment. ENNSATOX is considered valuable for risk assessments, prevention strategies and policymaking.	One of the model membrane tests has been patented and licensed as a generalized toxicity testing procedure which can be applied to investigate the activity of nanopartides. Additionally, control protocols have been defined to distinguish solubilised zinc from NP ZnO in toxicity assays.
FP7	GENESIS	An innovative solution based on advanced ICT for Environmental Management and Energy Efficiency that allows easy deployment and customization to thematic needs on a wide range of applications, at regional, national or Europe levels for various thematic fields.	The project consortium has developed an exploitation plan, which identifies the exploitable results of the project, defines the access conditions and licensing; and proposes concrete perspectives of reuse of GENESIS results beyond the project.
FP7	iPiE	An intelligent risk assessment and testing of Active Pharmaceutical Ingredients (APIs) in the environment. It embodies frameworks that utilize information from toxicological studies, pharmacological mode of action and in silico models.	The software system and predictive tools of iPiE were presented at the SETAC Europe Annual Meeting in 2019, demonstrating their use in early development programmes for new compounds.

FP	Project	Actual results	Development Stage
FP7	MicroDegrade	The project breaks ground at revealing bottlenecks of degradation at low, relevant (ug/L) concentrations by using a compound-specific isotope fractionation analysis (CSIA) of micropollutants.	MicroDegrade has introduced a novel analytical approach to the investigation of how the microbial degradation of trace pollutants is limited at low concentrations. The following implications have been pronounced: low-level water constituents such as NOM may not be persistent due to low concentrations. Based on isotopic evidence, turnover of substances at low concentrations may have been underestimated.
FP7	PHARMAS	An interdisciplinary approach to generate important data regarding exposure to PPS (i.e., antibiotics and anti-cancer drugs) including its concentrations in the environment and in both surface and drinking water. The results enable EU regulators and policy makers to make informed decisions on the issue of pharmaceuticals in the environment.	A prototype database for risk and hazard classification of pharmaceuticals has been developed. An initial pilot study was undertaken using three cytotoxic drugs, based on highest observed environmental concentrations, as well as the results obtained in the embryo toxicity assay.
FP7	SOLUTIONS	A monitoring toolbox composed of chemical tools for advanced analysis of emerging pollutants in both land and water. The project also developed an integrated system of models involving emission modelling, fate and transport modelling, and modelling of mixture risks to both ecosystems and human health via drinking water and fish consumption.	A pilot project for the establishment of regulatory monitoring of small streams in Germany under the National Action Plan for Sustainable Use of Pesticides, and the Joint Danube Survey 4 which has taken place in 2019.
FP7	TOX-TRAIN	The project builds upon a previously developed consensus-based tool that assesses the potential toxicity of products and technologies during their life cycle. The project provides an excellent platform to enhance the transfer of knowledge between the commercial and non-commercial sector in the area of toxic life-cycle impact assessment of technologies.	The project toolbox has been tested by implementing it in three case studies of common industrial processes. Researchers compared ecological and human toxicity impacts of different sludge-handling techniques, innovative wastewater treatment options and household exposure to toxins. The last includes, pesticide residues ingested by humans from consuming food crops.
FP7	CHEMAGEB	Different data compression, data pre-treatment and data modelling tools to investigate and process massive data obtained by MS, NMR, and DNA based analytical methods, along with extraction of environmental and toxicological information.	New chemometric and multi- and megavariate tools have been developed. Also, a detailed report on the effects of global change and chemical pollution on the genomic and metabonomic profiles of a selected set of representative target biological systems was delivered and used for global risk assessment. A CHEMAGEB laboratory was established, where PhD and postdocs have been working in the different tasks of the project during its time life.

FP	Project	Actual results	Development Stage
FP7	GLOBAQUA	GLOBAQUA approached the water scarcity issue by assembling multidisciplinary perspectives that encompass climate, hydrology, chemistry, ecology, ecotoxicology, economy, sociology and modelling.	A prototype of an interactive internet platform (Water-Hub) facilitating the connection to existing sources of information of potential relevance to GLOBAQUA have been in design and implementation stage.
FP7	WaterDiss2.0	The project addressed the gap between research results and policy implementation by developing a bridge. It linked the scientists and their relevant water research results to policymakers, authorities, and practitioners.	The analysis of the impacts and activities carried on during the WaterDiss2.0 project led for part to the design of new knowledge brokerage tools and generated recommendations and observations.
H2020	ANSWER	The project contributes to understanding the fate and transmission of antibiotics and its resistance from wastewater to the environment and humans, through soil, ground/surface water and crops, while investigating the risks associated with urban wastewater reuse in agriculture and how specific conditions may affect their spread.	ANSWER developed a database (hosted by the Norman Network) for information exchange on antibiotics, ARB and ARGs.
H2020	ECORISK2050	The project brings together a world leading and interdisciplinary consortium of universities, research institutes, industry, regulatory and governmental authorities to deliver a cohort of Early-Stage Researchers (ESRs). They will address the changing pressures that chemicals emitted by agricultural and urban activities pose to aquatic systems on the path to 2050 and beyond.	A set of modelling tools will be developed to assess the influence of global changes (GC) on ecosystem function and structure and its interaction with chemical stress at different levels of biological organization. The project is still ongoing.
H2020	LimnoPlast	The project develops innovative solutions to remove microplastics from the environment, and to find environmentally friendly polymers by applying a four-pronged approach: data assessment, training, technological solutions and behaviour change.	LimnoPlast will generate the following types of data: Data on physical samples and prototypes for the newly developed polymers and electro separation technology. The project is still ongoing.
H2020	CHEMO-RISK	A novel chemical risk assessment paradigm that integrates exposure and effect assessment of a broad range of chemicals into a single procedure.	A pilot study investigated different times of exposure of the silicone plasters by comparing the newly developed "chemometer" samplers with established formats (silicone wristbands) and assessing their prediction power of the blood levels of a range of participants of a cohort study.

Table 8. Actual results per project in Theme 3 – Prevention and remediation

FP	Project	Actual results	Development Stage
FP7	AFFIRM	The project produced an analysis of biofilm mediated fouling of nanofiltration membranes. More specifically, project identified the role of calcium on biofilm mechanical properties.	Significant advances were gained in the understanding of nanofiltration biofouling by applying techniques that include confocal microscopy, force spectroscopy, and infrared spectroscopy. In addition, an experimental programme was used informed by a scale-down technique together with mathematical modelling.
FP7	AquaCell	An innovative technology platform for the enhanced treatment of industrial wastewaters achieving cost reductions, electricity generation, and enabling water reuse for non-potable applications.	Carlsberg UK have agreed in principle to host a prototype once the product has been developed sufficiently in order to assess whether it will be effective in an industrial setting. A significant achievement is a Dynamic Flow Simulation that has been used to design two important features of pilot Microbial Fuel Cells MFC: manifold for inlet distribution and the drainage collector.
FP7	AQUAREHAB	Tools and technologies that help management and decontamination of polluted water systems (i.e. nitrates, pesticides, chlorinated and aromatic compounds, mixed pollutions, etc.) regardless of the type of pollution. Policy recommendation towards an integrated management of groundwater and surface water were formulated.	Prototypes for two management tools were developed within AQUAREHAB - REACHER (a decision support system (SSD) and REACHER local software. Also, a pilot field system that simulates flow conditions within the drainage channels was built in order to evaluate the introduction of bacteria/carrier combinations. Three patents have been filed for products developed within AQUAREHAB.
FP7	BIOTREAT	A water treatment biotechnology for removing pesticides, pharmaceuticals and other organic micropollutants from contaminated drinking water resources.	A prototype biofilter systems (metabolic and cometabolic) ready for commercialization. Further, a continuum biofilm-bioreactor model that describes nitrification in a pilot-scale rapid sand filter has been developed. This model has been enhanced by explicit inclusion of appropriate biokinetic terms to capture co–metabolism
FP7	CERAMPOL	An innovative filtration technology to increase the percentage of potable water in developing and industrialised countries. The filters possess an anti-fouling pre-filter made of polymeric nanofibres, a smart cleaning system employing piezoelectric crystals and a highly selective, nano-structured ceramic membrane.	An ion selective nanofibrous membrane prototype with high retention capacity towards the target rare earth elements was developed. The vibrating system prototypes were fabricated and tested with a fixed frequency swept sinusoidal driving voltage. The developed prototype has been fully tested for different selected wastewaters (mining industry, hydrometallurgy and hospital water) with successfully results for each application.

FP	Project	Actual results	Development Stage
FP7	ChitoClean	A unique approach for purifying drinking water which uses chitin from shrimp and crab carcasses to create water filters. The enhanced chitin-based materials ECMs will provide an environmentally friendly and health-promoting alternative to traditional methods of water treatment.	Enhanced Chitin-based Materials (ECMs) are to be implemented in prototypes of filtering units. Different kinds of prototypes were generated in order for the new technology to be applicable for different use: household filters, on-site water treatment in wells, big-scale treatment and integration into central water supply systems of small towns.
FP7	Clean Water	Visible solar-powered nanotechnology for purification of drinking water (mainly focused on cyanobacterial toxin MC-LR and endocrine disrupting compounds (EDC) in water supplies as well as classical water pollutants such us phenols, pesticides and azo-dyes).	A pilot plant for solar photocatalytic detoxification, based on the technology patented by PSA (Plataforma Solar de Almeria) and Ecosystem Environmental Services, S.A. Company, was specially designed and installed to carry out the validation tests of the scaled-up catalysts and processes for the removal of target toxics from water.
FP7	DEMEAU	A water technology that combats emerging pollutants. The project facilitates the uptake of knowledge, prototypes and practices from earlier EU research. In addition, it also demonstrates sustainable and cost-effective oxidation technologies for removing micropollutants from drinking water and wastewater.	A pilot scale treatment at two drinking water production plants in the Netherlands was conducted. Further experiments with ozone and ozone/H2O2 treatment in the pilot plant for drinking water treatment at the Water Supply Zurich were conducted.
FP7	ENDETECH	An enzyme-based water decontamination system to remove polluting pharmaceutical compounds. The system focuses on pharmaceutical products and endocrine-disrupting chemicals (EDCs) that are resistant to commonly used methods of wastewater treatment.	The best set-ups of the project were implemented in a pilot bioreactor.
FP7	ManureEcoMine	Upcycling manure and turning it into green fertiliser through the use of a multi-modular technology that can be flexibly applied to reduce the environmental impact of intensive animal husbandry in Europe.	Relevant patent searches have been conducted to further mine the patentability potential. Technologies of proven efficacy in the wastewater treatment field were combined in several process configurations to demonstrate their technological and environmental potential at pilot scale for cow and pig manure. The project prototype based on anaerobic co-digestion with biogas valorisation in a combined heat and power (CHP) unit and application of recovered nutrients as organic fertilisers was found as the most environmental-friendly option in both Dutch and Spanish scenarios.

FP	Project	Actual results	Development Stage
FP7	Nametech	Strengthening the European membrane market by making nanotechnology available to large-scale European membrane manufactures. The project brings together all required elements to enable the transfer of nanotechnology towards the field of water treatment, on both commercialisation stage and laboratory scale testing.	Nanoparticles deposition, coating techniques for nanopartides onto the membrane itself or onto the backbone of the membrane are developed and tested. These techniques will be used in the upcoming years to synthesise membranes for further laboratory and pilot tests. Further, when it comes to antifouling applications, ultrafiltration membranes with Ag-behenate and microfiltration membranes with Ag-benzotriazole are produced and tested in a pilot installation as well.
FP7	NANOPUR	The NANOPUR combats micropollutants (i.e., endocrine-disrupting compounds and antibiotics) by using nanotechnology to create advanced membranes for water treatment purification that can process high flow rates, while allowing a high retention of pollutants. The resulting membranes use around 500 times less energy than conventional membranes.	The project has resulted in several exploitable results and 5, possibly 6 patent application filings. Furthermore, the prototype membranes for lab-based testing on a small scale proved successful in retaining micropollutants such as diclofenac, metoprolol, vancomycin and endotoxins. The hydrophilized polyvinylidene fluoride (PVDF) membranes have been produced at pilot-scale and are ready for commercialization on the short term by one of the project partners after the in-line implementation of the plasma equipment.
FP7	NanoSelect	Nanomaterials-based water purification membranes for decentralised industrial and domestic water. NanoSelect has the potential to remove heavy metals while ensuring high-efficiency decentralised water cleaning, high adsorption rates and selectivity. It also features reuseable antifouling or lowfouling surfaces. The removal of water pollutants will have long-term benefits for human health and quality of life.	The demonstration of the modules and prototypes from Nanoselect was successful at the industrial sites and effectively reduced nitrates, dyes and suspended solids. One patent is filed and an agreement is executed on ownership of the final working prototype for water cleaning to clearly define the IP rights The IP generated from the project will be used as background for other national and EU projects by all partners. In addtion, a pilot scale project under H2020 to make the membranes and modules ready for market was under discussion when the project ended.
FP7	OxFloc	Novel wastewater treatment technologies whose resulting system combines filtration, oxidation and flocculation. The systems need only few chemicals and rely on electricity alone while having a quantified superior environmental benefit, a smaller plant footprint, lower operation costs and enable 100% water recycling as they work without salt-carrying chemicals.	A cell for electro-oxidation and hydrogen peroxide production was developed as part of the Oxfloc project to render the Oxfloc prototype independent of external hydrogen peroxide dosing and further reduce the organic load of the effluent.

FP	Project	Actual results	Development Stage
FP7	PHASEPLIT	PHASEPLIT brought together scientists from the commercial and research sectors to develop a decentralised, anaerobic wastewater reactor customised for SMEs that will allow them to comply with EU regulations and to reduce organic pollution in fresh water.	The Internal Circulator reactor (IC) has a patented design that saves operation costs by gas recirculation. The control system + electric cabinet has been implanted in a pilot plant prototype containing the reactors for two-phases, settler and auxiliary equipment. Phaseplit pilot plant is a complex biogas generation process able to work unattended in several locations. The plant has been provided with a remote system to monitor the plant status and make plant analysis though SCADA tools.
FP7	Routes	Novel techniques for sewage sludge treatment under different conditions in order to improve sludge quality and enable its use in agriculture. They minimise sludge production and recover valuable resources prior to disposal. The technique removed a number of volatile solids and resulted in significant biogas production and sanitisation of the sewage sludge.	Different process units (both lab and pilot scales) were developed and optimized and the integrated process for the production of a biopolymers value-added polyhydroxyalkanoate (PHA) appeared to be feasible. Also, production of biopolymers was successfully proved at pilot scale in the installation of AnoxKaldnes in Brussels which can be considered the first-of-their-kind piloting prototypes for the production of PHAs as an integral part of municipal wastewater treatment.
FP7	WaSClean	Novel materials and technologies for remediation of contaminated soils and groundwater from xenobiotic (e.g., man-made) contaminants. The technologies will contribute to the removal of toxic metals/metalloids and recalcitrant organic contaminants.	WaSClean outputs have been developed as platform technologies, so that different prototypes can be designed to meet the needs of different client groups.
FP7	WATERMIM	A nanoparticle system that can be used to remove specific compounds from polluted water, including purifying drinking water. Researchers selected the most promising techniques and used them to produce molecularly imprinted polymers (MIPs) for three trial compounds.	Two patent applications have been submitted within the project lifetime. A variety of Prototypes have been developed such as prototype of sandwich-type nanoparticles-based membranes, Prototype of nanoparticles-embedded membranes, Prototype of MIP films on/in ceramic substrates, Prototype of nanofiber-based membranes for sensors, Prototype of composite MIP adsorbent/catalyst systems via various techniques
FP7	WATERPLASMA	An innovative decontamination process based on a one atmosphere uniform glow discharge ("OAUGD") plasma reactor that eliminates recalcitrant molecules without the need of chemicals or filters. Reaction chamber, power electronics design, process optimisation, chemical/ toxicological analyses, and monitoring will ensure the resulting wastewater decontamination and will broaden knowledge about plasma decontamination.	Two main scenarios were tested in the project pilot plant. The industrial validation of the pilot scale prototype was carried out between November and December 2012 using industrial wastewater from two end-users: chemo-pharmaceutical industry and bio-pharmaceutical industry. Further, different bench scale prototypes, with planar and coaxial designs have been used for laboratory testing throughout the project. The coaxial configuration was chosen as the most adequate for scale up, due to the lower footprint in relation to the required electrode surface area.

FP	Project	Actual results	Development Stage
FP7	AquaFit4use	An innovative solution for sustainable water uses in four high water consumption sectors such as the chemical, paper, textile and food industries. The project developed and tested cost-effective technologies, tools and methods that have reduced freshwater needs (i.e., fighting biofouling by developing a biofiltration prevention technology - Denutritor).	The technological and economic benefits of tailor-made water treatment lines have been investigated by comprehensive pilot trials. The information and the results obtained during the pilot trials were used for the development of mathematical models.
FP7	LbLBRANE	A novel type of multilayer water filtration membrane technology that uses nanotechnology to produce robust self-cleaning membranes at low cost. The membrane system has major benefits compared to conventional treatment systems. It includes no use of solvents, ease of application, stability during harsh cleaning conditions, regeneration under mild and environmentally friendly conditions, high performance and an extended lifespan.	A prototype of rotating-membrane test cell was designed, built and preliminary tested. Within a short lab-scale pilot study, the LbL membranes using different supports were benchmarked and compared with a commercially available nanofiltration spiral wound module. The small-scale pilot study with real wastewater showed that the LbL membrane has serious potential to be competitive to real NF products already on the market. In total, two pilot test trails were executed with canal water while multiple pilot test trails were executed using digestate as pilot feed water. A patent violation from other competitors cannot be identified easily since the LbL film itself is just a few nanometres thick, therefore the project is non-patent.
FP7	LIMPID	Nano-structured materials that use sunlight to degrade pollutants. These materials, known as photocatalysts, may be incorporated into polymers, membranes and beads as new tools to remove pollutants from air and water. LIMPID's new photocatalytic nanocomposite materials could be used to completely remove any remaining toxins (i.e. pharmaceuticals, personal care products and endocrine disrupting chemicals) after the initial wastewater treatment.	A patent has been filed on the method of preparation and application of the composite multifunctional polymer partide dispersion. In addition, 4 patents were indicated as being filed or under submission.
FP7	MINOTAURUS	Novel techniques and approaches that test a number of biocatalysts (whole cells and enzymes) for the bioremediation of polluted groundwater and wastewater. The project explored the immobilisation of biocatalysts as a way to intensify the degradation of organic pollutants.	A prototype of an optotrode system, a 24-well oxygen sensor was developed. Several pilot testing were performed.

FP	Project	Actual results	Development Stage
FP7	MONACAT	Novel nano-scale catalytic water detoxification systems, that include drinking water application. MONACAT systems employ novel water purification technology that could provide industries with viable means of ensuring compliance with global environment safety regulations, keeping costs down and providing energy savings.	Nano carbon coatings were tested for industrial application, energy cost and adhesion of NPs simulating natural conditions. All tests were successful, supporting the suitability and safety of the composites for use in catalytic water treatment.
FP7	NATIOMEM	The project focuses on production of safe drinking water in rural areas of South Africa and the Middle East, and on remediation of grey wastewater for toilet flushing and irrigation that can be implemented on rooftops in Jordan's urban areas. The water treatment technology requires minimal electricity and infrastructure and has the potential to significantly increase the commercial competitiveness of partners.	Based on the results from laboratory testing, three pilot plants with photocatalytic membranes were designed and set up in South Africa and Jordan. Prototypes of the novel photocatalytic treatment should be constructed, tested and demonstrated (i.e., a prototype of a small-scale pilot water treatment plant).
FP7	P-REX	Sustainable sewage sludge management fostering phosphorus recovery from municipal wastewater for use in agriculture and energy efficiency. In addition, strategies for wide-scale phosphorus recovery and market penetration are also developed.	A patent has been submitted accordingly in 2014. Green polymers have been tested in lab-pilot- and full-scale to substitute chemical polymers commonly used for sludge thickening and drying.
FP7	WATERBIOTECH	Methods and strategies for establishing biological water treatment systems in African countries. WATERBIOTECH outcomes are expected to help reduce the pressure on freshwater resources by shifting the focus to the safe recycling of wastewater. This can replace drinking water in applications that do not require potable water, such as industry, irrigation, toilet flushing and the washing of clothes.	Know-how and best practices for African countries to sustainably manage polluted water resources using biological systems, including green plants and microorganisms. A major finding was that logistical and organisational issues are often the reason a particular water treatment technology has failed. The project produced a guideline and strategy document to help countries implement different water treatment technologies.
FP7	WaterDiss2.0	The project addressed the gap between research results and policy implementation by developing a bridge, linking the scientists and their relevant water research results to policymakers, authorities, and practitioners.	The analysis of the impacts and activities carried on during the WaterDiss2.0 project led for part to the design of new knowledge brokerage tools and generated recommendations and observations.

FP	Project	Actual results	Development Stage
FP7	MARSOL	The project offers a key approach for tackling water scarcity in Southern Europe by stimulating the use of reclaimed water and other alternative water sources in Managed Aquifer Recharge (MAR) and optimizing water resources management (WRM) through storage of excess water which can be recovered in times of shortage or by influencing gradients.	A prototype TDR sensor developed by the partner ICCS were installed. The optimal locations for the time domain reflectometry (TDR) sensors were selected based on the information from the site investigation program. The systems consist of low loss coaxial cables for the TDR signal that were sealed and connected to the TDR monitoring and data-logging system. In addition to the four monitoring wells at the wastewater treatment plant, three regional groundwater monitoring stations have been established under the MARSOL project to monitor the impact of the Malta South Managed Aquifer Recharge pilot project.
H2020	Eco-UV	Demonstration and characterisation of an innovative UV lamp and driving electronics technology for chemical-free water treatment and disinfection. The technology provides up to four times increased lifetime with greatly increased efficiency, and energy consumption reduced by 80%. Thus, it generates a lower carbon footprint, much improved energy use and greatly reduced lifetime costs.	Limited life testing of prototype lamps and ballasts has occurred with further testing scheduled. Two of the lamps have also been subjected to a life cycle cost and environmental effects analysis, and both these lamp and ballast systems have been filed as patents in the UK.
H2020	FAirWAY	Farm systems that produce good water quality for drinking water supplies. The project reviews policy, governance and farm water management approaches in order to protect drinking water resources in the EU and to identify and further develop innovative measures and governance approaches which will simultaneously increase the sustainability of agriculture.	A technical report with a review of existing support tools has been delivered. More than 150 decision support tools were identified in total, of which 36 were selected for further investigation based on their national importance and relevance to the project's aims. The outputs are expected to provide a blueprint for multi-actor engagement across different scales, which will allow agriculture and water policies to be addressed in a more integrated way. The project is still ongoing.
H2020	WATERPROTECT	The project has set up action labs (local coalitions in agricultural areas with water quality issues linked to drinking water production) in 7 European regions to raise farmers' awareness and encourage new practices. The project embodies innovative tools enabling safe drinking water in rural and urban environments.	The project ended in September 2020, but the WATERPROTECT community lives on at the EU level, with a forum dedicated to sharing experiences and contributing to future actions and research.
H2020	RUN4LIFE	An alternative strategy to efficiently recover nutrients at the source, in a decentralized approach for segregating concentrated waste streams such as black water (toilet wastewater), grey water (other domestic wastewater) and organic kitchen waste.	There was an analysis of similar related pilot experiences towards nutrient recovery from different waste streams. There are no patents, or prototypes developed for this project.

FP	Project	Actual results	Development Stage
H2020	AQUAlity	A multi-sensor automated water quality monitoring and control system for continuous use in recirculation aquaculture systems. The cost-efficient multi-sensor unit measures water quality parameters in fish farms. This monitoring and advice system was coupled to an intelligent automatic control system, which contained built-in knowledge of the farmed species.	All software developed are prototypes that have been able to show the function of the system in field trials and have been able to be utilised for training and demonstration purposes. There was a pre-prototype production, test and evaluation as well.
H2020	CLAIM	Innovative cleaning technologies and approaches, targeting the prevention and in situ management of visible and invisible marine litter in the Mediterranean and Baltic Sea.	An innovative pilot for the removal of microplastics has been developed, employing visible light (sunlight) photocatalysis with green nanotechnology-based coatings. The project is still ongoing.
H2020	GoJelly	A gelatinous solution to microplastic pollution by developing a TRL 5-6 prototype microplastics filter for commercial and public use, whose main raw material is jellyfish mucus.	The GoJelly consortium submitted a provisional patent on the efficacy of mucin extracted from jellyfish in flocculating micro-and nano-plastic particles in solution. Two patents on JF biomass processing for human consumption were deposited. The project delivers two new prototypes to the EC based on European JF collagen products.
H2020	PFS	A low cost, low energy enzyme treatment technology unit that removes organic micropollutants such as pharmaceuticals and medicine residues (APIs). PFS is based on modified enzymes which are 200 times more effective than native enzymes, resistant to both low temperature and low pH and with high levels of stability, and activity.	The project is preparing for full entry into the wastewater treatment market during 2021. The team has signed collaboration agreements with several key partners and have been able to secure several industry treatment projects with the pharmaceutical industry.
H2020	CGM	A cost-effective, low energy solution to unsustainable water usage through targeted capture of micropollutants from contaminated industrial wastewater such as per- and polyfluoroalkyl substances (PFAS). CGM production and treatment operations support a circular economy and reduce the CO2 footprint by more than 50 % upon implementation.	The project is now ready for use in a demonstration with a potential customer, planned as the final step in confirming its market readiness.

FP	Project	Actual results	Development Stage
H2020	VORTEX	The project applies stable isotope assays in tandem with lipidomics, NGS-based microbial diversity and functional gene analyses in order to assess marine degradation of plastics.	Several colonisation experiments were conducted including community analyses to determine potential unique microbial community patterns along with a DNA extraction. A method to identify and quantify nano plastic in the ocean environment was further developed and coupled photo oxidation and microbial degradation were investigated. The project is still ongoing.
H2020	ELECTRA	An electricity driven low energy and chemical input technology for accelerated bioremediation. ELECTRA relies on environmental technologies that facilitate and improve electron transfer during microbial degradation processes.	Two of the partners are working on IPR (patent application) for the multi-tubular module design. The project is still ongoing.
H2020	PANI WATER	Prototypes that support wastewater treatment for safe reuse of water in agriculture, in related industries, water-demanding businesses (e.g., textiles, pharmaceuticals), and the Indian water utilities as well as removal of contaminants drinking water.	PANIWATER will develop, deploy and validate in the field six prototypes for the removal of contaminants, including contaminants of emerging concerns CECs, from wastewater and drinking water. These prototypes will be deployed in peri-urban and rural areas in India. The preliminary prototypes were successfully tested. The project is still ongoing.
H2020	INDIA-H2O	A low-cost water treatment system for saline groundwater and industrial wastewaters using membrane and bio-mimetic approaches. The focus for developments will be in the arid state of Gujarat, where surface water resources are very scarce.	A prototype batch reverse osmosis system has also been installed at University of Birmingham. Forward osmosis (FO) units have been designed to enable reuse of the wastewater, and they will also enable the salinity of the discharged brine to match the requirements of the halophytic crops. The project is still ongoing.
H2020	GREENER	A low-cost hybrid solution that integrates bioremediation technologies with bio-electrochemical systems (BES). The systems break down organic contaminants (i.e. hazardous compounds, including polycyclic aromatic hydrocarbons, heavy metals and emerging pollutants that contaminate soils/sediments) through the action of electroactive bacteria while producing electricity.	As the project is still at an early stage of implementation, there has not been significant progress beyond the state of the art, as the initial experiments are still underway and no significant results have been generated yet. The project is still ongoing.

FP	Project	Actual results	Development Stage
H2020	REWATERGY	A reactor for applications on the water-energy nexus. An integrated network, led by industry in partnership with academic institutions focuses on a wide range of contaminants, while decreasing the energy demand of the water cycle with direct economic and social impacts to the EU. Increasing the resilience of distributed household safe drinking water systems and addressing potential health and safety challenges are among the goals of the projects.	The programme is particularly designed to cultivate an entrepreneurial spirit by the collaborative design, development and manufacturing of new prototypes aligned with the three research objectives. Hence, three prototypes have been developed. The project is still ongoing.
H2020	REGROUND	A low cost nanogeotechnology for the immobilisation of toxic contaminants (i.e., heavy metals, cyanide and polycyclic aromatic hydrocarbons PAHs).	Total of six pilot- and large-scale applications in different aquifers have confirmed the mobility of particles.
H2020	AquaNES	Water, wastewater treatment processes and management through improved combinations of natural and engineered components (cNES) will be catalyzed. Among the demonstrated solutions are natural treatment processes such as bank filtration (BF), managed aquifer recharge (MAR) and constructed wetlands (CW) plus engineered pre- and post-treatment options.	Typical applications of cNES involve the use of BF in drinking water production from surface waters, MAR to augment groundwater resources, and CW to treat wastewater and add buffering capacities in drainage systems.
H2020	ELECTRON4WATER	A chemical-free water purification technology which embodies three-dimensional (3D) electrode materials and electrochemical reactors. It uses low-cost nanostructured coatings to obtain higher energy efficiency for electrochemical removal of chemical and microbial contaminants. The project can be easily upscaled and applied to the production of larger electrochemical units.	The project is still ongoing.
H2020	ALGAMATER	A cost-effective, and eco-friendly wastewater treatment system. The project harnesses components found in highly concentrated wastewaters such as landfill leachate to feed microalgae which grow especially quickly by transforming ammonium and phosphates into proteins and other organic matter.	Two patents are in the process of submission according to the Reporting section of the project.
H2020	NextGen	Novel technological, business and governance solutions for water in circular economy in ten high-profile, large-scale, demonstration cases across Europe.	10 large scale demo cases of 10 different technologies deployed in 8 EU Member States to demonstrate CE approach The project is still ongoing.

FP	Project	Actual results	Development Stage
H2020	PAVITR	A cost-effective wastewater technology, which can be scaled up for government entities and investors. The technology will fight water pollutants (i.e., emerging, traditional contaminants), will address drinking water challenges, ensure the provision of safe water reuse, rejuvenate river water quality, and restore degraded ecosystems in India.	The consortium adapted an already ambitious set of prototypes (14 in total). All the prototypes have been assigned to an implementation partner in India and the technologies are connected to motivated stakeholders, who are contributing to their success. The project is still ongoing.
H2020	Saraswati 2.0	Real time monitoring and automation technology for decentralized wastewater treatment in India with a scope of resource/energy recovery and reuse in urban and rural areas. The tool adopts BATs tech in a flexible way.	Ten pilot technologies in 7 Indian States demonstrating enhanced removal of organic pollution (BOD, TSS), nutrients (particularly Nitrogen), organic micro-pollutants and pathogens will be piloted. It is expected that the technology readiness levels can be increased for all piloted technologies by 1-3 levels. The project is still ongoing.

5 Supporting uptake

This section explores several options for supporting uptake and establishing synergies between various types of stakeholders, as well as best practices to leverage the impact through dissemination and exploitation of R&I results.

5.1 Synergies and coordination mechanisms

This sub-section focuses on some identified and proposed approaches to establish synergies and coordination mechanisms for R&I programming with other stakeholders within the EU Programmes, Institutions, Member States and Associated Countries.

Synergies

Several good practices related to synergies between projects supported by the EU funding programmes for research and innovation have been identified. Some of the examples presented below include **collaboration between projects in the portfolio**, which have clustered and presented research achievements on a certain topic, thus facilitating knowledge transfer to policymakers and other water management actors. Other examples include projects which build on EU research activities outside the portfolio and projects which support the uptake of previously developed solutions, technologies and practices. In most cases, there have been observed synergies in the implementation of joint initiatives such as workshops, conferences and awareness raising campaigns, through which projects deliver integrated messages to EU stakeholders.

Three FP7 portfolio projects (CytoThreat, GLOBAQUA and ENDETECH) and one project supported by the Spanish Ministry of Economy and Competitiveness (SCARCE) co-organised a workshop on pharmaceutical residues[12]. The topic was tackled from a multidisciplinary perspective with partners from the four projects presenting their findings in four thematic sessions: 1) Analysis of pharmaceuticals in wastewaters and hospital effluents; 2) Fate and behaviour of pharmaceuticals in wastewater treatment plants and river water; 3) Remediation technologies; and 4) Risk assessment. The workshop was attended by 50 participants from research institutes and the environmental management sector.

A workshop on stressors affecting freshwater systems, including emerging and priority pollutants, was organised by three FP7 portfolio projects (MARS, GLOBAQUA and SOLUTIONS)[13]. The main objective of the workshop was to sum up the research conducted by the three projects on the impacts of stressors on river basins and explore new tools for improving river water management. A separate session was dedicated to science-policy dialogue and translating the project scientific findings into recommendations for improving the European regulatory frameworks on freshwater, with particular emphasis on the Water Framework Directive. In addition, approaches for communicating results to the general public, academic and policy actors

[12] Pharmaceuticals in wastewater and surface waters under multistressors situation: fate, adverse effects, risks and removal technologies

[13] New predictive tools to improve river water management from local to European scale

were discussed, with a specific focus on how the databases, scientific publications and water management tools produced by the projects might be best presented to different audiences.

The P-REX project, aimed at phosphorus recovery from sewage sludge, is an example of successful **collaboration with EU projects outside the portfolio**. P-REX presented its findings to another FP7 project aimed at phosphorus recovery from wastewater (RECOPHOS) and organised a training workshop for its team on the application of Life - Cycle Assessment methodologies. P-REX also collaborated with the PHORWater project funded by the LIFE+ Programme, which was aimed at developing a management model for phosphorus recovery and reuse from urban wastewater. In addition, P-REX joined BIOREFINE Cluster Europe, which interconnects projects within the domain of bio-based resource recovery.

DEMEAU, on the other hand, draws on **previous EU research projects** and promotes the uptake of technologies which have been tested on laboratory and pilot scale but are not yet widely implemented in practice. For example, hybrid ceramic membrane filtration has been explored within the TECHNEAU project funded under FP6, but its application has been hampered by a relatively high investment cost. DEMEAU has further promoted the technology by demonstrating its technical and economic feasibility. Similarly, advanced oxidation technologies have been studied under various EU projects (TECHNEAU, NEPTUNE, RECLAIM WATER) but concerns over the formation of oxidation by-products have been a major implementation barrier. To address it, DEMEAU has developed a decision tool for the implementation of oxidation technologies.

Coordination mechanisms

A number of projects in the portfolio have applied coordination mechanisms to align their activities with various **actors in the water sector at national level**. Those stakeholders were either directly engaged in project activities or targeted by communication and dissemination tools. Projects like WATERPROTECT and FAIRWAY have applied a multi-actor participatory approach in the analysis of management practices for the protection of drinking water resources. WATERPROTECT has created action labs in several EU countries, where farmers' associations, local authorities, water companies and consumer organisations jointly developed pesticide and nutrient monitoring strategies in locations affected by intensive agriculture. To upscale lessons learned, the consortium created the WaterProtect community[14] aimed at connecting key experts and stakeholders interested in designing and further developing water governance policy approaches while getting agricultural actors involved in the process.

Similarly, FAIRWAY has created multi-actor platforms, which provided input to the assessment of the drinking water quality indicators, governance models, measures and practices to decrease nitrate and pesticide leaching. The stakeholder groups involved in the platforms included farmers, advisory organisations, policymakers, water companies, retail companies, research organisations and regional authorities. DEMEAU is another project which actively involved the end users of solutions already developed, i.e. water utilities. They acted as launching customer and demonstration sites to demonstrate the effectiveness of technologies and foster their wider application.

[14] https://water-protect.eu/en/approach/waterprotect-community

Other projects coordinated their activities with various **associations, agencies and institutions at EU level**, including different Directorates-General (DGs) of the European Commission. In some cases, those actors contributed to the design of the conceptual framework of the projects. For example, the Stakeholder Board of the SOLUTIONS project included representatives of the Directorate-General for Environment (DG ENV), the European Environment Agency (EEA), the international commissions for the protection of the Rhine and Danube rivers, and the European Federation of National Associations of Water Services. The SOLUTIONS project also used monitoring data made available by the NORMAN network specializing in emerging pollutants, and the Information Platform for Chemical Monitoring developed by the European Commission's Joint Research Centre (JRC).

In other projects, decision-making bodies at EU level were invited to participate in various consultation activities and events such as stakeholder workshops and conferences. For example, representatives of the Directorate-General for Health and Consumers (DG SANCO[15]), the Directorate-General for Research and Innovation (DG RTD) and the European Food Safety Authority (EFSA) took part in the final stakeholder workshop organised by the CONFFIDENCE project.

In some projects, activities were carried out in close coordination with the relevant **thematic networks and platforms at EU level**. For instance, the AquaFit4Use project was based on priorities set by the Water in Industry working group of the EU Water Supply and Sanitation Technology Platform (WssTP). Similarly, the P-REX project joined efforts with the European Sustainable Phosphorus Platform to develop a matchmaking platform for supply and demand for recovered nutrients.

Several recommendations can be made to facilitate synergies and coordination between stakeholders within the EU R&I Programmes, institutions, Member States and Associated Countries as follows:

- **Project clustering** – R&I projects, which share a common theme or address similar issues related to micropollutants in water systems, could be grouped in clusters in a publicly available database. In this way, projects could either collaborate and form partnerships to deliver integrated messages or build on previously accumulated knowledge and further enhance and upscale solutions. Such an approach would also ensure coherence and complementarity in R&I programming.

- Establishing **collaborative platforms** for experts and stakeholders interested in specific challenges related to micropollutants in water systems. Expert communities should be open to representatives of both EU Member States and Associated Countries, allowing for knowledge spillover and solutions being replicated or adapted to different contexts. Such platforms could stimulate engagement with policy relevant research and create the background for future partnerships and collaborations.

- Applying a **participatory approach** to solution design and implementation – the inclusive approach is an essential instrument for generating trust and awareness among stakeholders and end-users and enhancing the credibility of solutions. The engagement

[15] Currently Directorate-General for Health and Food Safety (DG SANTE)

of stakeholders in the processes of prevention and remediation through multi-actor platforms and co-creation techniques has proven to be very successful for a number of projects in the portfolio and essential for introducing feedback mechanisms.

5.2 Best practices in dissemination and exploitation

This sub-section highlights good practice examples in the portfolio related to the dissemination and exploitation of achieved results. These include various promotion activities, awareness raising efforts and communication of challenges related to micropollutants in water systems.

For the identification of best practices in dissemination and exploitation activities, the following criteria have been applied to projects in the portfolio:

- Dissemination activities are **adapted to different types of audience** – examples presented below include projects with targeted outputs using appropriate formats for different target groups (e.g., research communities, industry actors, water companies, national authorities, EU policymakers, civil society). Dissemination strategies, key messages and channels used are tailored to each type of audience.
- **External opportunities are utilised** to maximise the uptake of research – selected projects have used established networks, existing conferences and events to raise awareness on the project's findings, enhanced knowledge and innovation (new solutions reaching the market).
- **Continuity** is ensured, i.e., arrangements are made to ensure that information on project results will not be lost, once the project comes to an end. Special attention is paid to projects whose deliverables are still publicly available.

Table 9 below presents examples of projects, which comply with at least two of the above-listed criteria. For each of these projects a good practice in terms of dissemination or exploitation of results has been described. The selection of good practices aimed to cover different types of activities related to dissemination (e.g., events; videos/animations; brochures/factsheets) and exploitation (e.g., demonstration events; market surveys; exploitation webinars; innovation workshops; training and capacity building activities).

Table 9. Best practices in dissemination and exploitation activities

	Project	Criteria for selection: *Adapted content*	Criteria for selection: *External outreach*	Criteria for selection: *Continuity*	Type of activity	Description
Dissemination activities	MARS	√ Dissemination activities adapted to different target groups (e.g., tailored seminars for river basin managers)	√ Cooperation with external projects (GLOBAQUA, SOLUTIONS, OpenNESS) and organisation of joint events.	√ All deliverables, tools, policy briefs, factsheets, publications, and databases created under the project are still publicly available on the project website.	Events	In April 2016, the MARS project organised the 'Multiple Pressures in River Basin Management' meeting in Vienna. It was attended by river basin managers, Water Framework Directive officials and aquatic scientists from across Europe to discuss approaches to managing multiple pressures on freshwaters.
	SMS	√ Dissemination activities adapted to different target groups (e.g., short lectures for children and youth)	√ Cooperation with another FP7 project (DEVOTES) and organisation of joint events	√ All deliverables and publications created under the project are still publicly available on the project website.	Events	In June 2017, the Marine Biology station in Piran, Slovenia, organised an "Open Doors Day" in honour of the World's Ocean Day 2017. Children, teenagers and adults were encouraged to visit the station and attend short lectures and interactive workshops. The SMS project was presented there, and the team explained to a public of all ages the issue of chemical water pollution, and the original solution developed by the project consortium. The children learned the concept of smart boxes and automated remote monitoring via the internet.
	DEMEAU	√ Tailored activities for specific target groups (e.g., utility events) and materials aimed at the general public (e.g. video animation)	N/A	√ All deliverables of the project are still publicly available on the project website.	Videos, animations	For awareness raising purposes, DEMEAU produced a short video animation, 'Dare to drink? Emerging pollutants in our water', which targets both policymakers 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 drinking water. As of December 2021, it has over 4,600 views on YouTube.

	Project	*Criteria for selection* *Adapted content*	*External outreach*	*Continuity*	Type of activity	Description
	P-REX	√ Various events tailored per type of audience (e.g., regional workshops with local farmers, fertilizer retailers and authorities)	√ Cooperation with another FP7 project aimed at phosphorus recovery from wastewater (RECOPHOS)	N/A	Videos, animations	A short video, 'P-REX Phosphorus recovery from sewage' has been produced to promote the matchmaking platform set up by P-REX to bridge the gap between supply (recovery) and demand (recycling) of recovered nutrients from liquid and solid wastes.
	SOLUTIONS	√ Tailored activities for specific target groups (e.g., scientific conferences) and materials aimed at the general public (e.g. videos broadcasted on German, Slovakian and Serbian television)	√ Cooperation with external projects (MARS, GLOBAQUA) and organisation of joint events.	√ All results, products, deliverables and publications created under the project are still publicly available on the project website.	Brochures, factsheets	The project team produced a factsheet with concise information on the motivation behind SOLUTIONS, its objectives, activities, case studies, as well as figures and numbers related to the project.
Exploitation activities	DEMEAU	√ Tailored activities for specific target groups (e.g., utility events) and materials aimed at the general public	N/A	√ All deliverables of the project are still publicly available on the project website.	Demonstration events	DEMEAU organised utility events to present the technology to water utilities and forward the results of project activities. Utility events varied by topic: Managed Aquifer Recharge (MAR) was covered in Scheveningen, Berlin and Barcelona; Hybrid Ceramic Membrane Filtration (HCMF) in Andijk and Roetgen; oxidation technologies in Neugut and Zürich; and bioassays in Paris. Along with utility events, DEMEAU organised workshops aimed at all stakeholders relevant for the implementation of the technology, ranging from authorities to utility operators, and laboratories.

	Project	*Criteria for selection* *Adapted content*	*External outreach*	*Continuity*	Type of activity	Description
	CERAMPOL	√ Tailored activities for specific target groups (e.g., workshops) and materials aimed at the general public	√ Cooperation with the Nano4Water cluster and organisation of joint events	N/A	Demonstration events	CERAMPOL demonstrated developed technologies to various industry representatives. The technologies were showcased at specialized events such as the 13th Conference of the European Ceramic Society, the Water Technology and Environment Control (WATEC) exhibition and conference in Tel Aviv, Israel, the International Conference on Membranes (ICOM) in Suzhou, China, and the 3rd International Conference on Electrospinning in San Francisco, USA.
	BRAAVOO	√ Tailored activities for specific target groups (e.g., scientific publications) and materials aimed at the general public (e.g., project video from the BRAAVOO special edition of the Euronews Futuris feature)	√ Cooperation with another FP7 project (KILL-SPILL).	√ All deliverables of the project are still publicly available on the project website.	Market survey; Exploitation webinar	BRAAVOO distributed a market survey among stakeholders to collect ideas on the potential for commercialisation of future biosensor products and their expected market volumes. In addition, an exploitation webinar was organised in order to provide critical information to BRAAVOO partners about exploitation, protection of IPR and strategies for the best use of project outcomes.
	Run4Life	√ Dissemination materials are tailored to specific country context (e.g., separate videos for each of the four demonstration sites in Belgium, Spain, Sweden and the Netherlands)	√ Cooperation with the European Sustainable Phosphorous Platform and the ICT4Water cluster; Organisation of joint events	√ All factsheets on fertiliser products and technologies developed, as well as publications created under the project are publicly available on the project website.	Innovation workshop	Run4Life organised a workshop focused on the business cases and models developed by each of the demo sites. Participating end-users received direct information about technologies and their practical implementation and were invited to provide feedback on the innovations of Run4Life. The innovation workshop also included a Masterclass by an expert from the water and environmental sector who provided the Run4Life partners with information on funding and investment opportunities after project completion.

	Project	Criteria for selection: *Adapted content*	*External outreach*	*Continuity*	Type of activity	Description
	ROUTES	√ Tailored activities for specific target groups (e.g., scientific conferences) and materials aimed at the general public	√ Participation in two International Fairs where the ROUTES project set up a dedicated stand, namely Ecomondo, (November 2012, Rimini, Italy) and Pollutec Horizons 2013 (Paris, France, December 2013)	N/A	Training and capacity building	Under ROUTES, a training course was held in Barcelona to train all scientists involved in the pathogens and pathogens indicator detection to use standardized methodologies in their activities. In this way, the training allowed for harmonisation of different procedures in pathogens detection.
	TOX-TRAIN	√ Tailored activities for specific target groups and materials aimed at the general public (e.g., USETox video on Vimeo)	N/A	√ All training courses and tutorials developed under the project are publicly available on the project website	Training and capacity building	Experts and practitioners are trained in applying the toxicity assessment USEtox tool through summer schools, training courses and tutorials available online. In 2020, a full-day short course was given at the Society of Environmental Toxicology and Chemistry (SETAC) Europe 2020 with 25 participants from 4 continents working in academy, industry, consulting and policy.

In addition, WATERDISS 2.0 should also be mentioned as a cross-cutting project that was specifically focused on dissemination. It analysed the findings of 63 water research projects funded by the FP6 and FP7 programmes and developed an Individual Dissemination Strategy (IDS) for their outputs. The IDS varied according to several elements: type of output; target group(s) and characteristics; utilisation goal(s)/ output objective(s); links and applicability to specific EU policies; barriers, which hinder the uptake of the specific output; activity/ channel(s) and dissemination materials; key messages; timing; and resources. The WATERDISS 2.0 project also developed the European Water Community platform as a common space dedicated to water research in Europe. Its membership comprises more than 600 actors from the entire water management and policy spectrum across Europe, including researchers, practitioners, decision makers (basin authorities, municipalities) and 'doers' (suppliers of technologies, consultancies, operators).

6 Policy recommendations

This section highlights the overall findings, conclusions and policy recommendations resulting from the portfolio analysis and encompassing the following elements:

Identified gaps in terms of knowledge and innovation

Based on the review of projects in the portfolio, several gaps in terms of knowledge and innovation on micropollutants in water systems have been identified. Certain types of pollutants have been addressed by a relatively small number of projects[16] and therefore, additional in-depth research is needed for them. These include:

- **Antibiotic resistant bacteria (ARB) and antibiotic resistant genes (ARGs)**: although a large number of projects in the portfolio focus on pharmaceuticals, very few have a narrow focus on antibiotics and challenges related to ARB and ARGs. Only one project (ANSWER) is specifically focused on antibiotics and mobile antibiotic resistance elements, and another two target these pollutants within the wider frameworks of pharmaceuticals (PHARMAS) and CECs (PANI WATER). To address this gap, targeted analyses on mobile antibiotic resistance elements in water systems are needed, as well as adequate prevention and remediation techniques.

- **Biocides:** challenges related to disinfectants, antiseptics and preservatives, as well as disinfection by-products (DBPs) are addressed by just three projects in the portfolio (in Theme 1 and 2). No projects providing prevention and remediation solutions for this type of pollutants have been identified in Theme 3. Therefore, additional research is needed to develop strategies and technologies to reduce biocides in water systems.

- **Microplastics:** a total of five projects in the portfolio focus on pollution caused by microplastics in water systems. R&I activities in the field of microplastics are especially scarce in Theme 1 and Theme 2, with only one relevant project in each of them. In addition, no project in the portfolio distinguishes between microplastics and nanoplastics, nor has it provided any targeted solutions for these two types of pollutants.

Key messages for decision-makers and policy recommendations

A number of projects have compiled their research findings in the area of micropollutants to formulate guidelines for the improvement and synchronisation of EU water sector policies. The main deliverables of such projects are policy briefs aimed at decision-makers at national and EU level. In terms of EU directives and policies covered, policy briefs could be classified in three groups.

[16] It should be noted that some actions under these topics have been taken since 2019 and are still ongoing. More specifically, these include Horizon 2020 WP 2020 actions on microplastics (e.g. CUSP cluster) and antibiotic resistant bacteria – ARB (e.g. ERA-NET Cofund AquaticPollutants) and Horizon Europe 2021 actions on microplastics. These projects have not been included in the portfolio, as they are considered still not enough advanced in their results.

The first group of policy briefs concerns the implementation of the **Water Framework Directive (WFD)**, which is the most widely covered legal act by projects in the portfolio. For example, policy briefs focused specifically on the WFD have been produced under GLOBAQUA and MARS.

Under GLOBAQUA, the following barriers to sustainable water management with regard to the WFD have been identified: different interpretations of the WFD objectives and misunderstanding of key concepts; exemptions left unresolved; ambiguity in the Common Implementation Strategy (CIS); and lack of real support for the policy shift required. To address these issues, the following recommendations for adaptation of EU water policies were provided:

- Enhancing public participation in the implementation of River Basin Management Plans (RBMPs) under the WFD through participatory tools for prioritisation of pressures on ecosystem services;
- Enabling Integrated Catchment Management (ICM) to mitigate pesticide pollution at source;
- Exploring the potential of water reuse as a water supply alternative.

Similarly, MARS produced a policy brief with WFD-related recommendations in three areas: monitoring and assessment; management measures; and policy integration. With regard to monitoring and assessment, it has been concluded that:

- Further CIS guidance should be developed on the strategic design of monitoring networks and greater implementation flexibility provided;
- When monitoring the effects of restoration, the use of 'early responding indicators' is advisable, i.e. species and metrics that respond rapidly to restoration;
- In WFD assessment, greater emphasis should be placed on reporting the progress of individual quality elements (as opposed to the overly strict 'one-out-all-out' principle);
- New monitoring tools such as earth observation, genomics, automated monitoring platforms and citizen science require checks on compatibility with the existing nationally approved methods.

With regard to WFD management measures, MARS formulated the following recommendations on the improvement of RBMPs and Programmes of Measures:

- Data and diagnostic tools to identify stressors should be used more frequently, as they enable a prioritisation of stressors and are essential to develop the most cost-effective management measures;
- The use of trait-based diagnostic tools to identify reasons for failure would contribute to more informed water management.
- The development and use of ecosystem service indicators can help to provide quantifiable messages about the benefits gained from improving the ecological status of water bodies.

With regard to policy integration, MARS underlined the importance of integrating the WFD with the EU Common Agricultural Policy (CAP) and most pressing climate change issues such as drought and water scarcity, which are not adequately addressed by the WFD.

The second group of policy briefs in the project portfolio is focused on **coherence between relevant EU directives and regulations**. Several projects explored the coordination between the WFD and the Drinking Water Directive, the Groundwater Directive, the Nitrates Directive and the Pesticides Directive, as well as the coordination between the WFD and EU regulations on industrial chemicals (REACH), pesticides (the Plant Protection Products Regulation), and biocides (the Biocidal Products Regulation).

For example, SOLUTIONS recommended better coordination between the WFD and all pieces of European chemicals legislation to improve protection of the aquatic environment from exposure to multiple pollutants. More specifically, policy briefs have made the following recommendations:

- Introducing consistent and comprehensive concepts for conducting mixture risk assessments. Risk assessment approaches to single chemicals are available but there is not a coherent framework providing for mixture risk assessment.

- Developing and implementing effective feedback loops between the WFD and other EU regulations to close data gaps that impede mixture risk assessment. As mechanisms for addressing such data gaps are not established in the WFD itself, data could be gathered through provisions in other EU regulations such as REACH, the Plant Protection Products Regulation, and the Biocidal Products Regulation.

- Using mixture risk assessment methods to improve the prioritisation of pollutants. Currently, compounds that are not WFD priority substances or river basin specific pollutants are insufficiently monitored, and hence, compounds not subject to monitoring cannot be prioritised.

Another project, assessing coherence in EU regulations and policies with regard to protecting drinking water resources, is FAIRWAY. There have been identified significant crossover or interdependencies between the WFD and the Drinking Water Directive, the Groundwater Directive, the Nitrates Directive and the Pesticides Directive. To better harmonise these directives, it was recommended to formalise these interactions and require cross-referencing with regards to monitoring and enforcement.

The AQUAREHAB project analysed the gap between water management on a river basin scale regulated by the WFD and groundwater management regulated by local legislation. While the WFD mainly focuses on the long-term and large-scale management of surface water within water bodies, groundwater issues are usually addressed by regional environmental authorities. It has been established that more efforts are needed to harmonise standards and legislation concerning risk assessment and remediation of contaminated sites. To this end, AQUAREHAB dedicated a policy brief on groundwater integration in water management at basin level, with the following recommendations:

- Approaches aimed at groundwater and surface water need to be combined and applied simultaneously in river basin management.

- Pollutants considered in the integrated water management approach should be extended to compounds relevant to groundwater (such as volatile compounds).
- The possibilities for creating an EU data inventory for local groundwater related problems in different countries should be explored.

Similarly, the P-REX project examined the coherence between EU and national legislation regarding phosphorous recovery from wastewater. The P-REX policy brief identified the need for action in the following four areas:

- Realistic and reliable European phosphorous recovery targets (especially from wastewater) are needed. In addition, a European roadmap should be designed, coupled with a list of the best available phosphorous recovery and recycling technologies.
- An obligation for national or regional action plans for phosphorous recovery, in line with the European goals, should be introduced.
- Clear guidelines are needed to stop different national interpretations of the current European legislation on recycling of phosphorous from waste, especially into fertilisers. Better integration of secondary raw materials and introduction of quality standards, including the incorporation of end-of-waste criteria into the European Fertiliser Regulation, are also recommended.
- National mechanisms for fair distribution of phosphorous recovery costs (e.g. fertiliser mixing quota, recovery obligations) should be secured. Demonstration projects should be financed to facilitate the market entry of innovative technologies and products.

The PHARMAS project recommended the introduction of an EU-wide risk and hazard classification system for medicinal products to minimise pharmaceutical-related risks to human health and ecosystems. The consortium concluded that such a system should be incorporated as a core element of the precautionary principle in EU environmental policies. Although the developed prototype was primarily aimed at practitioners (e.g., physicians and pharmacists), it was concluded that such a system could also be used by drinking water plant managers, river basin managers, managers of wastewater treatment plants, etc.

The MINOTAURUS project addressed some key implementation issues related to the WFD, the Groundwater Directive and the Priority Substances Directive, as well as the Thematic Strategy on Soil Protection. It examined the immobilisation of biocatalysts (enzymes, bacteria and microorganisms) as a technique of polluted groundwater and wastewater remediation. The suitability of these treatment processes was assessed in light of the existing legal and policy frameworks. Although MINOTAURUS did not produce policy recommendations per se, it did develop a supporting framework for policymakers to evaluate the proposed bioremediation strategies in terms of socio-economic acceptability and technological performance.

The third group of policy briefs is related to the **EU Common Agricultural Policy (CAP)** and its implications for the protection of drinking water resources vis-a-vis agricultural pollution. WATERPROTECT is one of the projects which formulated policy recommendations in this area as follows, among which:

- Establishing an institutional coordination mechanism at EU level, which is to harmonise water and agriculture policy objectives and implementation instruments, and take into account emerging challenges related to climate change;
- Efforts to streamline varying models, structures and procedures for the implementation of water and agriculture policies across EU MSs;
- Further exchange of information and data between different enforcement instruments and structures at national and EU level;
- Promoting multi-stakeholder partnerships and participatory water governance models.

Although not directly linked to the CAP, the BROWSE project has contributed to EU legislation on plant protection products (PPPs). More specifically, the BROWSE models for assessing the exposure of operators, workers, residents and bystanders to pesticides facilitated the implementation of Regulation 1107/2009 on the placing of plant protection products on the market, repealing Directive 91/414/EC. The project team recommended that the EU and national authorities involved in pesticides regulation use the software-based models when conducting regulatory risk assessment.

Recommendations related to dissemination and exploitation of project results

Most notably, the WATERDISS 2.0 project formulated recommendations related to the dissemination of project results. The main recommendations, concerning the lifetime of research projects, are as follows:

- Target group identification should be given priority;
- Creating ownership: engaging stakeholders into the project from the beginning;
- Creating a dialogue between stakeholders and the project consortium;
- Promoting the use of existing central knowledge hubs for information exchange (e.g. CORDIS);
- Ensuring that communication activities include knowledge brokering, translating and disseminating.

Another set of recommendations have been formulated by WATERDISS 2.0 for the period after project completion:

- Projects should allocate funding for dissemination of research findings after the end of the research phase of projects by engaging with technology platforms during and after the project. Alternative sources of funding should be explored for these activities, as they cannot be covered by EC grants, according to the grants' financial rules.
- The EC should consider funding specific dissemination activities based on suites of completed projects such as international study tours, group visits to pilot sites and educational and training activities. For this purpose, synergies with other EU funding

sources such as COSME, the Enterprise Europe Network, and the European IP Helpdesk, could be explored.

Although no project in the portfolio was specifically focused on the improvement of exploitation of research results, some general recommendations could be made. At a project level, it is recommended that:

- At an early stage of implementation, projects conduct market surveys among stakeholders and end-users to collect ideas on the potential for commercialisation of future products and their expected market volumes.
- At more advanced stages of implementation, projects conduct workshops with end-users, where direct information about developed products and their practical implementation is provided. At these events, end-users should be invited to provide feedback on the innovations developed. This exchange can aid the fine-tuning of solutions and smoothen their journey to commercialisation.
- Projects explore all possibilities for demonstration of developed solutions to relevant stakeholders. New products and technologies should be actively showcased at highly specialized events focused on narrow market segments.

To further facilitate exploitation, the EC could consider introducing regular updates in the CORDIS database related to the actual commercialisation of results after project completion. These could include information on market uptake, spin-offs, use of results by other projects, etc.

Annex 1. List of projects

Project Acronym	Project Title	Programme	CORDIS link
AFFIRM	Analysis of Biofilm Mediated Fouling of Nanofiltration Membranes	FP7	https://cordis.europa.eu/project/id/278530
AquaCell	An innovative technology platform for the enhanced treatment of industrial wastewaters achieving cost reductions, electricity generation and enabling water reuse for non-potable applications	FP7	https://cordis.europa.eu/project/id/262040
AQUAREHAB	Development of rehabilitation technologies and approaches for multipressured degraded waters and the integration of their impact on river basin management	FP7	https://cordis.europa.eu/project/id/226565
ARROWS	Advanced interfaced microsystems Research for analysis of Real-wOrld clinical, food, environmental and Waste Samples	FP7	https://cordis.europa.eu/project/id/257669
ATHENE	Designing new technical wastewater treatment solutions targeted for organic micropollutant biodegradation, by understanding enzymatic pathways and assessing detoxification	FP7	https://cordis.europa.eu/project/id/267897
BEEP-C-EN	Bio-sensor for Effective Environmental Protection and Commercialization - ENhanced	FP7	https://cordis.europa.eu/project/id/232082
BIOFOS	Micro-ring resonator-based biophotonic system for food analysis	FP7	https://cordis.europa.eu/project/id/611528
BIOTREAT	BIOTREATMENT OF DRINKING WATER RESOURCES POLLUTED BY PESTICIDES, PHARMACEUTICALS AND OTHER MICROPOLLUTANTS	FP7	https://cordis.europa.eu/project/id/266039
Browse	Bystanders, Residents, Operators and WorkerS Exposure models for plant protection products	FP7	https://cordis.europa.eu/project/id/265307
CERAMPOL	CERAMIC AND POLYMERIC MEMBRANE FOR WATER PURIFICATION OF HEAVY METAL AND HAZARDOUS ORGANIC COMPOUND	FP7	https://cordis.europa.eu/project/id/280995
ChitoClean	Enhanced chitin-based biosorbents for drinking water purification	FP7	https://cordis.europa.eu/project/id/315087
Clean Water	Water Detoxification Using Innovative vi-Nanocatalysts	FP7	https://cordis.europa.eu/project/id/227017
CONffIDENCE	CONtaminants in Food and Feed: Inexpensive DEtectioN for Control of Exposure.	FP7	https://cordis.europa.eu/project/id/211326

Project Acronym	Project Title	Programme	CORDIS link
CytoThreat	Fate and effects of cytostatic pharmaceuticals in the environment and the identification of biomarkers for and improved risk assessment on environmental exposure	FP7	https://cordis.europa.eu/project/id/265264
DEMEAU	Demonstration of promising technologies to address emerging pollutants in water and waste water	FP7	https://cordis.europa.eu/project/id/308339
ENDETECH	ENzymatic DEcontamination TECHnology	FP7	https://cordis.europa.eu/project/id/282818
ENNSATOX	Engineered Nanoparticle Impact on Aquatic Environments: Structure, Activity and Toxicology	FP7	https://cordis.europa.eu/project/id/229244
FOODSCAN	DEVELOPMENT OF AN AUTOMATED, NOVEL BIOSENSOR PLATFORM FOR PESTICIDE RESIDUE DETECTION	FP7	https://cordis.europa.eu/project/id/286442
FOODSNIFFER	FOOD Safety at the point-of-Need via monolithic spectroscopic chip identiFying harmFul substances in frEsh pRoduce	FP7	https://cordis.europa.eu/project/id/318319
GENESIS	Groundwater and dependent Ecosystems: NEw Scientific basIS on climate change and land-use impacts for the update of the EU Groundwater Directive	FP7	https://cordis.europa.eu/project/id/226536
iPiE	Intelligent Assessment of Pharmaceutical in the Environment	FP7	https://cordis.europa.eu/project/id/115735
ManureEcoMine	Green fertilizer upcycling from manure: Technological, economic and environmental sustainability demonstration	FP7	https://cordis.europa.eu/project/id/603744
MicroDegrade	Identifying and Overcoming Bottlenecks of Micropollutant Degradation at Low Concentrations	FP7	https://cordis.europa.eu/project/id/616861
Nametech	Development of intensified water treatment concepts by integrating nano- and membrane technologies	FP7	https://cordis.europa.eu/project/id/226791
NANOPUR	Development of functionalized nanostructured polymeric membranes and related manufacturing processes for water purification	FP7	https://cordis.europa.eu/project/id/280595
NanoSelect	Functional membranes/ filters with anti/low-fouling surfaces for water purification through selective adsorption on biobased nanocrystals and fibrils	FP7	https://cordis.europa.eu/project/id/280519
OxFloc	Integrated water treatment in a one-stage oxidative-adsorptive process to degrade and remove harmful substances	FP7	https://cordis.europa.eu/project/id/606216

Project Acronym	Project Title	Programme	CORDIS link
PHARMAS	Ecological and human health risk assessments of antibiotics and anti-cancer drugs found in the environment.	FP7	https://cordis.europa.eu/project/id/265346
PHASEPLIT	Two-phase Acid/Gas Anaerobic Reactor for Industrial Wastewater of Food & Drink SME industries	FP7	https://cordis.europa.eu/project/id/602007
PHOTOSENS	Large Area Photonic Crystal Chemical Sensors	FP7	https://cordis.europa.eu/project/id/263382
Routes	Novel processing routes for effective sewage sludge management	FP7	https://cordis.europa.eu/project/id/265156
SEA-on-a-CHIP	Real time monitoring of SEA contaminants by an autonomous Lab-on-a-chip biosensor	FP7	https://cordis.europa.eu/project/id/614168
SMS	Sensing toxicants in Marine waters makes Sense using biosensors	FP7	https://cordis.europa.eu/project/id/613844
SOLUTIONS	Solutions for present and future emerging pollutants in land and water resources management	FP7	https://cordis.europa.eu/project/id/603437
TOX-TRAIN	implementation of a TOXicity assessment Tool for pRActical evaluation of life-cycle Impacts of techNologies (TOX-TRAIN)	FP7	https://cordis.europa.eu/project/id/285286
WaSClean	Water and Soil Clean-up from Mixed Contaminants	FP7	https://cordis.europa.eu/project/id/612250
WATERMIM	Water Treatment by Molecularly Imprinted Materials	FP7	https://cordis.europa.eu/project/id/226524
WATERPLASMA	Water Decontamination Technology For The Removal Of Recalcitrant Xenobiotic Compounds Based On Atmospheric Plasma Technology	FP7	https://cordis.europa.eu/project/id/262033
AquaFit4use	Water in Industry, Fit-for-UseSustainable Water Use in Chemical, Paper, textile and Food Industry	FP7	https://cordis.europa.eu/project/id/211534
BRAAVOO	Biosensors, Reporters and Algal Autonomous Vessels for Ocean Operation	FP7	https://cordis.europa.eu/project/id/614010
CHEMAGEBE	CHEMemometric and High-throughput Omics Analytical Methods for Assessment of Global Change Effects on Biological and Environmental Systems	FP7	https://cordis.europa.eu/project/id/320737
GLOBAQUA	MANAGING THE EFFECTS OF MULTIPLE STRESSORS ON AQUATIC ECOSYSTEMS UNDER WATER SCARCITY	FP7	https://cordis.europa.eu/project/id/603629

Project Acronym	Project Title	Programme	CORDIS link
LbLBRANE	Regenerable active polyelectrolyte nanofiltration membranes for water reuse and metal/acid recovery	FP7	**https://cordis.europa.eu/project/id/281047**
LIMPID	Nanocomposite materials for photocatalytic degradation of pollutants	FP7	**https://cordis.europa.eu/project/id/310177**
MINOTAURUS	Microorganism and enzyme Immobilization: NOvel Techniques and Approaches for Upgraded Remediation of Underground-, wastewater and Soil	FP7	**https://cordis.europa.eu/project/id/265946**
MONACAT	Monolithic reactors structured at the nano and micro levels for catalytic water purification	FP7	**https://cordis.europa.eu/project/id/226347**
NATIOMEM	Nano-structured TiON Photo-Catalytic Membranes for Water Treatment	FP7	**https://cordis.europa.eu/project/id/245513**
P-REX	Sustainable sewage sludge management fostering phosphorus recovery and energy efficiency	FP7	**https://cordis.europa.eu/project/id/308645**
WATERBIOTECH	Biotechnology for Africa's sustainable water supply	FP7	**https://cordis.europa.eu/project/id/265972**
WaterDiss2.0	Dissemination and uptake of FP water research results	FP7	**https://cordis.europa.eu/project/id/265167**
MARS	Managing Aquatic ecosystems and water Resources under multiple Stress	FP7	**https://cordis.europa.eu/project/id/603378**
MARSOL	Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought	FP7	**https://cordis.europa.eu/project/id/619120**
Eco-UV	Low carbon footprint and eco-innovative UV water disinfection	H2020	**https://cordis.europa.eu/project/id/641702**
ANSWER	ANtibioticS and mobile resistance elements in WastEwater Reuse applications: risks and innovative solutions	H2020	**https://cordis.europa.eu/project/id/675530**
NanoScreen	Disruptive portable device for pre-screening of Persistent Organic Pollutants –POPs- in food products and water	H2020	**https://cordis.europa.eu/project/id/766742**
FAirWAY	Farm systems that produce good Water quality for drinking water supplies	H2020	**https://cordis.europa.eu/project/id/727984**
WATERPROTECT	Innovative tools enabling drinking WATER PROTECTion in rural and urban environments	H2020	**https://cordis.europa.eu/project/id/727450**
RUN4LIFE	RECOVERY AND UTILIZATION OF NUTRIENTS 4 LOW IMPACT FERTILIZER	H2020	**https://cordis.europa.eu/project/id/730285**

Project Acronym	Project Title	Programme	CORDIS link
ODYSSEA	Operating a network of integrated observatory systems in the Mediterranean sea	H2020	https://cordis.europa.eu/project/id/727277
AQUAlity	Interdisciplinar cross-sectoral approach to effectively address the removal of contaminants of emerging concern from water	H2020	https://cordis.europa.eu/project/id/765860
CLAIM	Cleaning Litter by developing and Applying Innovative Methods in European seas	H2020	https://cordis.europa.eu/project/id/774586
GoJelly	GoJelly - A gelatinous solution to plastic pollution	H2020	https://cordis.europa.eu/project/id/774499
PFS	A cost-energy-efficient treatment technology to remove pharmaceutical pollutants from water	H2020	https://cordis.europa.eu/project/id/804453
CGM	A next generation nano media tailored to capture and recycle hazardous micropollutants in contaminated industrial wastewater.	H2020	https://cordis.europa.eu/project/id/805997
VORTEX	Plastic in the Ocean: Microbial Transformation of an 'Unconventional' Carbon Substrate	H2020	https://cordis.europa.eu/project/id/772923
CoPs	Continuous hazardous water Pollutants sensing in the environment	H2020	https://cordis.europa.eu/project/id/820501
ECORISK2050	Effects of global change on the emission, fate, effects and risks of chemicals in aquatic ecosystems	H2020	https://cordis.europa.eu/project/id/813124
ELECTRA	Electricity driven Low Energy and Chemical input Technology foR Accelerated bioremediation	H2020	https://cordis.europa.eu/project/id/826244
PANI WATER	Photo-irradiation and Adsorption based Novel Innovations for Water-treatment	H2020	https://cordis.europa.eu/project/id/820718
INDIA-H2O	bIo-mimetic and phyto-techNologies DesIgned for low-cost purficAtion and recycling of water	H2020	https://cordis.europa.eu/project/id/820906
GREENER	InteGRated systems for Effective ENvironmEntal Remediation	H2020	https://cordis.europa.eu/project/id/826312
REWATERGY	Sustainable Reactor Engineering for Applications on the Water-Energy Nexus	H2020	https://cordis.europa.eu/project/id/812574
LimnoPlast	Microplastics in Europe's freshwater ecosystems: From sources to solutions	H2020	https://cordis.europa.eu/project/id/860720
REGROUND	Colloidal Iron Oxide Nanoparticles for the REclamation of Toxic Metal Contaminated GROUNDwater Aquifers, Drinking Water Wells, and River Bank Filtrations	H2020	https://cordis.europa.eu/project/id/641768

Project Acronym	Project Title	Programme	CORDIS link
INTCATCH	Development and application of Novel, Integrated Tools for monitoring and managing Catchments	H2020	**https://cordis.europa.eu/project/id/689341**
AquaNES	Demonstrating synergies in combined natural and engineered processes for water treatment systems	H2020	**https://cordis.europa.eu/project/id/689450**
CHEMO-RISK	Chemometers for in situ risk assessment of mixtures of pollutants	H2020	**https://cordis.europa.eu/project/id/715173**
ELECTRON4WATER	Three-dimensional nanoelectrochemical systems based on low-cost reduced graphene oxide: the next generation of water treatment systems	H2020	**https://cordis.europa.eu/project/id/714177**
ALGAMATER	Algamater - Using microalgae bioreactor technology to deliver the world's most cost-effective, energy-efficient, and adaptable system for the treatment of toxic industrial and landfill wastewater	H2020	**https://cordis.europa.eu/project/id/767333**
CyanoLakes	The Cyanobacteria Blooms Public Information Service	H2020	**https://cordis.europa.eu/project/id/730141**
NextGen	Towards a next generation of water systems and services for the circular economy.	H2020	**https://cordis.europa.eu/project/id/776541**
PAVITR	Potential and Validation of Sustainable Natural & Advance Technologies for Water & Wastewater Treatment, Monitoring and Safe Water Reuse in India	H2020	**https://cordis.europa.eu/project/id/821410**
Saraswati 2.0	Identifying best available technologies for decentralized wastewater treatment and resource recovery for India	H2020	**https://cordis.europa.eu/project/id/821427**

Annex 2. Detailed tables on Qualitative analysis

Table 10. Detailed table on qualitative analysis for Theme 1

Research Programme	Theme	Project Number	Project Acronym	Source						Deliverables								Publications					Impact				
				Agriculture	Waste/ sewage infrastructure	Industry	Aquaculture	Ships	Not specified	Demonstration event	Toolbox/ model	Patent	Pilot	Prototype	Business plan/ market research	Early warning system	Decision support system	Scientific publication	Peer-reviewed article	Policy brief	Guidelines	Conference proceedings	Social	Economic	Technological	Policy	Environmental
FP7	1	257669	ARROWS						✓		✓							✓					✓		✓		
FP7	1	232082	BEEP-C-EN	✓		✓				✓	✓			✓				✓						✓	✓		
FP7	1	611528	BIOFOS	✓								✓		✓				✓	✓				✓	✓	✓		
FP7	1	211326	CONffIDENCE	✓	✓	✓	✓			✓	✓			✓				✓	✓				✓		✓		
FP7	1	286442	FOODSCAN	✓						✓	✓			✓	✓			✓	✓				✓	✓	✓		
FP7	1	318319	FOODSNIFFER	✓							✓							✓					✓	✓	✓		
FP7	1	263382	PHOTOSENS		✓	✓				✓	✓								✓					✓	✓		✓
FP7	1	614168	SEA-on-a-CHIP				✓			✓	✓	✓		✓		✓		✓	✓		✓	✓	✓	✓	✓		✓
FP7	1	613844	SMS				✓	✓		✓	✓			✓	✓	✓		✓				✓	✓	✓	✓	✓	✓	✓
FP7	1	614010	BRAAVOO			✓	✓	✓		✓	✓			✓	✓	✓		✓	✓			✓	✓	✓	✓		✓
FP7	1	603378	MARS	✓		✓				✓	✓		✓					✓		✓	✓	✓		✓	✓	✓	✓
FP7	1, 2, 3	265167	WaterDiss2.0						✓	✓	✓		✓		✓			✓	✓	✓	✓	✓		✓		✓	✓
H2020	1	766742	NanoScreen						✓	✓		✓						✓					✓		✓		
H2020	1	727277	ODYSSEA						✓	✓	✓		✓			✓		✓	✓			✓				✓	✓
H2020	1	820501	CoPs		✓						✓				✓	✓		✓	✓				✓	✓	✓	✓	✓
H2020	1	689341	INTCATCH		✓						✓		✓				✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
H2020	1	730141	CyanoLakes	✓						✓	✓							✓	✓		✓	✓	✓	✓	✓		✓
H2020	1,3	821410	PAVITR		✓									✓	✓				✓			✓	✓	✓	✓		✓

Table 11. Detailed table on qualitative analysis for Theme 2

Research Programme	Theme	Project Number	Project Acronym	Source						Deliverables							Publications					Impact				
				Agriculture	Waste/ sewage infrastructure	Industry	Aquaculture	Ships	Not specified	Demonstration event	Toolbox/ model	Patent	Pilot	Prototype	Business plan/ market research	Early warning system	Decision support system	Scientific publication	Peer-reviewed article	Policy brief	Guidelines	Conference proceedings	Social	Economic	Technological	Policy	Environmental
FP7	2	267897	ATHENE		✓						✓							✓					✓		✓		
FP7	2	265307	Browse	✓						✓	✓							✓		✓		✓	✓		✓	✓	
FP7	2	265264	CytoThreat		✓					✓	✓							✓	✓				✓			✓	✓
FP7	2	229244	ENNSATOX						✓	✓	✓			✓				✓	✓						✓	✓	✓
FP7	2	226536	GENESIS	✓		✓				✓	✓							✓	✓		✓				✓	✓	✓
FP7	2	115735	iPiE		✓	✓				✓	✓							✓	✓				✓		✓		✓
FP7	2	616861	MicroDegrade	✓							✓							✓							✓		✓
FP7	2	265346	PHARMAS		✓					✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓		✓
FP7	2	603437	SOLUTIONS		✓					✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
FP7	2	285286	TOX-TRAIN			✓				✓	✓										✓		✓	✓	✓		✓
FP7	2	320737	CHEMAGEBE		✓	✓				✓	✓							✓	✓						✓		✓
FP7	2	603629	GLOBAQUA	✓	✓	✓				✓	✓			✓	✓			✓	✓	✓		✓	✓	✓	✓	✓	✓
FP7	1, 2, 3	265167	WaterDiss2.0						✓	✓	✓		✓		✓			✓	✓	✓	✓	✓		✓		✓	✓
H2020	2	675530	ANSWER		✓					✓	✓							✓					✓		✓		✓
H2020	2	813124	ECORISK2050	✓	✓	✓				✓	✓							✓	✓			✓	✓			✓	✓
H2020	2	860720	LimnoPlast		✓	✓				✓	✓							✓					✓	✓	✓	✓	✓
H2020	2	715173	CHEMO-RISK						✓				✓					✓	✓					✓	✓		✓

Table 12. Detailed table on qualitative analysis for Theme 3

Research Programme	Theme	Project Number	Project Acronym	Source						Deliverables								Publications					Impact				
				Agriculture	Waste/ sewage infrastructure	Industry	Aquaculture	Ships	Not specified	Demonstration event	Toolbox/ model	Patent	Pilot	Prototype	Business plan/ market research	Early warning system	Decision support system	Scientific publication	Peer-reviewed article	Policy brief	Guidelines	Conference proceedings	Social	Economic	Technological	Policy	Environmental
FP7	3	278530	AFFIRM						✓		✓							✓					✓		✓		
FP7	3	262040	AquaCell		✓	✓					✓		✓					✓						✓	✓		
FP7	3	226565	AQUAREHAB	✓	✓	✓				✓	✓	✓	✓				✓	✓		✓					✓	✓	✓
FP7	3	266039	BIOTREAT	✓	✓					✓	✓		✓	✓				✓	✓				✓	✓	✓		✓
FP7	3	280995	CERAMPOL		✓	✓				✓				✓				✓					✓	✓	✓		✓
FP7	3	315087	ChitoClean						✓	✓	✓			✓				✓					✓	✓	✓		
FP7	3	227017	Clean Water						✓	✓		✓	✓					✓					✓		✓		
FP7	3	308339	DEMEAU		✓					✓	✓		✓				✓	✓	✓				✓			✓	✓
FP7	3	282818	ENDETECH		✓					✓	✓		✓					✓	✓				✓		✓		✓
FP7	3	603744	ManureEcoMine	✓						✓	✓		✓	✓	✓			✓	✓					✓			✓
FP7	3	226791	Nametech	✓	✓	✓					✓		✓					✓					✓	✓	✓		✓
FP7	3	280595	NANOPUR	✓	✓	✓					✓		✓				✓	✓	✓				✓		✓		
FP7	3	280519	NanoSelect	✓	✓	✓				✓		✓		✓				✓	✓				✓		✓		✓
FP7	3	606216	OxFloc		✓	✓					✓			✓	✓									✓	✓		✓
FP7	3	602007	PHASEPLIT		✓	✓				✓	✓	✓	✓	✓	✓		✓	✓			✓	✓		✓	✓		✓
FP7	3	265156	Routes	✓	✓					✓	✓		✓	✓				✓	✓			✓			✓	✓	✓
FP7	3	612250	WaSClean	✓		✓				✓	✓			✓	✓			✓					✓	✓	✓		✓
FP7	3	226524	WATERMIM		✓	✓				✓	✓	✓		✓	✓			✓				✓	✓	✓	✓		✓
FP7	3	262033	WATERPLASMA		✓	✓				✓	✓		✓	✓	✓			✓	✓			✓	✓	✓	✓		✓
FP7	3	211534	AquaFit4use		✓	✓				✓	✓		✓					✓	✓			✓	✓	✓	✓	✓	✓
FP7	3	281047	LbLBRANE		✓	✓				✓	✓	✓	✓	✓	✓			✓	✓			✓	✓	✓	✓		✓
FP7	3	310177	LIMPID		✓					✓	✓	✓	✓		✓			✓	✓			✓	✓	✓	✓		✓
FP7	3	265946	MINOTAURUS		✓					✓	✓		✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓	✓
FP7	3	226347	MONACAT		✓						✓		✓	✓				✓	✓			✓	✓		✓		✓
FP7	3	245513	NATIOMEM		✓						✓		✓	✓				✓					✓	✓	✓		

Research Programme	Theme	Project Number	Project Acronym	Source						Deliverables								Publications					Impact				
				Agriculture	Waste/sewage infrastructure	Industry	Aquaculture	Ships	Not specified	Demonstration event	Toolbox/model	Patent	Pilot	Prototype	Business plan/market research	Early warning system	Decision support system	Scientific publication	Peer-reviewed article	Policy brief	Guidelines	Conference proceedings	Social	Economic	Technological	Policy	Environmental
FP7	3	308645	P-REX		✓					✓	✓	✓	✓		✓					✓		✓		✓	✓	✓	✓
FP7	3	265972	WATERBIOTECH		✓					✓	✓				✓			✓			✓	✓	✓	✓	✓	✓	✓	✓
FP7	3	619120	MARSOL	✓	✓	✓				✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
FP7	1, 2, 3	265167	WaterDiss2.0						✓	✓	✓		✓		✓			✓	✓	✓	✓	✓		✓		✓	✓
H2020	3	641702	Eco-UV						✓	✓				✓	✓			✓	✓				✓	✓	✓		✓
H2020	3	727984	FAirWAY	✓						✓	✓						✓		✓	✓			✓			✓	
H2020	3	727450	WATERPROTECT	✓						✓	✓							✓	✓	✓			✓	✓		✓	
H2020	3	730285	RUN4LIFE		✓					✓	✓		✓					✓	✓			✓	✓	✓		✓	✓
H2020	3	765860	AQUAlity						✓	✓	✓							✓	✓			✓	✓		✓		
H2020	3	774586	CLAIM		✓					✓	✓		✓	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓
H2020	3	774499	GoJelly						✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓
H2020	3	804453	PFS		✓					✓	✓		✓					✓					✓	✓	✓		✓
H2020	3	805997	CGM		✓	✓				✓	✓							✓					✓	✓			✓
H2020	3	772923	VORTEX		✓	✓	✓				✓							✓	✓								✓
H2020	3	826244	ELECTRA		✓								✓					✓	✓						✓		✓
H2020	3	820718	PANI WATER		✓					✓	✓	✓		✓					✓				✓	✓	✓		✓
H2020	3	820906	INDIA-H2O	✓	✓								✓	✓	✓			✓					✓	✓	✓		✓
H2020	3	826312	GREENER	✓		✓					✓				✓				✓				✓	✓	✓		✓
H2020	3	812574	REWATERGY		✓					✓				✓					✓				✓	✓	✓		
H2020	3	641768	REGROUND		✓	✓					✓		✓		✓			✓	✓				✓	✓	✓		✓
H2020	3	689450	AquaNES		✓					✓	✓				✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
H2020	3	714177	ELECTRON4WATER		✓					✓	✓							✓						✓	✓		✓
H2020	3	767333	ALGAMATER		✓	✓				✓				✓				✓					✓	✓	✓		✓
H2020	3	776541	NextGen		✓						✓				✓			✓					✓		✓	✓	
H2020	3	821427	Saraswati 2.0		✓					✓	✓		✓		✓			✓					✓		✓		✓
H2020	1,3	821410	PAVITR		✓									✓	✓				✓			✓	✓	✓	✓		✓

Annex 3. Projects which applied for Horizon Results Booster services

The Horizon Results Booster is a package of specialised services, which aims to maximise the impact of R&I public investment and further amplify the added value of the Framework Programmes (FPs). Services are delivered to FP7, Horizon 2020 and Horizon Europe projects at no cost and fully supported by the European Commission.

The **Portfolio Dissemination & Exploitation Strategy (PDES)** service is divided in two main streams addressing Dissemination & Exploitation strategies, activities and goals. The aim of Dissemination services (Module A and B) is to strengthen the capacity of Project Groups in disseminating, maximising the dissemination of a portfolio of results and offering a wider and more complete view to potential users. The aim of Exploitation service (Module C) is to support single projects in exploiting their research results and enhance beneficiaries' capacity to improve their exploitation strategy.

The aim of the **Business Plan Development (BPD)** service is to assist beneficiaries to bring their results closer to the market by developing an effective business plan, and by preparing to secure appropriate funding for the implementation of project results.

The aim of the **Go To Market (GTM)** service is to assist beneficiaries in making their project results ready for commercialisation. The service supports beneficiaries in identifying and/or addressing potential obstacles to the exploitation of project results and reach commercialisation.

As the Horizon Results Booster package was introduced relatively recently, a limited number of projects in the portfolio have applied for these services, as described below:

- ODYSSEA requested PDES Module A, PDES Module C and BPD services but opted out from all three, before the service delivery started.
- CLAIM successfully completed PDES Module C, BPD and GTM Business Services for co-design of a commercialization plan.
- PANI WATER successfully completed PDES Module A and PDES Module B services.

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The report presents the results of a portfolio analysis of projects focusing on micropollutants in water systems and funded under the 7th EU Framework Programme for research, technological development and demonstration activities (2007-2013) and Horizon 2020, the EU Framework Programme for research and innovation (2014-2020). The review provides an overview and a detailed assessment of research and innovation advances on micropollutants according to three pre-defined themes:

1) Measuring and monitoring
2) Evaluating and assessing
3) Prevention and remediation.

After a quantitative analysis, the report maps and assesses projects' relevance in relation to types of pollutants, sources of pollution and a set of impacts. It presents the actual results achieved by projects in terms of enhanced knowledge and innovative solutions and highlights options for synergies and coordination mechanisms and best practices in dissemination and exploitation.

The review also identifies several gaps in terms of knowledge and innovation on micropollutants in water systems and makes policy recommendations resulting from the portfolio analysis. Detailed tables compiling the assessment done on the project portfolio complement the report.

Studies and reports

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