Procure 4Health

# Open Market Consultation Document

## (including Annexes)

Open Market Consultation for the future Pre-Commercial Procurement of R&D services concerning on-site treatment of hospital wastewater

February 2024

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# Disclaimer and Copyright



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Economic operators and other stakeholders are being informed that any information regarding the setup and execution of both the procurement process and the execution of any contract/framework agreement as a result of the procurement process as well as public summaries of the results of the PCP project, including information about key R&D results attained and lessons learnt by the procurers during the PCP, can be shared after consultation with the respective R&D provider by the PROCURE4HEALTH Consortium with(in) the context of the contract and consequently can be analysed, (re-)used and published by the PROCURE4HEALTH Consortium. Details should not be disclosed that would hinder application of the law, would be contrary to the public interest, would harm the legitimate business interests of the R&D providers involved in the PCP or could distort fair competition between the participating R&D providers or others on the market.

The PROCURE4HEALTH project receives funding under the European Union's Horizon Europe framework program for research and innovation under the grant agreement No 101057209. The EU is however not participating as a contracting authority in the procurement.

A Prior information notice, or PIN, has been published in TED to announce the Open Market Consultation on potential future procurement activity (notice publication number: 6662-2024).

The original language of this open market consultation is English.

# Abbreviations and Acronyms

| | |
|---|---|
| CET | Central European Time |
| COTS | Commercial Off-The-Shelf |
| EAFIP | European Assistance for Innovation Procurement |
| EC | European Commission |
| EU | European Union |
| FAIR | Findable, Accessible, Interoperable and Reusable |
| FRAND | Fair, Reasonable and Non-Discriminatory |
| GDP | Gross Domestic Product |
| GDPR | General Data Protection Regulation |
| GPA | Government Procurement Agreement |
| HE | Horizon Europe |
| H&Sc | Health & Social Care |
| IPRs | Intellectual Property Rights |
| OMC | Open Market Consultation |
| PBG | Public Buyers Group |
| PCP | Pre-Commercial Procurement |
| PIN | Prior Information Notice |
| R&D | Research and Development |
| RFI | Request For Information |
| SMEs | Small and Medium Enterprises |
| SOTA | State Of The Art |
| TED | Tenders Electronic Daily |
| TRL | Technology Readiness Level |
| WTO | World Trade Organisation |

# Key Definitions

| | |
|---|---|
| Consortium | Group of public and/or private entities (including public buyers and supporting organisations) that are part of the PROCURE4HEALTH project. For more information: https://procure4health.eu/founding-members/ |
| Contractor | A company or entity that has been awarded a contract under the PCP. |
| Lead Procurer | A Public Buyer who acts as a Procurer in the PCP and purchases the R&D services on behalf of itself and other Public Buyers (in this case, Reseau Des Acheteurs Hospitaliers IDF). |
| Public Buyer | A public entity who purchases goods or services from the market and is subjected to the public procurement regulation. |
| Technology provider | A company or entity who develops and/or sells technology in the market. |

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# 1 Purpose of the Open Market Consultation

## 1.1 Scope and main objectives

This document describes the objectives and rules applicable to the Open Market Consultation (OMC) of the project PROCURE4HEALTH for the future Pre-Commercial Procurement of Research & Development services concerning on-site treatment of hospital wastewater.

The OMC begins on the date of the publication of the Prior Information Notice (PIN) in the Tenders Electronic Daily (TED) and ends on the date indicated in this document, unless the public buyers involved decide to terminate it prematurely.

Through this OMC, the Public Buyers Group (PBG) of PROCURE4HEALTH (identified in section 2) with Reseau Des Acheteurs Hospitaliers IDF (RESAH) as lead procurer, aims to challenge the market to develop innovative solutions to effectively remove toxic substances, infectious compounds, pharmaceutical residues, and pathogens from hospital wastewater on the hospital's premises.

Nowadays, hospitals discharge considerable amounts of chemicals and microbial agents in their wastewaters, such as antibiotics, X-ray contrast agents, disinfectants, and pharmaceuticals. Many of these chemical compounds resist normal wastewater treatment. The presence of those substances in hospital wastewater poses an environmental and health risk (e.g. the risk of waterborne transmission and potential outbreaks or contamination of drinking water sources).

In this context, the purpose of the OMC is to inform technology providers and other relevant stakeholders about the needs of the PBG and to gather their input about the PROCURE4HEALTH challenge for developing a solution to sanitize hospital wastewater on-site with the following required functionalities:

- Channeling the hospital wastewater into a centralized treatment facility.
- Separating/treating highly soluble reagents like sodium azide or other hazardous chemicals.
- Removing large solid debris and coarse materials from the wastewater.
- Working stably despite high concentrations of disinfection agents.
- Treating persistent organic pollutants.
- Meeting the required wastewater discharge standards by disinfecting hospital wastewater.
- Reducing nutrient concentrations (like nitrogen and phospherus).
- Filtering and separating HWW through advanced treatment technologies.
- Handling properly any sludge that might form.
- Including monitoring devices and sensors to measure important parameters like pH, temperature, dissolved oxygen, and pollutant concentrations.
- Odor control.

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- If possible, depending on local regulations and requirements, reusing the treated hospital wastewater for non-potable applications within the hospital, such as irrigation, toilet flushing, or cooling tower makeup water.

Another objective of the OMC is to understand the technology providers' capabilities to satisfy the public buyers' needs and to obtain their input on the viability of the procurement plans and conditions as described in this document and annexes.

In sum, the objectives of this OMC are to:

1) Validate the findings of the State-Of-The-Art (SOTA) analysis and the viability of the set of technical and financial provisions.
2) Raise awareness of the industry and relevant stakeholders regarding the upcoming PCP.
3) Collect insights from the industry and relevant stakeholders (including users) to finetune the tender specifications.

This OMC is performed under the law of the lead procurer (RESAH), which is French law.

The contracting authorities involved in the PROCURE4HEALTH project are not legally bound in any way by the outcome of the OMC.

Starting an OMC does not mean that the PBG will start a tendering or purchasing procedure. If this OMC is followed by a tendering procedure and/or purchasing procedure, the PBG reserves the right to adjust and/or supplement the solution described in this document on every element. No rights can be derived from statements and/or communications during this OMC in any future tendering procedure and/or purchasing procedure.

The OMC is not part of any pre-qualification or selection process. No advantage or disadvantage will be given to any technology provider / group of technology providers to the detriment of others during the OMC and the sub-sequent competitive procedure for the award of contracts.

All information provided during the OMC and other background information will be published online in English.

Where appropriate, parts of the information received from market parties can be shared with the EC.

## 1.2 Who can participate?

The target groups of this OMC are technology providers and end users. All interested parties are invited to take part in the OMC. However, please note that technology providers established in countries not eligible to participate in Horizon Europe Innovation Actions in any capacity cannot participate in the PCP procedure. Nevertheless, it is possible to form alliances of technology vendors (consortia).

Participation in the OMC is voluntary and non-binding and is at the own expense and risk of market operators. A market operator cannot charge any costs to the PBG for participation in the OMC or for (re-)use of its information in the context of a future procurement procedure.

Participation in this OMC is not a condition for submitting a tender in the subsequent procurement, does not lead to any rights or privileges for the participants, and is not part of any pre-qualification or selection process. The provided input in this OMC will not be used to evaluate future proposals.

## 1.3 Activities & timetable

The OMC will take place in the form of:

- An online event on 3 April 2024 (in English).
- A Request for Information (RfI) – a questionnaire using the EU Survey tool.
- Other activities as deemed necessary within the scope of the project.

The timetable of activities and required actions of the OMC is as follows:

| Date | Event |
|---|---|
| **5 January 2024** | Publication of the general Prior Information Notice (PIN) on TED: https://ted.europa.eu/en/notice/-/detail/6662-2024 |
| **March 2024** | Publication of the Prior Information Notice (PIN) on TED (specific for this challenge). |
| **4 March 2024** | Publication of the OMC documents on the project's website: www.procure4health.eu<br>Publication of the EU Survey questionnaire: https://ec.europa.eu/eusurvey/runner/Procure4Health-water-treatment |
| **3 April 2024** | OMC Event in English (online) (10:00 – 11:30 CET). |
| **18 April 2024** | Deadline for the submission of questions via the OMC questionnaire (17:00 CET). |
| **6 May 2024** | Publication of the OMC findings, including all questions and answers to the OMC questionnaire. |
| **8 May 2024** | Closure of the OMC. |

*Table 1: OMC Timetable*

The PROCURE4HEALTH Consortium is entitled to adjust the planned activities and the timetable above, and to include new activities at any time according to the needs and responses of the market. Furthermore, it may decide to terminate the OMC for its own reasons at any time. In that case, the PROCURE4HEALTH Consortium will publish such modifications or termination on TED and the project's website (www.procure4health.eu).

The event and webinars celebrated within the framework of the OMC could be recorded. In that case, by attending the physical event you will consent to be recorded. By using your video and microphone during the webinars you will consent to be recorded. If you do not want your voice and image to be recorded during the webinars, you may ask your questions using the chat. The PROCURE4HEALTH Consortium shall use those records for the purpose of the project only.

In addition, please be aware that photos may be taken during the meetings. The PROCURE4HEALTH Consortium shall use those photos for the purpose of the project only.

## 1.4 Registration

Parties interested in participating in the OMC activities are requested to register here.

## 1.5 Procedure

The OMC starts on the date of its publication in TED and ends on the date set in the timetable, unless terminated earlier.

Interested parties are requested to register through the link provided above in order to participate in the events and receive additional information about the project. The questionnaire should be filled out before the deadline indicated in the timetable above.

The PROCURE4HEALTH Consortium will support interested parties throughout the whole OMC during the events and by answering questions through a Q&A document which will be published on the project's website.

Additional written contributions in the form of a Request For Information (RFI) questionnaire or other questionnaires (via the EU Survey platform) aiming to collect market information on innovative and commercial solutions may be requested.

The responses to the questionnaires should not contain any confidential information. As the questionnaire is intended to explore the market "as is", there are no wrong or right answers. The answers provided will be used as input for the procurement strategy and contract conditions.

After processing and analysing the answers, the PROCURE4HEALTH Consortium will disseminate the results to the widest possible audience. Nevertheless, all answers provided by market parties will be anonymized and treated as confidential. The PROCURE4HEALTH

Consortium will therefore not provide information about specific answers from market operators. Only the general findings and a summary of the answers will be provided. The results of this OMC will be published on the project's website.

In case the information provided in this document and annexes needs further clarification, market operators may ask questions during the events, or via the contact email address (hello@procure4health.eu).

Market operators that wish to provide additional confidential information during the OMC can send an email to the email address indicated above. The information must be clearly marked as confidential. Confidential information will not be included in the OMC report.

## 1.6 Annexes

The following annexes are part of this document:

- Annex I – Request for Information questionnaire.
- Annex II – Use case.
- Annex III – Market analysis report.

The annexes form an integral and inseparable part of this OMC document. In the event of any conflict between the provisions of this document and the annexes, the provisions of the OMC document shall prevail.

# 2 The Procure4Health project

## 2.1 Context and objectives

The PROCURE4HEALTH project aims to address the challenges faced by Health & Social Care (H&Sc) systems in the European Union through innovation procurement. Every year, over 250,000 public authorities in the EU spend around 14% of GDP (around €2 trillion per year) on the purchase of services, works and supplies, where Health & Social Care (H&Sc) represents approximately 10% the GDP[1]. The rising costs of H&Sc continue to strain global health systems, prompting the need for innovative solutions. The EC places a high priority on the digital transformation of H&Sc[2], fostering novel approaches and tools to guarantee the ongoing suitability of H&Sc systems. Reforms and innovative solutions are imperative for H&Sc systems to enhance resilience, accessibility, equity, sustainability [3], and effectiveness. In this context, innovation procurement has the vital role of stimulating innovation from the demand side.

Despite the potential benefits of innovation procurement, several obstacles hinder its widespread adoption across the EU. These barriers include the fragmentation of health systems, legal disparities, bureaucratic challenges, language barriers, and a reluctance among policymakers and H&Sc procurers to embrace innovation procurement. Procure4Health aims to overcome these challenges through the creation of a (wide coverage) network and consolidated database for knowledge exchange and sharing of best practices, and furthermore, through the identification and prioritization of common needs (in a catalogue) for the preparation of concrete innovation procurement projects and action plans in the H&Sc sector.

PROCURE4HEALTH provides an appropriate environment for public and private procurers, as well as the wider H&Sc community, to effectively share knowledge, build capacities of procurers, define common needs and advance innovation procurement in the EU. PROCURE4HEALTH proposes a comprehensive methodology to establishing and running an H&Sc innovation procurers' network which follows established principles for community building and good experience exchange.

The primary objective of PROCURE4HEALTH is to establish and manage a network comprising H&Sc procurers. These procurers are tasked with deploying H&Sc innovations across the EU and associated countries. The aim is to identify common needs and develop effective innovation procurement strategies based on Europe-wide market consultations. These strategies, including PCP, PPI, or Innovation Partnerships, will be transformed into actionable plans for procuring research and development as well as innovative solutions,

[1] https://single-market-economy.ec.europa.eu/single-market/public-procurement_en
[2] European Commission (2018). *Communication on enabling the digital transformation of health and care in the Digital Single Market; empowering citizens and building a healthier society*. Brussels, 25.4.2018, COM(2018) 233 final.
[3] HCWH (2019). "Health Care's Climate Footprint: how the health sector contributes to the global climate crisis and opportunities for action". *Climate-smart health care series - Green Paper Number One.*

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ultimately enhancing the services provided to patients and citizens. Hence, the solid objectives are:

## 2.2 PCP challenge and main requirements

The envisaged future PCP – i.e. a joint procurement of R&D services – is intended to be launched to reinforce public demand driven innovation in end-user services in the area of Health & Social Care. PCP has the potential to be an effective demand-side innovation action and a useful tool to close the gap between supply and demand for innovative solutions. Solutions are expected to achieve TRL 7-8.

The future PCP should deliver successful innovative and fully tested product(s) and/or service(s) that meet the common need of the PBG to procure research, develop innovative marketable solutions, speed up the time-to-market and provide best value for money.

The PBG aims to develop an on-site system capable of effectively removing toxic substances, infectious compounds, pharmaceutical residues, and pathogens from hospital wastewater. This system would channel the hospital wastewater into an on-site centralized treatment facility and mitigate the environmental repercussions of water sanitation. Furthermore, it needs to comply with the specific functionalities described in Annex II.

## 2.3 The Pre-Commercial Procurement approach

This OMC concerns a future PCP of R&D services to be performed in their majority in the EU Member States or Associated Countries.

PCP is an approach that allows public procurers to buy R&D from several competing technology providers in parallel, to compare alternative solution approaches, and to identify the best value-for-money solutions that the market can deliver to address their needs. In PCP, there is a risk-benefit sharing under market conditions between the public procurer and the technology providers, and a clear separation between the PCP and the deployment of commercial volumes of end-products.

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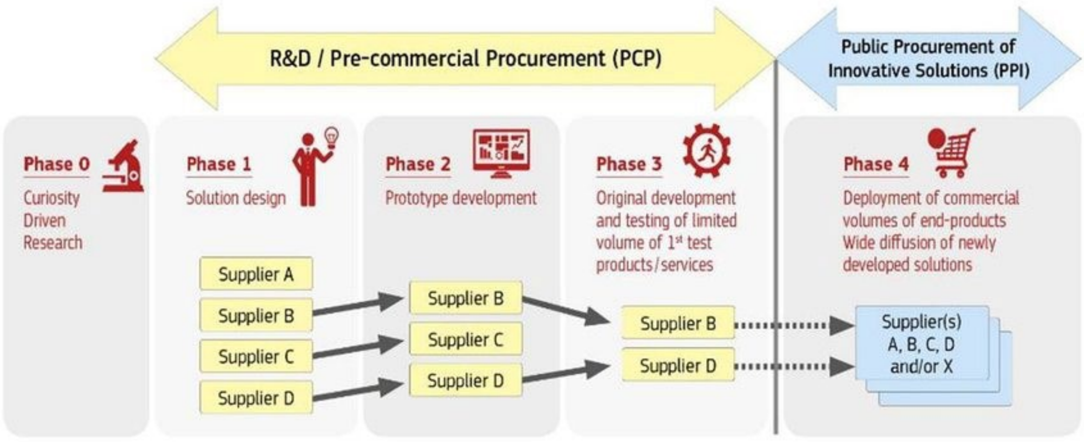


*Figure 1: PCP and PPI, according to the European Commission (2016).*
*Based on "Pre-commercial procurement: driving innovation to ensure sustainable high quality public services in Europe", COM(2007) 799 final.*

Along with the R&D services, the PCP allows to purchase some products providing that the value thereof is **less than 50 % of the total value of the contract.**

The PCP tender will start with the publication of the contract notice along with the request for tenders, the framework agreement, and the phase contracts. After evaluating the offers submitted by the technology providers according to the rules established in the tender documents, the contracts will be awarded, and a contract award notice will be published. The process will be monitored to ensure sound deployment, integration and validation of the PCP.

The PCP procedure is composed of three phases of solution design, prototype implementation, and validation and demonstration of the solutions.

- **Phase 1. Solution design:** During this phase, the contractors will be asked to describe the solution providing the complete architecture and design thereof and verifying the technical, economic and organizational feasibility of their solution to address the PCP challenge.

- **Phase 2. Prototype implementation:** This phase concerns the development of the first prototypes of the solutions, which will be tested. Contractors will develop a first prototype based on the design documents delivered in the previous phase and test their solutions in lab conditions. Prototypes will be tested and verified to provide a measure of the technical performance of each solution in a controlled environment. During and at the end of the phase 2, the Public Buyers will request from the contractors a series of deliverables in order to evaluate their progress and the performed activities and obtained results.

- **Phase 3. Validation and demonstration of the solutions:** It will validate the final solutions (at least two) in diverse conditions, using the detailed scenarios and processes developed in the verification and validation strategy. During phase 3, a feedback mechanism will be established between the Public Buyers Group and the selected contractors in order for the latter to receive requests for improvements directly from the end users. The Public Buyers will request from the contractors an Integration Report. Finally, a Field Acceptance Report related to the accomplishment that the two final solutions which have been deployed and that the validation tests have been successfully performed in a real operational environment will be requested.

After each phase, intermediate evaluations will be carried out to progressively select the best of the competing solutions. The contractors with the best-value-for-money solutions will be offered a specific contract for the next phase.

The contractors will retain ownership of the Intellectual Property Rights (IPRs) that they generate during the PCP and will be able to use them to exploit the full market potential of the developed solutions.

**Contracts implementation**

During the implementation of the PROCURE4HEALTH PCP, effective tools will be used in order to monitor performance of the R&D suppliers and provide regular feedback during each phase. Each contractor will be assigned a main contact person (their supervisor) appointed by the procurers as the main point of contact.

More specifically the monitoring process will be divided in 3 set of activities:

- **Pre-monitoring:** A kick-off meeting per contractor will be scheduled at the beginning of each PCP phase and the selected contractors will be requested to present their implementation schedule for the PCP phase that they are entering in. During the same meeting, the supervisor will present the framework for the review. The objective is to establish a close and fruitful communication channel with the contractors, in order to ensure from the early beginning of the action that the project is implemented according to the needs of the buyers.

- **Monitoring:** Contract implementation will be monitored and reviewed against the expected outcomes for each phase. The intensity of monitoring and communication between the PBG and the contractors will increase from phase 1 to phase 3. For instance, regular meetings with the contractors by videocall or face-to-face, on-site visits to the contractors' locations to check and discuss the status of the work and progress, or any other suitable way. Ad-hoc meetings and on-site inspections are also possible in the event that the R&D development has halted or slowed down.

  The contractors are mandated to present monthly the current status of the work and describe the progress made. All the documentation generated by the contractors will be reviewed and the ideas and recommended areas to pursue will be highlighted in post-review activities.

- **Post-monitoring:** At the conclusion of the monitoring activities, the supervisor will provide written feedback for each contractor at each PCP phase. This feedback will generally consist of overall comments and remarks about the contractor's outcomes under review. Monitoring activities will be continued after the PCP is completed. Specifically, it will be checked whether the contractors are successfully commercializing the R&D results within the call-back period defined in the PCP framework agreement. If that is not the case, the PROCURE4HEALTH Consortium will ask the R&D suppliers to give licenses under FRAND terms to other third parties, or will ask to transfer back the ownership of results to the PBG.

## 2.4 The Public Buyers Group

The PROCURE4HEALTH Consortium brings together 18 public buyers from different EU Member States (Belgium, Denmark, Estonia, France, Greece, Italy, Norway, Poland, Portugal, Spain, Sweden, Turkey, United Kingdom). For the purpose of the PCP, the PBG will be represented by RESAH as lead procurer.

**RESEAU DES ACHETEURS HOSPITALIERS IDF - RESAH (France)**

RESAH is a public interest group whose objective is to support the pooling and professionalization of purchasing and logistics for stakeholders operating in the health, medico-social, social, public and private non-profit sectors.

In order to achieve these objectives, RESAH acts within the framework of two areas of activity: the purchasing center whose purchasing volume reached 2 billion euros in 2022; and the resource and expertise with a responsible hospital buyer's desk, a training center, a publication activity and digitalization tools for the purchasing and logistics function.

The RESAH purchasing center offers more than 5,700 contracts concluded with 1,000 suppliers and falling within 11 purchasing families: medicines, medical devices, laboratory, biomedical, general equipment, general services, hotels, building and energy, transport and vehicles, IT, general services.

**SERVICIO ANDALUZ DE SALUD (Spain)**

Servicio Andaluz de Salud is responsible for the provision of healthcare to the population in the region (8,4 million citizens). It is a wide network based on high-quality, patient-centred, accessible care. It has more than 1,500 primary centres spread throughout the territory and grouped in Health Districts, the managerial unit at this level of care. The healthcare network also includes 52 hospitals with different complexities. Provision is free of charge at the point of care with the exception of part of the medication.

Servicio Andaluz de Salud has adopted corporate-wide information systems as a strategy to cope with ever increasing user mobility and a healthcare delivery model that involves many complex multidisciplinary professional teams. This, linked with the concept of integrated health and the evolving role of empowered patients in democratic societies, leads to the concept of the Single Health Record and the establishment of unified procedures.

**SYKEHUSINNKJOP HF (Norway)**

Sykehusinnkjop HF Hospital Procurement Trust operates as a central purchasing body for Norway's healthcare sector, collaborating with specialists and end-users nationwide. The trust, with six divisions and around 300 employees, provides specialized procurement services for the specialist health service. It emphasizes the principles of "the best agreement" to enhance financial flexibility, delivery capacity, and security of supply, contributing to future-oriented health services. Additionally, its strategic plan underscores precision and continuous improvement.

Aligned with the specialist health service's vision and core values, including respect, quality, and safety, Sykehusinnkjop HF prioritizes innovation, knowledge, commitment, and professionalism. The trust aims to be a flexible and solution-oriented entity at the forefront of market developments. It procures a range of healthcare essentials, such as IT equipment, pharmaceuticals, and medical-technical equipment, while actively promoting ethical and environmentally friendly purchasing practices. Finally, through partnerships with health regions, the trust collaborates closely to define and deliver services, ensuring alignment with regional needs and upholding responsible procurement practices.

**SKÅNE LANS LANDSTING (Sweden)**

Region Skåne constitutes one of the 21 main administrative divisions (counties) in the country of Sweden, encompassing a total of 33 municipalities. Region Skåne, the governing body of the southernmost county in Sweden, holds autonomous authority and manages crucial sectors such as healthcare, trade and industry development, public transport, and cultural affairs, administering a populace numbering 1,402,425 citizens (as of 2021). Its headquarters are in Kristianstad, but it also has a presence in every municipality in Skåne. Simultaneously, Region Skåne oversees around 34,000 employees, primarily engaged in healthcare, including hospitals, primary healthcare units, and dental services. The region prioritizes an open and tolerant community, fostering creativity and innovation.

**ZESPOL OPIEKI ZDROWOTNEJ W SUCHEJ BESKIDZKIEJ (Poland)**

The hospital in Sucha Beskidzka, established in 1982, stands as one of the region's largest and most advanced medical facilities. The Health Care Facility offers a comprehensive range of services, including primary healthcare, specialist outpatient care, inpatient treatment, emergency care, rehabilitation, long-term care, dialysis, and occupational medicine services. Additionally, the hospital has over 20 specialist clinics, 15 hospital wards, boasts more than 80 excellent doctors, and has served over a million satisfied patients.

**TURKIYE CUMHURIYETI SAGLIK BAKANLIGI (Turkey)**

The Turkish Ministry of Health is responsible for formulating and implementing health policies, planning and delivering healthcare services, and safeguarding patients' interests. Its duties encompass public health protection, disease risk reduction and prevention, health services administration, international public health risk prevention, health education and research development, and market regulation of medicines, cosmetics, and medical devices.

The ministry plays a pivotal role in managing the health system, formulating policies for health institutions nationwide, ensuring a balanced distribution of resources, and promoting equal, quality, and efficient healthcare services throughout the country. It collaborates internationally and across sectors, determines strategies, objectives, and plans, and exercises guidance, monitoring, evaluation, and supervision. In emergencies and disasters, the ministry plans and executes health plans, takes measures to eliminate regional differences in health service access, and directs relevant institutions and organizations to address factors impacting human health.

**SERVICIO GALEGO DE SAÚDE (Spain)**

The Galician Health Service (Servizo Galego de Saúde, SERGAS) is the public entity responsible for the health service and primary care activity in the Region of Galicia. It coordinates a network of 14 hospital centers, including 3 tertiary Care Hospital clusters (ranging from 1200 to 1500 beds each), 4 secondary care hospitals (ranging from 400 to 1200 beds), and 7 Countryside Hospitals (ranging from 100 to 300 beds each), along with over 450 primary care centers, covering the entire region. The strategic goals of SERGAS focus on optimizing integrated assistance mechanisms, ensuring citizens' rights, modernizing and humanizing the public health system, and promoting continuity of care through patient-centered organizations.

Under the Ministry of Health's supervision, SERGAS fulfills crucial functions, including providing healthcare through the Galician public healthcare network, distributing financial resources for care activities, governing and managing health centers, coordinating allocated resources, and implementing teaching and research programs. With a commitment to dynamic and patient-centered care, SERGAS plays a central role in the regional administration, overseeing and ensuring the delivery of quality healthcare services in Galicia.

**NHS NATIONAL SERVICES SCOTLAND (United Kingdom)**

NHS National Services Scotland has a crucial role in the Scottish healthcare system, functioning as a Non-Departmental Public Body under the Scottish Government's oversight. Committed to values such as customer focus, integrity, and excellence, it offers national strategic support services and expert advice to NHS Scotland. Its main activities focus on improving healthcare delivery, promoting efficiency, and supporting health and care transformation. NSS's strategic objectives include placing customers at the forefront, enhancing service value, improving operational processes, and fostering a positive work environment. With a focus on remobilization and stakeholder feedback, NSS aims to prioritize efforts in enabling health and care transformation, supporting NHS Scotland with excellent services, and assisting organizations involved in health and care.

It provides services that support innovation and procurement in Scotland, including a Health Innovation Assessment Portal for stakeholders to submit their ideas and/or innovative products or technologies that could benefit Scotland's health and care services.

**SPMS - SERVICOS PARTILHADOS DO MINISTERIO DA SAUDE EPE (Portugal)**

The Shared Services of the Ministry of Health (SPMS) is a legal entity operating under public law with a business-oriented character. Its primary mission is to provide shared services in procurement and logistics, financial management, human resources, and information and communication systems and technologies to entities within the health sector. It operates as a pivotal entity in centralizing, optimizing, and rationalizing the acquisition of goods and services in the National Health Service, playing a crucial role in enhancing efficiency and coordination.

SPMS's services encompass procurement and logistics strategy, financial management and accounting, human resources focusing on efficiency and automation, and information and communication systems and technologies. It plays a pivotal role in advancing digital health literacy and driving strategic initiatives, such as the National Strategic Telehealth Plan, to create more opportunities and improve healthcare services.

**WOJEWODZKI SZPITAL SPECJALISTYCZNY W OLSZTYNIE (Poland)**

The Provincial Specialist Hospital in Olsztyn is a healthcare facility and a regional leader in innovative medical services. It is composed of numerous departments and treats over 27,000 patients while conducting 27,128 consultations annually. The hospital follows a patient-centric approach and continually invests in modernization.

The hospital actively engages in public procurement, emphasizing innovation, and has conducted around 16 tender procedures exceeding 215,000 euros, covering diverse needs from infrastructure to advanced medical equipment, including robotics.

**AZIENDA REGIONALE PER L'INNOVAZIONEE GLI ACQUISTI S.P.A. (Italy)**

The Regional Agency for Innovation and Purchasing (ARIA) supports and promotes development in the Region of Lombardy, with a strong emphasis on healthcare innovation. It supports more than 400 organizations, including healthcare authorities, hospitals, municipalities, and other public bodies across Lombardy and neighboring regions. In addition, it actively contributes to the digitization and innovation of public health services.

In 2020, ARIA launched and managed over 110 tenders, reaching a substantial value of 2.5 billion euros. Its impact extends beyond conventional healthcare services, encompassing over 5.8 million electronic health records, 14 million online visits booked, 33.5 million digitized reports, and 118 million electronic recipes. Through collaboration with the Lombardy Region, ARIA is pioneering new standards, experimental models, and interoperability in healthcare, thereby shaping the future landscape of digital health services.

**SERVICIO ARAGONÉS DE SALUD (Spain)**

The Aragonese Health Service (SALUD) serves as the public health provider for the Region of Aragón, managing and coordinating the healthcare resources within the region. It integrates numerous centers, services, and establishments throughout the Region, strategically organized into eight sectors. These sectors encompass primary care, specialized care, socio-sanitary care, and mental health, each tailored to its specific geographical area. Beyond conventional healthcare, SALUD adopts a multidisciplinary approach, addressing a spectrum of health-related issues and actively incorporating societal concerns into its overarching mission.

**SIHTASUTUS POHJA-EESTI REGIONAALHAIGLA (Estonia)**

The North Estonia Medical Centre stands as a leading healthcare provider in the country. It functions as a regional hospital and holds competence to deliver specialized medical care. Its main objective is to provide high-quality specialized medical care and ambulance services, serve as a training base for healthcare professionals, and engage in healthcare-related study and research.

The Medical Centre boasts a workforce of over 4,800 individuals, including doctors, nurses, caregivers, and specialists. With more than 500 doctors and around 100 medical residents, the institution comprises 7 clinics and 32 specialist centers. Annually, the Medical Centre provides specialized medical care to approximately 144,000 patients, with over 24,500 receiving treatments on the hospital. Emergency medicine serves around 84,000 patients each year, offering emergency health services to an average of 230 patients per day.

**5 YGIONOMIKI PERIFERIA THESSALIAS & STEREAS ELLADAS (Greece)**

The 5th Regional Health Authority of Thessaly and Sterea Ellada, two administrative regions in Greece, is dedicated to planning, coordinating, supervising, and controlling the operations of Health Service Providers within its Health District. Furthermore, through its Health and Social Solidarity Organizations, the Authority focuses on providing essential information on primary and secondary healthcare, as well as insights on health initiatives, scientific events, educational, and research programs. Serving as a comprehensive hub, its platform also facilitates various opportunities, including requests for purchases or procurement.

It has actively participated in projects such as "Smart and Healthy Ageing through People Engaging in Supportive Systems – SHAPES," a European IA (Innovation Action) Research and Innovation Programme (€20,944,318.75). This initiative, involving 14 Member States, aimed to transform integrated Primary Health Care services delivery at national and European levels. Another notable project is "A Universal Cyber Security Toolkit for HealthCare Industry – SPHINX" (€4,999,435.00), focused on creating an integrated, intelligent cybersecurity tool to protect the privacy and integrity of patients' medical data, enhance the security of Health IT systems, services, and infrastructures, and increase patients' trust in them.

**REGION VASTERBOTTEN (Sweden)**

The Region of Västerbotten assumes responsibility for delivering quality healthcare and medical services to all residents of Västerbotten County, funded through taxes, government grants, and patient fees. The region operates non-profitably, as mandated by the Health and Medical Services Act, with the overarching goal of ensuring good health and equitable care for everyone. It is organized into four areas of activity: Primary Care, Services, Hospital Care, and Dental Care. These services, including health centers and infirmaries, operate with a business-like approach with an annual budget exceeding SEK 9 billion.

The region is committed to enhancing the innovative capabilities of the Swedish healthcare system, ensuring the delivery of optimal care to the general public while using public resources efficiently and sustainably through active collaboration with employees, academia, industry, and various public actors at local, regional, and national levels.

**VELINDRE NATIONAL HEALTH SERVICE TRUST (United Kingdom)**

Velindre National Health Service Trust stands as one of the 12 legally mandated health organizations in Wales. It operates the Velindre Cancer Center providing specialist treatment, education, and R&D non-surgical tertiary oncology services to a population of 1.7 million in South East Wales. In addition to this role, the Trust manages the Welsh Blood and Transplant Services, extending its specialized services to a population of 3,3 million individuals all over Wales involving tasks like the collection and production of blood and its components, crucial for treating patients and supporting transplant programs.

Furthermore, the Trust hosts the NHS Wales Shared Services Partnership, which provides a wide range of support services such as procurement to NHS Wales, as well as the Health Technology Wales, a national body committed to enhancing the quality of healthcare in Wales by proactively identifying and adopting technological advancements and/or innovative care models.

**REGION HOVEDSTADEN (Denmark)**

The Region of Hovedstaden constitutes one of the 5 main regions in Denmark, encompassing a total of 29 municipalities, including the city of Copenhagen. Its governance is vested in a regional council comprising 41 elected members, overseeing a populace numbering 1,910,395 citizens (as of 2023). The responsibilities and activities of the Region of Hovedstaden range from healthcare services and innovation to international cooperation, as well as climate and environmental matters.

The Region of Hovedstaden places a pronounced emphasis on health research and innovation, fostering robust collaborations with enterprises, universities, and other stakeholders to establish the groundwork for future healthcare services, innovative treatments, technologies, and healthcare delivery. Additionally, it is crucial to highlight its status as one of Denmark's largest purchasers, wielding a substantial procurement volume ranging between DKK 12-14 billion. The region strategically engages in procurement and tendering processes, guided by the overarching objective of "getting the most health for the money - for the benefit of the patients."

**MERCURHOSP ASBL (Belgium)**

MercurHosp ASBL constitutes a central purchasing body responsible for carrying out public procurement procedures on behalf of its members, with the latter ones retaining the right of participation or abstention from the aforementioned procedures. Its network of members consists of Belgian general, psychiatric, and non-acute hospitals, including other healthcare institutions (rest, care, rehabilitation homes, associations in favor of children, people with disabilities, etc.) directly or indirectly linked to them.

It is legally recognized as a non-profit organization, building up on the vision of promoting innovation and adding value to the healthcare sector in Belgium through professional procurement and international networking. Its main objective is to create a common structure that will ultimately provide a range of services necessary for the organization of hospital care based on contracts for services and supplies in all categories of purchases.

# 3 State-of-the-art analysis: preliminary results

This section presents the preliminary result of the market analysis and, in particular, the state-of-the-art (SOTA) analysis. The objective of this analysis was to identify existing technologies that can tackle the procurement challenge together with an analysis of the related patents and standards, and to estimate the TRL thereof.

The SOTA analysis performed within the PROCURE4HEALTH project reveals a complex landscape within the wastewater treatment domain. The findings, derived from a combination of IPlytics platform searches (www.iplytics.com) and desk research, offer a good understanding of the technological landscape.

The comprehensive analysis of patents in the field of medical wastewater treatment and management presents a landscape rich in innovative approaches and technologies. The patents cover a wide array of areas, including the treatment of hospital sewage, separation of pathogenic microorganisms, advanced wastewater treatment processes, and inventive water treatment methods and devices. The diversity in inventions extends to addressing high-risk toxic wastewater, laboratory wastewater, and even environmentally friendly agents for pathogen removal in medical wastewater.

Examining the patent landscape reveals a broad application spectrum across industry domains, primarily in Pharmaceuticals and Waste and Wastewater. Academic institutions and businesses actively contribute to patent filings, indicating a thriving research and innovation hub with potential for economic and technological growth. The presence of initiatives like "Caring Nature", focusing on sustainable healthcare solutions, further underscores the opportunity for innovation, particularly in water sanitation.

The dispersion of patent applicants in this domain, with no single major applicant dominating the market, suggests a high potential for ongoing innovation. The industry trends over the last decade show a steady increase in patent filings, indicating sustained interest and activity. The geographic distribution emphasizes the United States as a leader in innovation, with Eastern Asian countries and Canada following closely. Notably, the European Union lags behind, reinforcing the potential for increased innovation in the region.

Furthermore, the analysis of relevant standards, particularly the scarcity of standards specifically addressing hospital wastewater, highlights a potential gap and opportunities for innovation. The limited number of identified standards suggests untapped potential for developing new solutions in the field.

In summary, the patent and standards analysis collectively portray a dynamic and promising landscape for innovation in hospital wastewater treatment. While the preceding analysis identified numerous applications and functionalities applicable to the desired solution - both on-site and off-site - in addressing the challenge of Hospital Wastewater (HWW), it did not pinpoint a comprehensive solution that adequately addresses all the specified requirements. A wider market analysis report is included as Annex III.

# 4 Request for Information

The Request for Information survey is part of the OMC of the PROCURE4HEALTH project. It should provide the PROCURE4HEALTH Consortium with feedback from the market about the challenge concerning on-site treatment of hospital wastewater.

Technology providers are invited to answer all the questions of the survey (one survey per company). The results will be considered when drafting the tender documents for the future PCP.

The survey should be filled out online and submitted via the following link: https://ec.europa.eu/eusurvey/runner/Procure4Health-water-treatment

Please note that taking part in this survey is not a prerequisite for participation in the future PCP and does not give any advantage to any technology provider. All information provided in the questionnaire will be anonymized, summarized and published online in English on the project's website.

Your personal data will be collected, processed, stored and used by the PROCURE4HEALTH Consortium with the only purpose of gathering information from the market within the framework of the PROCURE4HEALTH project. Personal data will be treated as strictly confidential according to the General Data Protection Regulation (Regulation 2016/679 of the European Parliament and of the Council - GDPR). You may exercise your right to access your personal data and the right to rectify such data by contacting: hello@procure4health.eu.

# Annex I – Request for Information questionnaire

| QUESTIONS FOR TECHNOLOGY PROVIDERS | |
|---|---|
| **PCP challenge and requirements** | |
| 1 | Do you have any suggestions regarding the scope of the envisaged PCP? |
| 2 | If you were to develop the solution, could you indicate an estimated budget for the development and deployment of the solution? Please justify your answer. |
| 3 | Do you have knowledge of any suitable technology or combination of technologies for on-site treatment of hospital wastewater? Yes / No.<br>If yes, please elaborate. |
| 4 | Do you know any developments in the field of water treatment technologies that PROCURE4HEALTH needs to take into account? Yes / No.<br>If yes, which ones? |
| 5 | Do you foresee any barriers to implement on-site treatment of hospital wastewater? Yes / No / I do not know.<br>If yes, please elaborate |
| 6 | Can you tackle all or part of the requirements of this challenge? Yes / No / I do not know yet.<br>If yes, please explain.<br>If I do not know yet, what additional information would you need? |
| 7 | Can you identify relevant functionalities that have not been described in the market consultation document? Yes / No<br>If yes, please elaborate. |
| 8 | Can you provide any other recommendations regarding on-site treatment of hospital wastewater? |
| **State-of-the-art (SOTA) analysis** | |
| 9 | Do you think there is room for technological development beyond the state of the art? Please explain. |
| 10 | What kind of solutions or developments would you propose? |
| 11 | Do you know the TRL of those solutions/developments? |

| | |
|---|---|
| 12 | Can the proposed solutions or developments treat highly soluble reagents and other hazardous chemicals? Yes / No.<br>If yes, please indicate which substances can be treated. |
| 13 | Can you identify any patents or standards that are relevant to the on-site treatment of hospital wastewater challenge? |
| 14 | Are you aware of any patents that may constitute a barrier for you to deliver a solution in the envisaged PCP procurement? |
| **Miscellaneous** | |
| 15 | What information do you still need in order to make a good plan of action for the development and/or implementation of solutions suitable to address the on-site treatment of hospital wastewater challenge? |
| 16 | Do you have specific requirements to achieve the functionalities that PROCURE4HEALTH should take into account? Yes / No.<br>If yes, which ones? |
| 17 | How could you contribute to the on-site treatment of hospital wastewater challenge? Please explain. |
| 18 | What are the risks associated to the development and implementation of a solution that tackles the functional needs of PROCURE4HEALTH? |
| 19 | Do you have any suggestions and/or remarks? |

# Annex II – Use case

## ON-SITE TREATMENT OF HOSPITAL WASTEWATER (HWW)

### Context

Hospital wastewater (HWW) poses a significant environmental and health risk due to the presence of medicines, pharmaceuticals, pathogens, and other hazardous substances. Traditional wastewater treatment methods employed by hospitals are often inadequate in effectively removing these contaminants.

### Scope of the problem: Reusable Face masks in Public Health Context

Hospitals discharge considerable amounts of chemicals and microbial agents in their wastewaters. Problem chemicals present in hospital wastewater belong to different groups, such as antibiotics, X-ray contrast agents, disinfectants and pharmaceuticals. Many of these chemical compounds resist normal wastewater treatment.

- Environmental.
- Human.
- Loss of water that can be reused.

### Use case

On-site system capable of effectively removing toxic substances, infectious compounds, pharmaceutical residues, and pathogens from hospital wastewater.

### Keywords

- Hospital wastewater treatment.
- Innovative wastewater treatment technology.
- Pharmaceutical wastewater treatment.
- Pathogen removal in wastewater.
- Advanced disinfection systems.
- Contaminant removal in hospital wastewater.
- Hospital wastewater pre-treatment.
- Greenhouse gas reduction in wastewater treatment.
- Regulated wastewater discharge systems.
- Chemical-free wastewater treatment.
- Microbial inactivation in hospital wastewater.

- Residue removal in hospital wastewater.

## SITUATION

| AS IS NOW | WISH SITUATION |
|---|---|
| Due to the presence of medicines, pharmaceuticals, pathogens, and other hazardous substances in HWW there is an environmental and health risks posed on the environment and the public. | With an improved wastewater treatment system, the discharge from hospitals would have a reduced environmental impact through the discharging toxic substances, infectious compounds, pharmaceutical residues, and pathogens into the environment or municipal water and minimize the risks on public health by ensuring the removal of disease-causing agents from hospital wastewater (the risk of waterborne transmission would be reduced and potential outbreaks or contamination of drinking water sources). |

## REQUIRED FUNCTIONALITIES

- Channel the hospital wastewater into a centralized treatment facility.
- Being able to separate/treat highly soluble reagents like sodium azide or other hazardous chemicals.
- Removal of large solid debris and coarse materials from the wastewater.
- Works stably despite high concentrations of disinfection agents.
- Treating persistent organic pollutants.
- Meet the required waste-water discharge standards by disinfecting HWW.
- Reduce nutrient concentrations (like nitrogen and phospherus).
- Filter and separate HWW through advanced treatment technologies.
- Proper handling of sludge that might form.
- Include monitoring devices and sensors to measure important parameters like pH, temperature, dissolved oxygen, and pollutant concentrations.
- Odor Control.
- Reuse water opportunities depending on local regulations and requirements, treated hospital wastewater may be suitable for various non-potable reuse applications within the hospital, such as irrigation, toilet flushing, or cooling tower makeup water.

## FIVE STEPS TO ACHIEVE DREAM STATE

- Identify all the sources of hospital wastewater (HWW) discharges within your hospital.
- Determine the types of healthcare pollutants present at each of the identified disposal channels.
- Familiarize yourself with the national and EU regulations and guidelines governing the discharge of hospital wastewater.
- Determine how the innovative solution can be integrated into your existing wastewater management system.
- Train relevant staff members on the operation, maintenance, and monitoring procedures of the new wastewater treatment system.
- Regular sampling and analysis of treated wastewater and regular assessing the performance of the wastewater treatment system and identify opportunities for optimization and improvement to ensure that the integrated system meets the expected outcomes.

# Annex III – Market analysis report

Procure 4Health

# Market Analysis

# "On-site treatment of hospital wastewater"

Authors: ZENIT GmbH

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| | |
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# Abstract

Procure4Health project aims to create a community of procurers and relevant stakeholders interested in Innovation Procurement in the healthcare sector.

# Disclaimer



[1] PU = Public (automatically posted online; SEN = Sensitive-Limited under the conditions of the grant agreement; EU classified = RESTREINT-UE/UE-RESTRICTED, CONFIDENTIEL-UE/EU-CONFIDENTIAL, SECRET-UE/EU-SECRET under Decision 2015/444

## Table of Contents

# 1. INTRODUCTION

ZENIT has conducted over the last months many expert interviews about wastewater treatment before visiting the trade fair Pollutec and writing the Market Analysis. It was established that wastewater, including that from hospitals, is treated almost exclusively in municipal/centralised wastewater treatment plants. This means that the treatment of hospital wastewater on-site is still a very big exception.

For this reason, the Market Analysis first discusses what could or should be the best option: centralised and/or decentralised wastewater treatment.

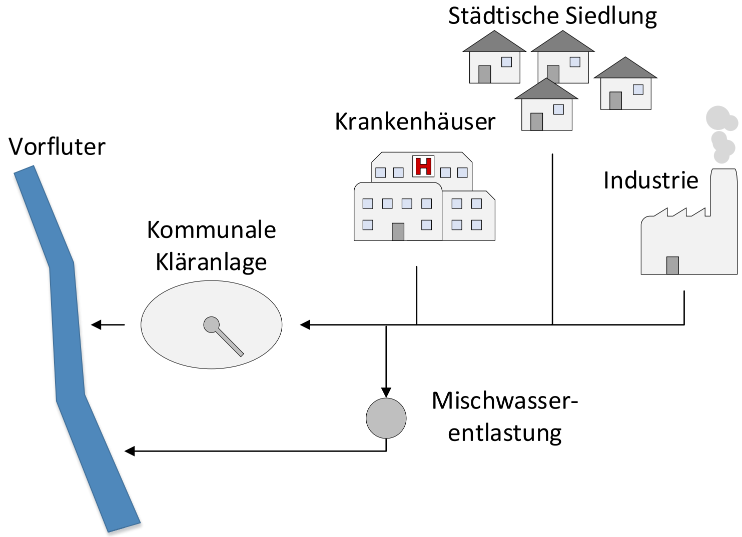
Wastewater treatment in centralised wastewater treatment plants has developed over the last few decades from the first to the third treatment stage. Each time, this has meant further or new development of the technologies to make this purification possible. Now the fourth treatment stage is under discussion, the implementation is still weak, but this fourth treatment stage could treat hospital wastewater (HWW) much better than the third stage.

However, experts are in favour of purifying particularly problematic substances as close as possible to the source, i.e. the hospital. The Market Analysis includes the problems with typical HWW, and which solutions are already existing on the market for the treatment. But the crucial issue is where to treat the HWW. Should it be centralized or decentralized at the hospitals. Both kinds of treatment have advantages and disadvantages.

The question of whether new technologies need to be developed for decentralised purification could not be answered conclusively. What is certain is that the technologies used in municipal wastewater treatment plants could also be used decentral plants in hospitals. Some technologies may have to be miniaturised or adapted. But it is also possible that new or further developed for specific substances must be developed.

The most regular situation is the following, that HWW will be mixed with wastewater from households and industry and treated in municipal wastewater treatment plants.[2]

[2] Marten Klatt, Falk Beyer, Jörn Einfeldt, Endstation für Medikamentenreste und Multiresistenzen: Dezentrale Behandlung von Krankenhausabwasser?, 32.Hamburger Kolloquium zur Abwasserwirtschaft, 6./7.9.2022, page 2, https://www.haw-hamburg.de/fileadmin/Bilder-zentral/News-Presse-Veranstaltungen/2021/PDF/Abwasserkolloquium_TUHH_2022_Tagungsbandbeitrag_Klatt-Beyer-Einfeldt_Online.pdf




Hospital wastewater (HWW) poses a significant environmental and health risk due to the presence of medicines, pharmaceuticals, pathogens, and other hazardous substances. Traditional wastewater treatment methods employed by hospitals are often inadequate in effectively removing these contaminants.[3][4] At the Institute for Hygiene and Public Health of the University Hospital Bonn the team "Environmental Microbiology" made in 2023 some analysis about the contamination by multi-resistant germs like 4MRGN. The result was that after the treatment at the municipal wastewater plant the water was still contaminated. The probes of the Rhine water behind the treatment plant contained still up to 4% of 4MRGN it can be lethal as shown in the TV production. The reasons have been the missing fourth stage of treatment and a poor monitoring. The case of Bonn is for sure not a single case.[5]

An Indian research team (led by VK Parida) published in 2022 the following graphic which shows the generation of different contaminants from the hospital and healthcare facilities and their subsequent pathway into different aqueous environments. They analysed publications from whole the world including nine European countries as well as Türkiye.[6]

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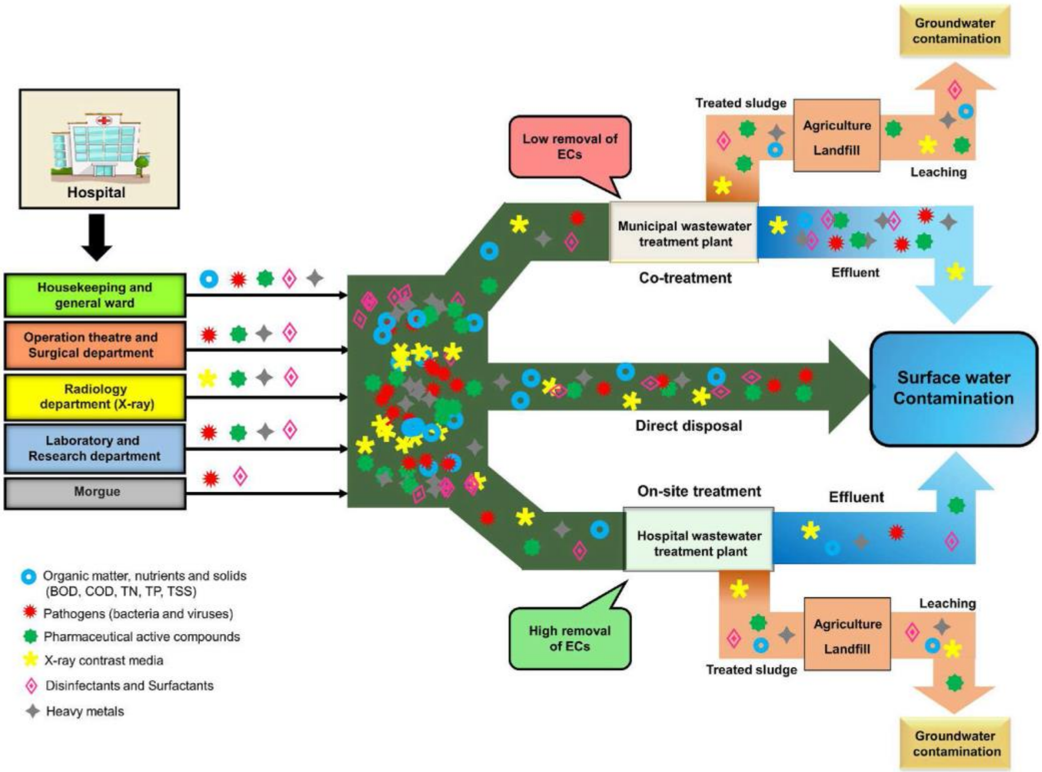
[3] VDI ZRE, Ressourceneffiziente Wasserkonzepte für Krankenhäuser, Berlin 2015, page 25-28, https://www.ressource-deutschland.de/fileadmin/user_upload/1_Themen/h_Publikationen/Kurzanalysen/2015-Kurzanalyse-11-VDI-ZRE-Krankenhaeuser.pdf

[4] Umweltbundesamt (Federal Environment Agency, Germany): Arzneimittel in der Umwelt - vermeiden, reduzieren, überwachen, 2014, page 7-13 https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/01.08.2014_hintergrundpapier_arzneimittel_final_.pdf

[5] Dr. Nicole Zacharias in https://www1.wdr.de/fernsehen/westpol/videos/klinikkeime-in-der-umwelt-100.html (regional TV WDR, 17.12.2023)

[6] Vishal Kumar Parida, Divyanshu Sikarwar , Abhradeep Majumdera, Ashok Kumar Gupta: An assessment of hospital wastewater and biomedical waste generation, existing legislations, risk assessment,




The Procure4Health team at ZENIT made an extensive desk research, which includes analysis of scientific articles and documents as well as from relevant associations, visited relevant trade fairs like Pollutec (Lyon) and MEDICA (Düsseldorf). Many interviews with experts from these institutions and with providers from such technologies from industry and research have been made.

# 2. SCOPE OF THE PROBLEM

On European level the Water Framework Directive (2000/60/EC) and the Groundwater Directive (2006/118/EC) have been adopted.[7] These directives are setting out rules to halt deterioration in the status of EU water bodies and achieve good status for Europe's rivers, lakes, and groundwater. For the hospital wastewater treatment both directives are the base for the purification needs and development of new technologies to treat the hospital wastewater. In October 2022 the proposal for a "Directive amending the Water Framework Directive, the Groundwater Directive and the Environmental Quality

treatment processes, and scenario during COVID-19, Journal of Environmental Management 308 (2022) 114609, page 5 https://www.sciencedirect.com/science/article/pii/S0301479722001827

[7] https://environment.ec.europa.eu/topics/water/groundwater_en#ref-2022-proposal-to-revise-list-of-groundwater-pollutants

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Standards Directive" (COM(2022) 540 final) was adopted.[8][9] In these documents all relevant pollutants are mentioned. A huge part is coming from pollution through medication, hospital treatment, etc. Therefore, the efficient removal of pollutants, microorganisms and pharmaceutical residues hospital wastewater is of great importance.[10]

Hospitals discharge considerable amounts of chemicals and microbial agents in their wastewaters. Problem chemicals present in hospital wastewater belong to different groups, such as antibiotics, X-ray contrast agents, disinfectants, and pharmaceuticals. Many of these chemical compounds resist normal wastewater treatment.[11][12][13][14]

With an improved wastewater treatment system, the discharge from hospitals would have a reduced environmental impact through the discharging toxic substances, infectious compounds, pharmaceutical residues, and pathogens into the environment or municipal water and minimize the risks on public health by ensuring the removal of disease-causing agents from hospital wastewater (the risk of waterborne transmission would be reduced and potential outbreaks or contamination of drinking water sources.)

The main results for the scope of the problem are:

While wastewater from hospitals and other clinical facilities is like domestic wastewater in terms of many physico-chemical wastewater parameters, it contains increased concentrations of active pharmaceutical ingredients and antibiotic-resistant bacteria etc., which are released untreated into the environment via discharge systems, particularly in mixed systems, and thus pose an ecotoxicological and health risk[15]

The hospital network "Health Care Without Harm Europe" stated clearly that hospitals are pollution hotspots for specialized pharmaceuticals.[16] The high concentrations of active pharmaceutical ingredients and hospital-specific pathogenic germs in hospital wastewater pose a risk to the environment and humans. In separation systems, the lack of degradation of active pharmaceutical ingredients in wastewater treatment plants without further wastewater treatment is of primary importance, while in mixed

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[8] https://environment.ec.europa.eu/document/download/6e618dec-c528-4ba8-8900-1e020eefe393_en?filename=Proposal%20for%20a%20Directive%20amending%20the%20Water%20Framework%20Directive%2C%20the%20Groundwater%20Directive%20and%20the%20Environmental%20Quality%20Standards%20Directive.pdf

[9] https://environment.ec.europa.eu/document/download/5aa45d99-811a-4e45-b89a-c10e30745fc1_en?filename=Annexes%20to%20the%20proposal_0.pdf

[10] Roland Damann, MicroBubbles (SPRIND), 21.09.2023

[11] Veit Flöser, Vortrag: Abwasserbelastung durch Krankenhäuser – ein Problem? zum 2. Krankenhaus-Umwelttag NRW der Krankenhausgesellschaft NW e. V., 26.9.2006 in Bochum

[12] https://www.abfallmanager-medizin.de/abfall-abc/kontrastmittel-im-krankenhaus/

[13] https://iww-online.de/dbu-projekt-merkmal-ruhr-minimiert-den-eintrag-von-roentgenkontrastmitteln-in-die-ruhr/##

[14] Horst Träger, FKT (Association Hospital Technologies), 3.8.2023

[15] Marten Klatt, etc., page 1

[16] HCWH, Pharmaceutical residues in hospital wastewater. Five case studies from European hospitals, 2021, page 7, https://noharm-europe.org/documents/pharmaceutical-residues-hospital-wastewater

Funded by the European Union.

systems the entry of pathogenic germs and their resistance genes via mixed water discharge plants is the main issue. [17]

Wastewater treatment plants widely vary in their capacity to eliminate these active substances; one study recorded removal rates ranging from 0%-97%. This means that parent compounds or their metabolites can be discharged into the aquatic ecosystem through effluents and enter the water cycle. Pharmaceuticals are biologically active, often mobile (particularly in the case of metabolites), and not readily biodegradable in the environment. As they are designed to interact with living systems at low doses, even low concentrations in the environment are a concern.

Up to 90% of orally administered pharmaceuticals are excreted into wastewater as active substances in the faeces and urine of patients. Whilst common medicines are often consumed in the community, more specialised pharmaceutical products such as cytostatic drugs, some antibiotics, and X-ray contrast agents are mainly administered in hospitals.[18]

Only around 20% of APIs (Active pharmaceutical ingredients) in municipal wastewater come from healthcare facilities. Nevertheless, hospital wastewater's contribution to the pharmaceutical load released into the environment can widely vary based on factors such as number of beds, services provided, and number and types of wards and units.[19]

The European INTERREG project PILLS ("Pharmaceutical Input and Elimination from Local Sources") found out that when the relatively large consumption of pharmaceuticals in private households is compared with the much smaller level of consumption in hospitals, it is clear that point sources treatments at the hospitals can only ever be part of the solution. But it is stated that the concentration of antibiotic resistance integrons per litre and the proportion of bacteria with antibiotic resistance integrons is in hospital wastewater much higher than in municipal wastewater or rivers.[20] Certain pharmaceuticals (X-ray contrast media, cytostatics and some antibiotics) are distributed in much higher amounts in hospitals than at home. This offers the opportunity to eliminate high amounts of these specific pharmaceuticals from the environment by decentralised hospital wastewater treatment plants.[21]

Currently, there is no single process that can be used for the comprehensive treatment of hospital wastewater regarding the elimination of micropollutants, antibiotic-resistant bacteria and antibiotic resistance genes to a high degree. The combination of several

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[17] Marten Klatt, etc., page 1

[18] HCWH, Pharmaceutical residues in hospital wastewater. Five case studies from European hospitals, 2021, page 3

[19] HCWH, Pharmaceutical residues in hospital wastewater. Five case studies from European hospitals, 2021, page 6

[20] http://www.pills-project.eu/PILLS_summary_english.pdf, 2007-2012, INTERREG IV B project, page 10

[21] http://www.pills-project.eu/PILLS_summary_english.pdf, 2007-2012, INTERREG IV B project, page 20

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processes, so-called hybrid processes, is necessary for hospital wastewater treatment to guarantee water and health protection.[22]

The techniques for eliminating trace substances and antibiotic resistance do exist, but they are complex and expensive and for this reason alone are certainly not equally useful for all hospitals. In addition, it has been shown that the pharmaceutical substances most frequently found in water typically do not originate from hospitals but are for the most part discharged into wastewater from private households. Therefore, the establishment of advanced wastewater treatment technologies in hospitals would only be appropriate where, for example, the elimination of hospital-specific antibiotic resistance or certain antibiotic substances is concerned.[23][24]

# 3. HOSPITAL WASTEWATER: CENTRALISED TREATMENT VERSUS DECENTRALISED TREATMENT

Municipal or central wastewater treatment plants are primarily designed to eliminate biodegradable substances and nutrients and are therefore not able to completely remove pharmaceutical substances.[25]

As the findings in surface waters show, wastewater treatment plants with three treatment stages cannot completely remove all pharmaceutical residues from the wastewater. A relatively expensive but very effective method of eliminating even traces of pharmaceuticals and their degradation products is to equip wastewater treatment plants with an additional purification stage. Such additional purification steps are primarily ozone treatment of the wastewater and/or activated carbon filtration. Equipping the largest wastewater treatment plants accordingly, which would already ensure the treatment of 50% of the wastewater volume, would be cost-efficient and would result in the retention of numerous active substances that currently still pass through the wastewater treatment plants.[26]

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[22] Marten Klatt, etc., page 8
[23] Veit Flöser, Ingenierbüro Flöser, Email 19.8.2023, expert group at DWA (German Association for Water, Wastewater and Waste)
[24] Veit Flöser: Untersuchungen zur Relevanz von Krankenhausabwasser im Abwasserentsorgungsgebiet des OOWV im Rahmen des EU-Fördervorhabens DENEWA, Abschlussbericht, 2015, page 16/17 and http://www.denewa.eu/denewa/werkpakketten/behandeling-van-ziekenhuisafvalwater?lang=11
[25] HCWH, Pharmaceutical residues in hospital wastewater. Five case studies from European hospitals, 2021, page 5
[26] Umweltbundesamt (Federal Environment Agency, Germany): Arzneimittel in der Umwelt - vermeiden, reduzieren, überwachen, 2014, page 16 https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/01.08.2014_hintergrundpapier_arzneimittel_final_.pdf

Funded by the European Union.

To analyse relevant solutions to eliminate the risky ingredients of the hospital wastewater it is to know that the technological solutions for a centralised treatment at the municipal wastewater treatment plants are quite different as if the treatment is decentralised in/at the hospitals.
From the German Association for Water, Wastewater and Waste (DWA) we learned that contaminated water is produced at hospitals in higher concentration than in the private households, but not all ingredients are so risky that it would be better to eliminate them directly in the hospital.

It is a question of costs for the hospital wastewater treatment centralised at the municipal wastewater treatment plant with the fourth stage of purification. The treatment of the hospital wastewater has also high costs for the hospitals and their owners. Here the best solution is, if a new hospital will be constructed is the easiest way to integrate such internal treatment plant. But most of the hospitals are already existing for years. That makes a cost-friendly integration difficult and often there is not enough space to integrate such treatment plants.

In 2007/2008 a pilot project was running at the local Kreiskrankenhaus in Waldbröl (Germany) in cooperation with the Technical University of Aachen.[27][28] In the city Sneek/Netherlands started a demo installation in the year 2014.[29]
There are not so many examples for decentralised wastewater treatment at the hospitals yet.
Denmark decided that the new constructed regional hospitals should have decentralised treatment, these are the hospitals which are the most polluting, because they treat all kind of diseases, especially the high polluting cancer treatment. An example is the hospital Herlev.[30] The older/smaller ones which are less polluting are in Denmark connected to the municipal treatment plant. This was a political decision in Denmark.
In the Netherlands there are also some examples of decentralised treatment, like the Erasmus University Medical Center (Rotterdam) or the Marienhospital (Gelsenkirchen/Germany).[31] Here the filtration system from Mann+Hummel has been implemented combined with upstreamed activated carbon.[32]

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27 German Technical and Scientific Association for Gas and Water (DVGW), press release 3.7.2008 for DPA (German Press Agency), Email of Elisabeth Hörning
28 Marten Klatt, etc., page 6
29 https://www.dutchwatersector.com/news/demo-site-for-experimental-treatment-of-hospital-wastewater-officially-opened-in-sneek-the
30 Marten Klatt, etc., page 6
31 http://www.pills-project.eu/PILLS_summary_english.pdf, 2007-2012, INTERREG IV B project, page 11
32 Julian Klein, Mann+Hummel, interview at Pollutec 10.10.2023

# 4. REMARK – STATE OF THE ART AT POLLUTEC TRADE FAIR (LYON, OCTOBER 2023)[33]

A ZENIT team member[34] visited the Pollutec trade fair to see the offered technologies for the purification of wastewater from households and industry. There was no specific section for hospital wastewater. Pollutec is the largest environmental trade fair in Europe with 1546 exhibitors from industry and research in 2023, including from the fields of energy, water, wastewater, and air pollution control. A reference to hospitals was mentioned in exceptional cases. This means that the topic of hospital wastewater is known in theory and research, but very little happens in terms of implementation, otherwise the environmental technology industry would present much more on this topic. In contrast, however, there is a lot of industry-related work. It was clearly to see that hospital wastewater is technologically much closer to industrial wastewater than to household wastewater. If it is difficult to find any direct technologies for hospital wastewater at Europe's largest trade fair, this means that we are either thinking in the completely wrong direction, which is rather unlikely. Or it means that there is still a great need for general development or that technologies for the purification of industrial wastewater need to be adapted and further developed for the purification of hospital wastewater. In particular, the treatment of hospital wastewater directly in the hospital must be politically desirable and then the wastewater technology industry would develop new processes and new products.

# 5. EXISTING SOLUTIONS FOR HWW TREATMENT IN GENERAL

There are several technologies being used and developed for treating hospital wastewater, which is essential for sustainable development and environmental protection. These technologies are designed to address the complex mixture of contaminants that hospital wastewater typically contains.

In the broadest sense, products that are used in wastewater treatment, such as filtration, pipes and ozonation systems, could theoretically be described as COTS

[33] https://www.pollutec.com/en-gb/who-is-coming/exhibitor-list.html#/

[34] Juan-J. Carmona Schneider participated also at the matchmaking event of the Enterprise Europe Network: https://green-days-pollutec-2023.b2match.io/

(commercially available off-the-shelf)[35]. But they are not software/hardware products from the ICT industry, but primarily products from mechanical and process engineering.

In fact, all the products mentioned in the market report are already on the market and in use in wastewater treatment, so they are to be classified as TRL 9. I will highlight the exceptions.

Here's a summary of the key technologies:

1. Membrane Bioreactors (MBR): MBR technology uses membranes with controllable porous and nonporous structures for molecular separations. It has demonstrated high removal efficiency for organic compounds in hospital wastewater[36]
2. Disinfection Technologies: These include incineration, chemical disinfection, and physical disinfection. The choice of technology depends on the specific situation and the nature of the waste being treated.[37]
3. Tertiary Treatment: While conventional primary and secondary treatment units often struggle to completely remove emerging contaminants (ECs) and other micropollutants, tertiary treatment processes are required for the complete removal of these substances from hospital wastewater[38]
4. Degradation Reaction Catalyzed by Fe0 Under Microwave Irradiation: This technology has been effective for treating hospital wastewater containing high concentrations of specific compounds like diclofenac and ibuprofen[39]
5. Electrochemical Technologies: These have been developed to decrease chemical risks in hospital wastewater, particularly from pharmaceuticals. The methods include conventional treatments like filtration, adsorption, or biological processes, as well as advanced oxidation processes (AOPs)[40]

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[35] https://en.wikipedia.org/wiki/Commercial_off-the-shelf

[36] Yan Zhao, Yangbo Qiu, Natalie Mamrol, Longfei Ren, Xin Li, Jiahui Shao, Xing Yang, Bart van der Bruggen, Membrane bioreactors for hospital wastewater treatment: recent advancements in membranes and processes, Front. Chem. Sci. Eng. 2022, 16(5): 634–660, https://doi.org/10.1007/s11705-021-2107-1

[37] Wang J, Shen J, Ye D, Yan X, Zhang Y, Yang W, Li X, Wang J, Zhang L, Pan L. Disinfection technology of hospital wastes and wastewater: Suggestions for disinfection strategy during coronavirus Disease 2019 (COVID-19) pandemic in China. Environ Pollut. 2020 Jul;262:114665. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7194566/#:~:text=This%20section%20first%20summarizes%20main,technologies%20used%20in%20different%20situations

[38] Vishal Kumar Parida, Divyanshu Sikarwar , Abhradeep Majumdera, Ashok Kumar Gupta: An assessment of hospital wastewater and biomedical waste generation, existing legislations, risk assessment, treatment processes, and scenario during COVID-19, Journal of Environmental Management 308 (2022) 114609, https://www.sciencedirect.com/science/article/pii/S0301479722001827

[39] Lubomira Kovalova, Hansruedi Siegrist, Heinz Singer, Anita Wittmer, Christa S. McArdell, Hospital Wastewater Treatment by Membrane Bioreactor: Performance and Efficiency for Organic Micropollutant Elimination, Environ. Sci. Technol. 2012, 46, 3, 1536–1545, https://doi.org/10.1021/es203495d

[40] Moratalla, Á.; Cotillas, S.; Lacasa, E.; Cañizares, P.; Rodrigo, M.A.; Sáez, C.: Electrochemical Technologies to Decrease the Chemical Risk of Hospital Wastewater and Urine. Molecules 2021, 26, 6813. https://doi.org/10.3390/molecules26226813

6. Activated Sludge Processes (ASPs): Alongside MBRs, ASPs are a major and effective method for hospital wastewater treatment, especially considering the recent COVID-19 outbreak and its implications on wastewater management[41]
7. Microflotation: This process utilises fine air bubbles to separate suspended solids and oily contaminants. It is often used as a pre-treatment method to remove larger solids and fats before further treatment stages follow. Microflotation is cost-effective but requires a subsequent treatment stage to combat microbial contamination.[42]
8. Advanced Oxidation Processes: In combination with other technologies like packed activated carbon, ozonation, and UV irradiation, advanced oxidation processes are employed for treating hospital effluent worldwide, showing promising results[43][44] These technologies are particularly effective at inactivating microorganisms such as bacteria and viruses. Ozonation has the added benefit of also breaking down some pharmaceutical compounds. The main disadvantage is the high energy consumption, which has an impact on operating costs.[45]
9. Combination of microflotation and oxidative processes: These two processes are often combined in a treatment chain to increase the efficiency of wastewater treatment. For example, a microflotation unit could be placed upstream of an ozonation plant to extend the service life of the more expensive ozonation plant.[46]

The most interesting technologies at Pollutec are the following, some to improve the technologies for the purification of the wastewater in the central municipal wastewater treatment plans, some to be implemented also in decentralised treatment plants. Some of the interview partners (listed at the end of the market report) have been recommended by Pollutec exhibitors. As mentioned above mostly for industrial wastewater treatment, but also usable for the specific needs of the hospital wastewater treatment:

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[41] Liu, A.; Zhao, Y.; Cai, Y., Kang, P.; Huang, Y.; Li, M.; Yang, A. Towards Effective, Sustainable Solution for Hospital Wastewater Treatment to Cope with thePost-Pandemic Era. Int. J. Environ. Res. Public Health 2023, 20, 2854 https://doi.org/10.3390/ijerph20042854

[42] Roland Damann, MicroBubbles, 21.092023

[43] Afzal Husain Khan, Nadeem A. Khan, Sirajuddin Ahmed, Aastha Dhingra, Chandra Pratap Singh, Saif Ullah Khan, Ali Akbar Mohammadi, Fazlollah Changani, Mahmood Yousefi, Shamshad Alam, Sergij Vambol, Viola Vambol, Anwar Khursheed, Imran Ali: Application of advanced oxidation processes followed by different treatment technologies for hospital wastewater treatment, Journal of Cleaner Production, Volume 269, 2020,122411, https://www.sciencedirect.com/science/article/pii/S0959652620324586

[44] Geeta Bhandari, Parul Chaudhary, Saurabh Gangola, Sanjay Gupta, Ashulekha Gupta, Mohd Rafatullah, Shaohua Chen, A review on hospital wastewater treatment technologies: Current management practices and future prospects, Journal of Water Process Engineering, Volume 56, 2023, 104516, https://www.sciencedirect.com/science/article/pii/S221471442301036X

[45] Roland Damann, MicroBubbles (SPRIND), 21.09.2023

[46] Roland Damann, MicroBubbles (SPRIND), 21.09.2023

- Nomado (France): the French company produce modular water solutions, which means not in big plants, but in container. Their Plug&Play treatment plants are tailor-made developed and constructed.[47] For example, for industries, like pharmaceutics and chemistry. As engineering company, they integrate all necessary existing technologies into the container. They are suitable to integrate them into hospital facilities because they need only little space. [48]
- Moleaer (USA): They have strong activities in Europe. They are a pioneer of the nanobubble technology. This technology can improve the existing treatment processes in central wastewater treatment plants. Through selective oxidation of inhibitory contaminants, nanobubbles provide in-situ chemistry using air to achieve best-in-class wastewater treatment. Which also less energy consumption, less chlorine demand, etc.[49] The discussion with Moleaer has shown that their technology is not yet ready for smaller, decentralized HWW treatment plants.[50]
- Mann+Hummel (Germany): The German company, worldwide active, is one of the leaders in filtration technologies e.g. wastewater treatment. They have experience in municipal wastewater plants as well as in the pharmaceutical industry and in hospitals. Also, Mann+Hummel technologies/filtration systems are not yet suitable for small treatment plants at hospitals. They suggest as best solution to add/to use reverse osmosis, which is very good to the requested application, but very energy intensive, because of the pressure of 80 bar needed.[51]
- Berghof (Germany): The company has decades of experience in filtration, also for the wastewater treatment for the pharmaceutical and chemical industry. [52] Berghof produces tubular membrane filtration systems (MBR, direct Ultrafiltration.[53][54] Berghof has different kinds of membrane modules.[55] For example, the Dutch company Pharmafilter use Berghof membranes (in an MBR) for the decentral treatment of HWW for about 10 years at several hospitals in The Netherlands. The quality of the permeate allows us even, to further process the wastewater into grey water free of micro pollutants to be reused in the hospitals.[56]
- Pharmafilter (Netherlands): this Dutch company is a plant engineering using Berghof membrane technology for hospital wastewater management/treatment.

[47] Nathalie Schmitt, nomado, Pollutec 10.10.2023
[48] https://www.nomad-o.com/en/wastewater-treatment/
[49] https://www.moleaer.com/about/

[50] Marc-Andre Lyachenko, 24.10.2023
[51] https://www.mann-hummel.com/en/filtration/water-filtration-for-cleaner-water.html, https://www.mann-hummel.com/en/products/healthcare-pharmaceuticals.html

[52] https://www.berghofmembranes.com/pharmaceutical-chemical/
[53] https://www.berghofmembranes.com/technology/
[54] https://www.berghofmembranes.com/applications/
[55] https://www.berghofmembranes.com/tubular-uf-membrane-modules/
[56] Stefan Hertel, Pharmafilter, 18.10.2023

The wastewater treatment facility at the hospital must have a small size. It is an also a psychological issue, because of the visibility of the treatment plant. This small facility should treat all the hospital wastewater. They should be able to be connected to the hospital internal sewage water system and from there cleaned to the public canalization. Pharmafilter has implemented some treatment plants in the Netherlands, the biggest at Erasmus University Medical Center, a small one in Terneuzen. Two further one in Delft and Nijmegen.[57]

- Nx filtration (Netherlands): the Dutch company has a world unique concept. It is the filtration in only one step with their direct nanofiltration membranes (hollow fiber). It removes organics from polluted water including micropollutants, antibiotics, bacteria, viruses and PFAS.[58] The technology was tested by Veolia for municipal treatment plants.[59] The technology should be also suitable for decentralized treatment plants as hospitals, but no experience yet.
- Nereus (France): The company has developed several innovative services and products which all use membranes for the filtration to be used several different industries, also for hospital wastewater.[60]Nereus is coordinating the project SAVE[61]. SAVE is developing together with the municipal wastewater treatment plant of Toulouse (France). The SAVE project involves designing, evaluating, and demonstrating the performance of an innovative combination of processes for treating domestic wastewater and sludge. The experimental process aims to produce water without any detected micropollutants or risks of antibiotic or viral resistance (Covid, etc.). This technology is in development and testing for the central municipal wastewater treatment. The TRL is now 4/5. After finishing the SAVE project, it is to be seen, if the technology works well for the municipal plants and if the technology can also be used miniaturised for the in-hospital plants.
- Eco Water Solution (Germany): They are an engineering and consulting company in wastewater treatment. They are planning and constructing smaller plants, e.g. plant for a rehab hospital in Germany. Their Biotopp system combined with UV, ozonation and activated carbon meet the quality of the fourth stage treatment.[62][63]

For the centralised municipal wastewater treatment for the first three stages of purification all necessary technologies are existing. These technologies may be further developed for e.g. more efficiency, less energy consumption. But nothing could be found on the Internet or got as information from the interviews and the visit at Pollutec

[57] Stefan Hertel, Pharmafilter, 18.10.2023
[58]https://nxfiltration.com/solutions/water-treatment-and-reuse/

[59] https://nxfiltration.com/veolia-expands-pilot-testing-with-nx-filtrations-hollow-fiber-nanofiltration-technology/
[60] https://nereus-water.com/en/products/ m
[61] http://filiere-save.com/
[62] Leon Roggatz, Pollutec 10.10.2023
[63] https://www.ecowatersolution.de/kleinkl%C3%A4ranlagen

Funded by the
European Union.

2023/Lyon that disruptive new technologies are in discussion. We learned that there are additional specific technologies for a fourth purification stage, which would solve a lot of environmental problems. So, also these technologies are existing.

Unfortunately, the fourth stage is not yet obligatory in the European Union. But there are some already implemented, not only in Switzerland.[64] This means that the fourth stage of purification is an important topic for the Action Plan of Work Package 5.

Besides the technical solutions which have been identified at Pollutec there are further technologies to be mentioned, these are coming from companies identified by Enterprise Europe Network partners:

- Alpha Cleantec (Switzerland):
  Alpha Cleantec can treat drug leftovers, based on laboratory tests they developed in the past. All other substances´ categories listed are usually found in municipal wastewaters treatment plants. Thus, Alpha Cleantech can treat them as well, provided they are organic.[65][66] The TRL are between 7 and 9 depending on the technology. They are strong in R&D, in collaboration with the Hebrew University of Jerusalem.[67]
- Green Ocean (Germany/Switzerland):
  Green Ocean is a start-up for NextGen technologies for the treatment of highly toxic industrial wastewater. They are in the development, construction, and operation of wastewater. They developed ORCAN® utilises activated oxygen as the main oxidant (radical formation), while the sub-stoichiometrically dosed oxidant keeps the reaction cycle "running". The space-time yield of the reactor of 5 to >15 kg COD / m3 h and the autothermal, continuous process allows small, compact plants. They have a special reactor design and the high cavitation offer a unique process efficiency. The Advanced Flotation (FRES:H®) enables particularly high extraction efficiencies and low space requirements.[68][69] The TRL are between 7 and 9 depending on the technology.
- MicroBubbles (Germany): MicroBubbles is a SPRIND project/company founded by Roland Damann. MicroBubbles is revolutionizing microflotation and establishing it as the key technology in modern wastewater treatment by bringing it in-situ into the water. Combined with an in-house developed control algorithm. MicroBubbles offer

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[64] Carraro, E., Bonetta, S., Bonetta, S. (2017). Hospital Wastewater: Existing Regulations and Current Trends in Management. In: Verlicchi, P. (eds) Hospital Wastewaters. The Handbook of Environmental Chemistry, vol 60. Springer, Cham. https://doi.org/10.1007/698_2017_10
[65] Mail of Mr Raymond Hernandez, Alpha Cleantec, 29.8.2023
[66] https://alphacleantec.com/wastewater-and-goundwater-treatment/
[67] https://alphacleantec.com/research-development/
[68] Peter Muth, GreenOcean, meeting 13.6.2023 at RuhrSummit, https://2023.ruhrsummit.de/stages/pitch-stage/
[69] https://www.greenocean.tech/en/our-solutions/

individually adaptable solutions for complex water matrices. The specialization towards the elimination of microplastics and micropollutants is a major step forward in tackling the global challenges of today. MicroBubbles is now in the development/demonstration phase, so TRL 6.[70][71] The technology is primarily in development for microplastics but can be easily used also for other kind of micropollutants, e.g. in the hospital wastewater.

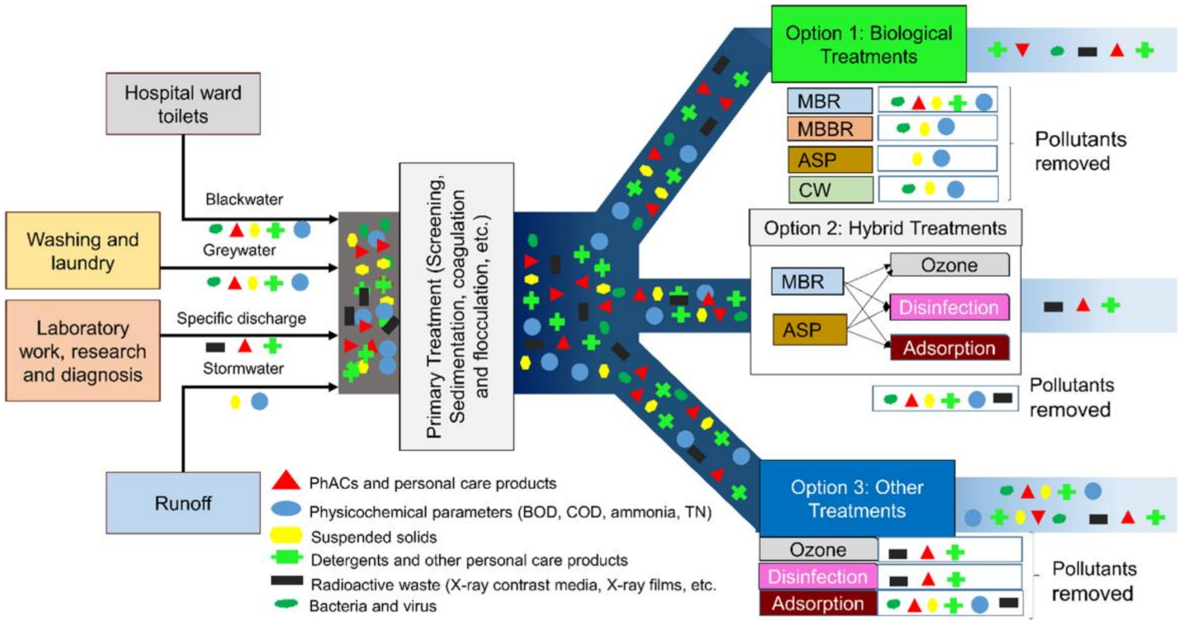
- HES-SO (Switzerland): Prof. Fabian Fischer and his team developed the "Microbial Fuel Cells". The construction of large microbial fuel cells (MFCs) and their long-term reliability are current challenges. MFCs generate power while purifying wastewater, save electricity, avoid pollutant stripping into the air. Micropollutants are degrading by 67% now.[72][73] The TRL is 5. This technology can be further developed for hospital wastewater on-site treatment and then with a much higher degradation rate.

# 6. SPECIFIC EXISTING SOLUTIONS FOR TREATMENT IN/AT HOSPITALS

The Hospital wastewater treatment can be centralised within the hospital, but it is also possible to (pre-)treat contaminated water where it is produced, e.g. in hospital rooms, laboratories, or operating theatres.

This graphic shows the different options existing of the sources of hospital wastewater and which options of different pilot/full-scale treatment units are existing to remove various pollutants in hospital.[74]

[70] https://microbubbles.org/en/the-idea/
[71] https://www.sprind.org/en/projects/microbubbles/
[72] Maxime Blatter, Louis Delabays, Clément Furrer, Gérald Huguenin, Christian Pierre Cachelin, Fabian Fischer, Stretched 1000-L microbial fuel cell, Journal of Power Sources, Volume 483, 31 January 2021, 229130, https://www.sciencedirect.com/science/article/pii/S0378775320314245?via%3Dihub
[73] https://www.zdf.de/dokumentation/zdfinfo-doku/natur-macht-geschichte--mikroben-100.html (from minute 40:30 onwards)
[74] Abhradeep Majumder, Ashok Kumar Gupta, Partha Sarathi Ghosal, Mahesh Varma :A review on hospital wastewater treatment: A special emphasis on occurrence and removal of pharmaceutically active compounds, resistant microorganisms, and SARS-CoV-2, Journal of Environmental Chemical Engineering 9 (2021) 104812, page 10, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7680650/




# 7. EXAMPLES FOR THE (PRE-)TREATMENT ON THE SPOT

The German company MOVEO has a system for the prevention of nosocomial infections. The disinfection system for sink drains in clinical sanitary areas. Its continuous and fully automatic disinfection process prevents the production of infectious bio-aerosols and thus the transfer of pathogens from the wash basin to the patient.[75]

Examples for the common treatment in a process system:

The results from PILLS project have shown that advanced treatment is necessary to eliminate most pharmaceuticals from wastewater. Biological treatment is not enough.

The purification with biological treatment (e.g. a membrane bioreactor) plus ozone and/or activated carbon or UV/$H_2O_2$ or reverse osmosis was found to be effective to achieve this elimination.

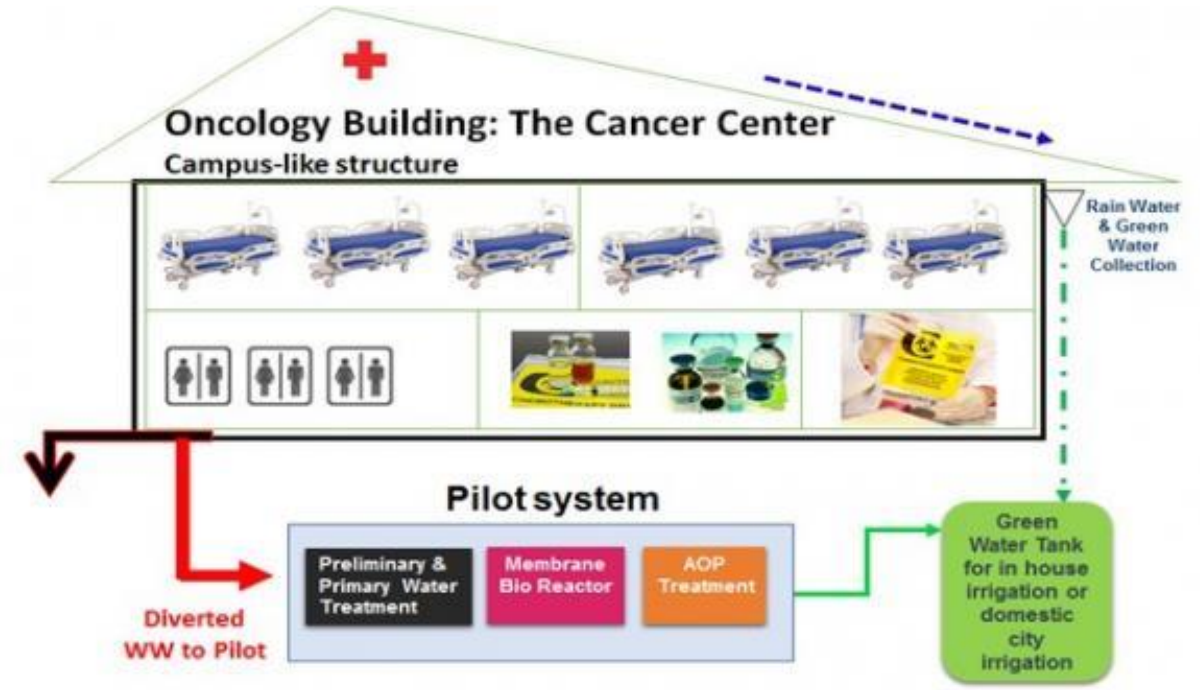
With the advanced treatment with ozone or Powered Activated Carbon (PAC) an elimination of 80% could be achieved for most of the investigated compounds, but not

[75] https://www.moveomed.com/images/downloads/en/MoveoMed-MoveoSiphon-Flyer-6s-EN-web-221101.pdf

for all of them. Activated carbon filtration with a fresh GAC filter (granulated activated carbon) and Reversed Osmosis led to high elimination rates for all compounds. The advanced oxidation process UV/H2O2 was effective to remove all the analyzed pharmaceuticals by used of a high fluence.[76]

In the Herlev (Denmark) project of Grundfos BioBooster A/S, the process chain MBR + ozonation + GAK + UV, a total of 99.9 % of the micropollutants (with the exception of the X-ray contrast media) were removed. In addition, the number of pathogenic germs (E. coli, enterococci and noroviruses) was below the detection limit.[77]

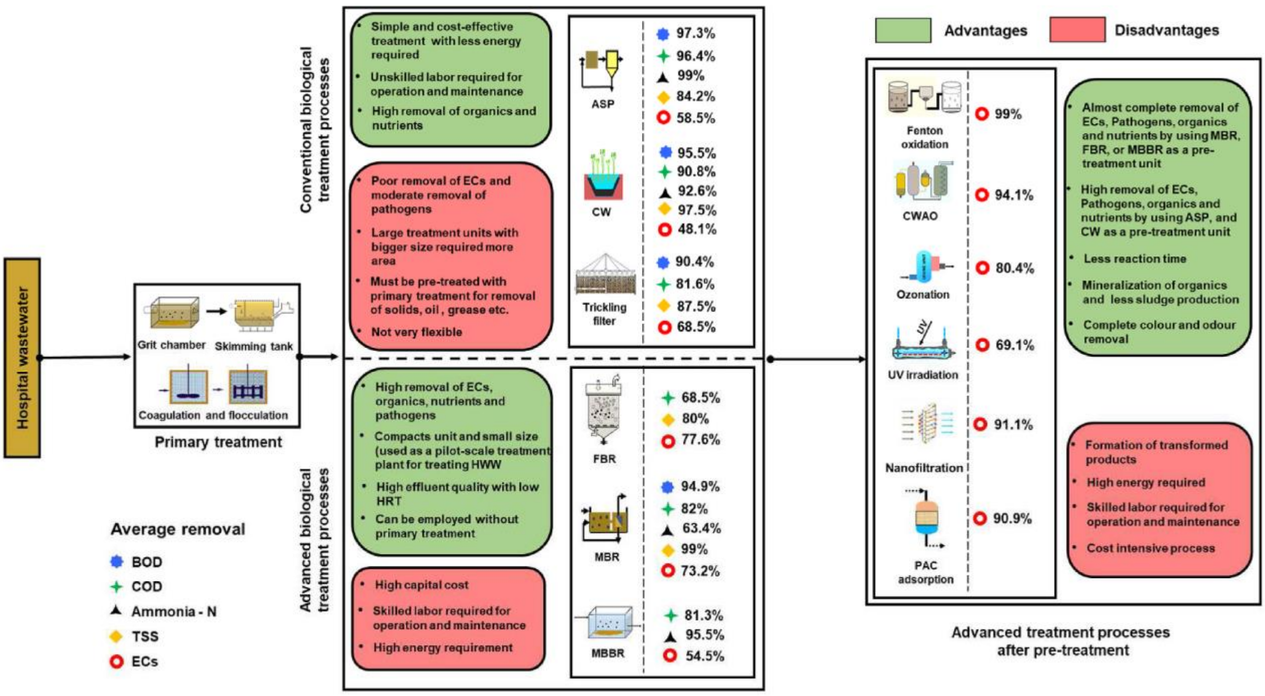
In Israel at the Tel Aviv University Prof Dror Avisar was working on a study with the objective to promote local and efficient treatment of wastewater in hospitals in Israel and abroad before discharging them into the municipal Wastewater Treatment Plants. This is especially important for Israel and other countries with aridity and groundwater problems.




Advanced treatment technologies will be carried out in the research to reduce effluent contamination: multi-stage biological decomposition including carbon, phosphorus, and nitrogen reduction in ventilated, semi-ventilated and non-ventilated ventilates, physical removal by ceramic membrane and advanced ozone oxidation.[78]

[76] Pharmaceutical residues in the aquatic system– a challenge for the future. Insights and activities of the European cooperation project PILLS, 2007-2012, INTERREG IV B project, page 20, http://www.pills-project.eu/PILLS_summary_english.pdf
[77] Marten Klatt, etc., page 6
[78] https://en-wrc.tau.ac.il/Hosp ital_WW_treatment

The Indian researcher team (led by VK Parida) shows in the following graphic the recommended treatment methods for HWW remediation based on existing pilot/full-scale units along with their advantages and disadvantages.[79]




# 8. GAPS

1. Development of specific treatment facilities within hospitals to eliminate of hospital-specific antibiotic resistance or to reduce the use of certain antibiotic agents. They must be smaller and cheaper, so new technologies must be developed, especially, if the treatment must be integrated into existing hospital facilities.
2. Problem Region Västra Götaland:
   "Regarding wastewater from hospitals, we have had a big issue about that here for several years. The machines in our hospital labs analysing samples from patients use a variety of reagents which are mixed with preservatives, mainly sodium azide. The machines are connected to the tap water for rinsing during the analysis and the water ends up in the sewage. Here comes the problem: The reagents contain only

[79] VK Parida et al.; page 14

traces of sodium azide, but it ends up in the wastewater and the hospitals are not allowed to release sodium azide into the wastewater. The hospitals must thus collect/remove the sodium azide from the wastewater. This is not doable since it is extremely diluted.
The only solution is then to collect the wastewater from the machines and send it to incineration. We speak about thousands of litres of water to incineration every week (!!!) - Impossible!
If we don´t do this, the local environmental authorities can close down the hospital – also impossible!"
A potential solution could be machines designed in a way that the first round of wastewater (that contains the azide) ends up in a separate tank that can be taking care of as hazardous waste and not connected to the sewage.

3. Roland Damann as expert for water purification sees as challenges and need for research: The main problems lie in the adaptability of the technologies to variable wastewater qualities and in energy consumption. There is a need for research to find energy-efficient and effective solutions for the specific context of hospital wastewater. The use of microflotation and oxidative processes can achieve a significant improvement in wastewater quality, although cost and energy efficiency are constant considerations. Wastewater treatment in hospitals is a complex challenge, as wastewater is rarely identical. Depending on the departments and the respective medical procedures, the ingredients in the wastewater can vary greatly. This requires a customised treatment strategy. While microflotation and oxidative processes each have their own advantages and limitations, it is often the targeted use of a combination of both methods that provides the most effective and efficient solution. Future research should focus on how these processes can best be adapted and optimised to meet the variable and complex requirements of hospital wastewater.[80]
4. Moleaer sees a need for research and development regarding nanobubbles in the direction of hospital standards.[81]
5. Prof. Fabian Fischer (Switzerland) is interested to further develop his technology for wastewater treatment (Microbial Fuel Cells) to purify hospital effluents that contain unusually high concentrations of contaminants such as contrast agents used to detect tumors, cytostatics from oncological treatments, antibiotics, leaked drugs, and their metabolites with micropollutant properties, multi-resistant bacteria, and other pathogens. In addition, all other wastewater such as from the hospital kitchen, sanitary installations and other facilities typically associated with a hospital. They envision a microbial fuel cell that treats all these pollutants at an adapted flow rate to such an extent that the purified water is free of the various pollutants and micropollutants. Electricity is saved and produced as a by-product of the cleaning process.[82]

[80] Roland Damann, MicroBubbles (SPRIND), 21.09.2023
[81] Marc-Andre Lyachenko, eMail 9.11.2023
[82] Prof. Fabian Fischer, eMail 26.02.2024

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# 10. Interviews

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2. Karin Gerhardy, Senior Technical Manager Water Quality, DVGW e. V. (German Technical and Scientific Association for Gas and Water), 1.8.2023
3. Sabine Thaler, Head of Department Research & Innovation, DWA (German Association for Water, Wastewater and Waste), 1.8.2023
4. Horst Träger, President, FKT-Verband Krankenhaustechnik (Association Hospital Technologies), 3.8.2023
5. Barbara Flach, Export manager, MoveoMed, 4.8.2023
6. Leif Grundmann, CEO, Cluster MedEcon Ruhr, 4.8.2023
7. Tim aus der Beek, Head of Water ressources management, (IWW Rheinisch-Westfälisches Institut für Wasserforschung gemeinnützige GmbH, institute for water research), associated to University Duisburg-Essen, 4.8.2023
8. Adrian Treis, Head of Water ressources management, Emschergenossenschaft/Lippeverband (largest wastewater management company and operator of wastewater treatment plants in Germany), 14.8.2023
9. Roland Damann, CEO, Microbubbles, 19.8.2023
10. Veit Flöser, Owner/CEO, Ingenierbüro Flöser, 19.8.2023
11. Jéromine Albertini, Director Strategic Partnerships, Veolia France, 21.8.2023
12. Kristiane Wencki, CEO, IWW (IWW Rheinisch-Westfälisches Institut für Wasserforschung gemeinnützige GmbH, institute for water research), associated to University Duisburg-Essen, 23.8.2023
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14. Antonin Vondruska, Export Department Manager, Asio New, Brno (Czech Republic), Pollutec, 10.10.2023
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16. Rim Kenzari, Cluster manager, Pôle de compétitivité Chimie-Environnement Auvergne-Rhône-Alpes (Water, Air, Sun, Energy), Solaize (France), Pollutec, 11.10.2023
17. Nathalie Schmitt, International Business Developer, and Guillem Coste, Project engineer, Nomado, Marseille (France), Pollutec 10.10.2023
18. Remi Duvillard, Area Sales Manager France, and Yann Mocaer, Application Engineer, NX filtration, Enschede (Netherlands), Pollutec, 11.10.2023
19. Jörg Winter, NX filtration, Area Sales Manager DACH, 2.11.2023
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21. Daniel Vildozo, General Director, Condorchem Envitech, France, Pollutech 11.10.2023
22. Zsolt Rasztovits, Business Development Manager Eastern & Northern Europe, and Cesar Herrera, Process water Engineer, Moleaer, Hawthorne CS (USA), Pollutec 11.10.2023
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24. Julian Klein, Manager Sales Europe, Water & Fluid Solutions, Mann+Hummel, Wiesbaden (Germany), Pollutec 10.10.2023
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26. Antonio Sempere, Global Sales Director, Berghof Membrane Technology, Leeuwarden (Netherlands, headquarter Gwermany), Pollutec 11.10.2023
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