Procure 4Health

Market Consultation Report

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

May 2024

Funded by the European Union

GA n° 101057209

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

Abbreviations and Acronyms

CET	Central European Time
EC	European Commission
EU	European Union
GDPR	General Data Protection Regulation
HE	Horizon Europe
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
TED	Tenders Electronic Daily
TRL	Technology Readiness Level
WTO	World Trade Organisation

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1 Purpose of the Open Market Consultation

1.1 Introduction

This document describes the results of 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 aimed, on one hand, to inform technology vendors regarding the potential future PCP. On the other hand, it intended to understand their capabilities to satisfy the procurers' needs and to obtain their input on the viability of the procurement plans and conditions as described in the OMC document and annexes.

The OMC was published through a Prior Information Notice (PIN) in the Tenders Electronic Daily (TED) on 28 March 2024. The rules and objectives of the PROCURE4HEALTH OMC, as well as the challenges, the potential public buyers and the PCP approach were described in the OMC Document with Annexes. This document was published the PROCURE4HEALTH website (www.procure4health.eu).

Market parties were also requested to fill out a questionnaire in the EU Survey. The deadline to fill out the questionnaire was 18 September 2023. The intention of the questionnaire was to explore the market 'as-is', therefore there could not be wrong or right answers. The responses to the questionnaire could not contain any confidential information. The information obtained will be used as input for the procurement strategy and conditions.

The OMC was performed under the law of the Lead Procurer - Reseau Des Acheteurs Hospitaliers IDF (RESAH) - which is French law.

After processing the questions and responses of all suppliers, this document has the objective of communicating the results to the market. In this context, all information provided by technology vendors is treated as commercially sensitive and specific details will not be communicated to any supplier. Only the general findings are summarised and communicated in this report. This anonymised report (excluding the confidential information) will be published in May 2023 on the PROCURE4HEALTH website (www.procure4health.eu).

By carrying out the open market consultation, the procurers do not commit to subsequently deploying a procurement procedure. Moreover, in case this OMC will be followed by a procurement procedure, the public procurers reserve the right to change any elements that define the desired solution. No rights can be derived from any statements made by the procurers during the OMC. Participation in the OMC is not a precondition for bidding in the future PCP.

The data collected, processed, stored and used by the PROCURE4HEALTH Consortium has the only purpose of implementing the PROCURE4HEALTH project and is handled according to the General Data Protection Regulation (Regulation 2016/679 of the European Parliament

and of the Council - GDPR). Participants may exercise their right to access their personal data and the right to rectify such data by contacting: (hello@procure4health.eu)

1.2 Activities & timetable

The OMC took 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.

The timetable for the OMC was set 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 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

Parties interested in participating in the online event were requested to register through the Microsoft Teams invitation link which expired after the event. A total of 66 people registered to the event (23 public organisations, 20 private organisations, 11 SMEs, 3 start-ups, and 9 other types of organisations). The market engagement was very satisfactory since a total of 72 attendees participated in the event.

The webinar within the framework of the OMC was recorded. The video recording is available on the website of Procure4Health (https://procure4health.eu/omc-on-site-treatment-of-hospital-wastewater/).

2 The OMC results

2.1 The OMC procedure and reporting

The OMC started on the date of its publication in the EU's Supplement to the Official Journal (TED) and ended on the date set in the timetable above.

Interested parties were requested to register in order to participate in the events and receive additional information of the project. Additional written contribution in the form of a Request For Information (RFI) questionnaire was requested through the EU Survey questionnaire. The responses to the questionnaire could not contain any confidential information. The questionnaire was 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.

The PROCURE4HEALTH Consortium supported interested parties throughout the whole OMC during the webinar, and by answering questions through a Q&A document which was published on the project's website.

Market operators who wished to provide additional confidential information during the OMC could send this to the email: hello@procure4health.eu. The information had to be clearly marked as confidential. Confidential information is not included in the OMC report.

The language of this market consultation is English.

2.2 Open Market Consultation report

After processing and analysing the answers, the PROCURE4HEALTH Consortium aims to disseminate the results to the widest possible audience through this OMC report. Nevertheless, all answers provided by market parties are anonymized. The PROCURE4HEALTH Consortium will therefore provide only the general findings and a summary of the answers obtained in the EU Survey questionnaire. The OMC Report is published on the website of PROCURE4HEALTH.

Based on the feedback provided in the EU Survey questionnaire, the majority of respondents belong to start-ups and SMEs, as indicated in the figure below.

Type of organisation:

		Answers	Ratio
Start-up		4	30.77 %
SME		4	30.77 %
Public organisation		2	15.38 %
Private organisation		1	7.69 %
Other		2	15.38 %
No Answer		0	0.00 %

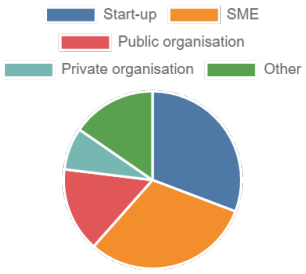


Figure 1.- Type of organisations who replied to the Request for Information using the EU Survey tool.

The participants who replied to the EU Survey questionnaire are from organisations in Switzerland, Spain, the United Kingdom, Germany, Italy, Belgium, Türkiye, the Netherlands and Poland.

2.3 Summary of results

This section summarises the feedback provided to each of the 19 questions of the EU Survey under 3 topics: (1) The PCP challenge and requirements; (2) The State-Of-The-Art analysis; and (3) Miscellaneous.

2.3.1 The PCP challenge and requirements

1) Do you have any suggestions regarding the scope of the envisaged PCP?

Participants provided suggestions regarding the scope of the envisaged PCP. Key themes include the importance of understanding the chemistry of wastewater and solutions accordingly, advocating for source-based treatment over end-of-pipe approaches to enhance efficiency, and considering water circular solutions for resource optimization. Suggestions encompassed multi-stage processes combining biological and chemical methods, integrating advanced technologies like AI for automated analytics and self-optimization, and addressing commercial concerns to accommodate solutions developed independently. Specific recommendations ranged from collecting hazardous substances before discharge to utilizing advanced oxidation plants for treatment. Overall, participants emphasized a comprehensive approach considering varying wastewater compositions, site conditions, and regulatory requirements to effectively address hospital effluent treatment.

A summary of the answers is provided below:

- One respondent emphasized the importance of thoroughly analyzing and understanding the chemistry of hospital wastewater before implementing standardized solutions, highlighting the need for precise problem analysis to achieve treatment effectiveness and cost efficiency. They suggested considering effective treatment technologies at the source of concentrated effluent streams

rather than focusing solely on end-of-pipe solutions to address the complexity of wastewater composition.

- Another respondent proposed a multi-stage treatment process for hospital wastewater, including filtration, biological processes, and oxidation, to effectively address various contaminants. They emphasized the need for advanced system technologies incorporating automated analytics and self-optimization to cope with diverse wastewater challenges and optimize treatment efficiency and cost savings.
- A participant raised concerns about equity and flexibility in business case development for commercially available solutions, particularly regarding IP protection and payment terms. They suggested considering commercially available solutions and addressing concerns around contract structure and IP to ensure inclusivity in the procurement process.
- Suggestions were made for collecting and treating hazardous substances like cytostatic drugs and X-ray contrast agents before discharge into the sewerage system. Additionally, they proposed treating infectious, pharmaceutical, and pathogenic substances using advanced oxidation plants dispersed in modules across hospital areas.
- Electrochemical oxidation and separation processes were recommended for hospital effluent treatment, highlighting their effectiveness for on-site treatment.
- The scope of the PCP was deemed appropriate, with a focus on various technologies for on-site treatment of hospital wastewater, considering factors like wastewater characteristics, legislation requirements, and available resources.
- Some respondents did not provide further suggestions, indicating agreement with the existing scope of the 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.

Participants provided a range of estimates for the budget required to develop and deploy the solution, highlighting the complexity and variability of factors involved. Estimates varied from 160,000 to 3,000,000 euros, depending on factors such as technology selection, solution scope, and site-specific requirements. Some emphasized the need for comprehensive analysis before providing a precise estimate, while others outlined detailed breakdowns of costs for different project phases and components. Estimates encompassed expenses for personnel, subcontracting, materials, and testing, with considerations for equipment, infrastructure, regulatory compliance, and analytics. The wide range of estimates reflects the diverse approaches and considerations involved in developing effective wastewater treatment solutions for hospital environments.

A summary of the answers is provided below:

- One respondent indicated that estimating the budget for developing a wastewater treatment solution is challenging due to various factors, including the choice of technology, solution size, engineering and installation costs, staff training, and

regulatory compliance. They emphasized the need for a detailed feasibility study to accurately estimate the budget.

- Another participant suggested a budget range of 750,000 to 3,000,000 euros for the development and deployment of a wastewater treatment solution, depending on the scope and nature of the technologies to be implemented. They highlighted the importance of thorough analysis and understanding of requirements to identify the most suitable solution.
- One respondent proposed a phased budget plan, with estimates of 160,000 euros for Phase 1, 500,000 euros for Phase 2, and 1,000,000 euros for Phase 3. They outlined the allocation of funds for personnel, subcontracting, and fungible resources across different phases of the project.
- Estimating the budget for a solution was viewed as premature by another respondent, who suggested waiting for the PCP call to be published to provide a more accurate estimate based on specific requirements and validation phases.
- A budget range of 50,000 to 100,000 euros was suggested by one participant, depending on the implementability of previously validated proof-of-concepts for industrial wastewater treatment solutions.
- Respondents representing a manufacturer of on-site treatment plants proposed quotations ranging from 60,000 to 600,000 euros, depending on the capacity of the plant and customization requirements based on hospital waste production.
- Another respondent outlined the need for a budget of €1,500,000 to develop test units for hospital sanitation standards and conduct trials for two years. They emphasized the assessment of stability, performance, operations, maintenance, and sludge handling during the trial period.
- The cost of analysis was identified as an additional budgetary consideration, with the assumption that university hospitals could contribute to the analysis costs.

3) Do you have knowledge of any suitable technology or combination of technologies for on-site treatment of hospital wastewater?

The majority of participants are aware of suitable technologies for on-site hospital wastewater treatment. Participants suggested various technologies suitable for the on-site treatment of hospital wastewater. These included next-generation oxidation and flotation solutions provided by one respondent, as well as systems for eliminating contaminants. Other technologies mentioned encompass nanofiltration, non-thermal atmospheric plasma for generating plasma-activated water, and advanced oxidation-reduction processes. Recommendations ranged from physical, chemical, and biological treatment methods to nanotechnology applications, emphasizing the importance of tailored solutions and combinations of technologies to address specific wastewater characteristics effectively. Additionally, environment-friendly chemical oxidation and systems for lab fluid waste disinfection were highlighted as viable options.

The answers below are provided:

- One respondent highlighted the limitations of current market-available wastewater treatment technologies, emphasizing the importance of tailored solutions to address the specific chemistry and sustainability needs of hospital wastewater. They presented Green Ocean's innovative approach to wastewater treatment, including next-generation oxidation and flotation technologies.
- Pharmafilter was mentioned by another participant as having a successful track record in treating hospital wastewater, with deployed on-site WWTPs at several hospitals. The system effectively eliminates chemical pharmaceutical and microbiological contaminants, producing purified wastewater suitable for reuse within the hospital environment.
- A respondent described a nano-filtration pilot rig capable of treating hospital wastewater, producing both 'good' water and 'bad' water with concentrated contaminants.
- Non-thermal atmospheric plasma technology and plasma-activated water were identified as potential solutions for water purification, offering a diverse range of reactive oxygen and nitrogen chemical species for contaminant removal.
- Another respondent indicated awareness of various technologies suitable for on-site treatment of hospital wastewater, including direct previous extraction technologies, final extraction technologies, and advanced oxidation-reduction processes. They emphasized the effectiveness of a specific version of Advanced Oxidation technology, potentially combined with absorption and/or ultrafiltration techniques.
- Various treatment methods, including physical, chemical, biological, and nanotechnology-based approaches, were proposed by one participant, highlighting the need for a detailed assessment to determine the most appropriate technology or combination of technologies for specific applications.
- Environment-friendly chemical oxidation, either standalone or in combination with other technologies, was suggested as an effective treatment approach.
- A respondent discussed the importance of a combination of technologies for optimal results, recommending separate solids from liquids, effluent polishing through reedbed filtration, nano-filtration for particle and pathogen removal, and activated carbon for color removal. They also noted the importance of properly treating sludge to mitigate greenhouse gas emissions.

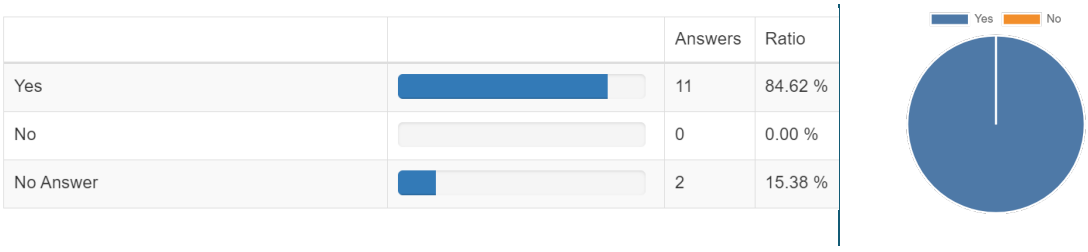


Figure 2.- Answers for the questions regarding suitable technology or combination of technologies for on-site treatment of hospital wastewater

4) Do you know any developments in the field of water treatment technologies that PROCURE4HEALTH needs to take into account?

A majority of respondents have knowledge of developments in water treatment technologies. The responses provided cover various aspects of advancements and considerations in water treatment technologies. These include mentions of principles of Green Chemistry, policies like the EU Green Deal, confidential technologies for extraction from contaminated effluent, renewable energy sources, smart sensors, and non-chemical disinfection methods. Additionally, the respondents refered to ongoing projects in the Netherlands and Switzerland, as well as capabilities for technical improvements in on-site treatment plants.

A summary of the answers is provided below:

- One respondent emphasized the principles of Green Chemistry, highlighting its impact on industrial development and its focus on environmental protection, resource efficiency, and waste minimization. They discussed Green Ocean's comprehensive approach to wastewater treatment, integrating flotation, next-generation oxidation technology, and biological post-treatment while adhering to the principles of Green Chemistry.
- Another respondent mentioned the importance of considering the revised Urban Wastewater Directive and EU policies like the EU Green Deal, which aim for "zero pollution to water," including pharmaceuticals and antibiotics. They noted the economic feasibility of technologies capable of eliminating micro-pollution from hospital effluents.
- A third respondent acknowledged the technology of previous extraction from contaminated effluents, particularly urine from neoplastic patients, followed by treatment in a chemical reactor using advanced oxidation.
- The integration of renewable energy sources, smart sensors, and monitoring technologies in water treatment plants was suggested by another respondent to reduce operating costs, minimize environmental impact, and improve operational efficiency.
- Collaboration opportunities with projects like "Medicijnresten in Noord" in the Netherlands and the “Regain Project” were highlighted as potential avenues for technical improvement in wastewater treatment.
- The respondent mentioned the wastewater treatment step used in municipal plants in Switzerland as a noteworthy development, albeit not decentralized.
- Lastly, a respondent expressed readiness to provide technical improvements in on-site treatment plant technology.

		Answers	Ratio
Yes		7	53.85 %
No		4	30.77 %
No Answer		2	15.38 %

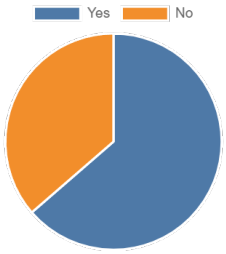


Figure 3.- Answers for the questions regarding developments in the field of water treatment technologies.

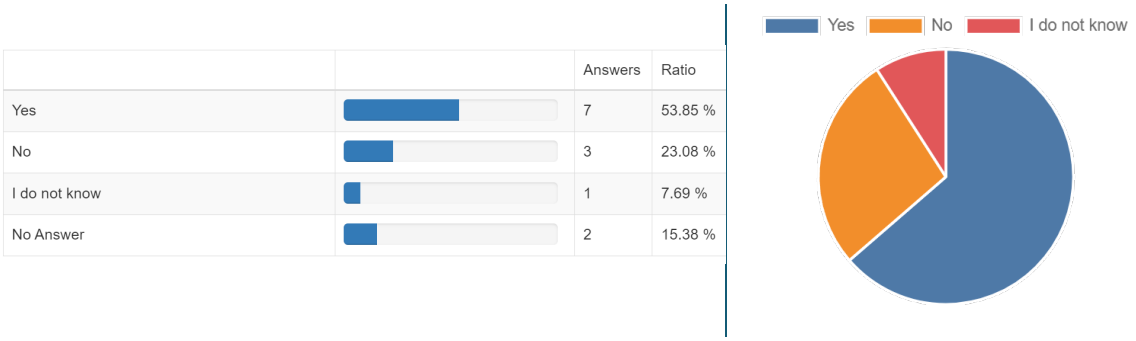
5) Do you foresee any barriers to implement on-site treatment of hospital wastewater?

A majority of respondents acknowledge potential barriers to implementing on-site hospital wastewater treatment. Three participants responded negatively, indicating that they do not foresee any barriers. One participant expressed uncertainty regarding potential barriers. The responses highlight various barriers to implementing on-site treatment of hospital wastewater. These include technical complexity, cost constraints, space limitations, stakeholders' engagement, lack of personnel with expertise, high installation and operating costs, infrastructure requirements, regulatory compliance, and the need for education and updated legislation to support such initiatives.

A summary of the answers is provided below:

- One respondent highlighted the importance of awareness regarding the complexity of hospital wastewater management. They emphasized the need for understanding the environmental threats posed by highly contaminated wastewater and the necessity of modernizing outdated infrastructure to develop tailored solutions effectively.
- Another respondent expressed the need for detailed information about the specific substances the solution must remove from hospital wastewater. They emphasized the importance of having sufficient time to study optimal solutions based on this information and raised concerns about legislative compliance regarding non-toxic and non-hazardous pharmaceutical substances.
- Implementing on-site treatment of hospital wastewater was acknowledged to face various barriers, including technical complexity, cost constraints, space limitations, and stakeholder engagement issues. It was noted that these barriers vary depending on the context and location.
- Difficulty in finding personnel with expertise in wastewater treatment technologies, high installation and operational costs, infrastructure limitations, and compliance with strict regulations were identified as potential barriers to implementing on-site wastewater treatment systems.
- Respondents highlighted the challenge of reconciling innovative solutions with existing regulations and the need for quicker adaptations or open spaces for trials to align regulations with technological advancements.

- Education about wastewater treatment was underscored as a primary concern, followed by considerations regarding legislation, particularly regarding the permissibility of on-site treatment, responsibility for treatment results, and implementation costs.



		Answers	Ratio
Yes		7	53.85 %
No		3	23.08 %
I do not know		1	7.69 %
No Answer		2	15.38 %

Figure 4.- Answers for the questions regarding barriers to implement on-site treatment of hospital wastewater.

6) Can you tackle all or part of the requirements of this challenge?

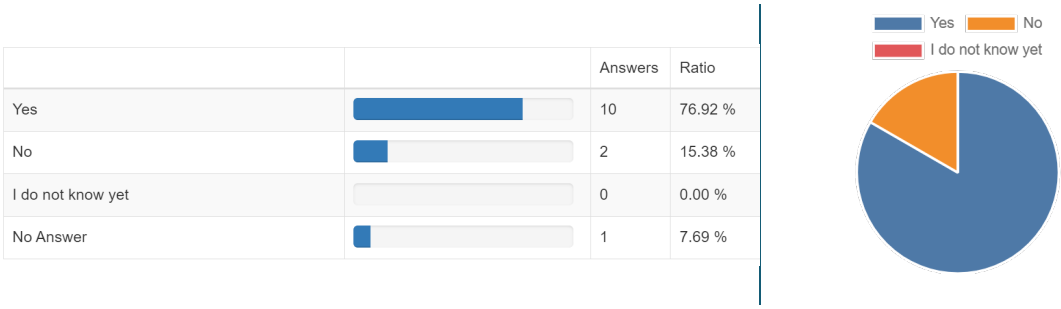
Ten participants responded affirmatively, indicating that they could tackle all or part of the challenge requirements. This majority suggests that there is confidence in addressing the challenge. Two participants stated that they could not tackle the challenge requirements. The responses outlined various approaches to addressing all or part of the requirements of the challenge. These include problem analysis, expertise in chemical process engineering, resource efficiency, deployment of capital, membrane technology for water reuse, management of healthcare and hazardous waste, collaboration with regulatory bodies, investment in suitable technologies, electrochemistry, new carbon-based materials, expertise in wastewater treatment systems, collaboration with partners, introduction of patent solutions, and electro-chemical treatment of wastewater.

A summary of the answers is provided below:

- One participant confirmed its ability to analyze operational product processes deeply and develop sustainable solutions for problematic wastewater, leveraging their expertise in chemical process engineering, technology development, and mechanical and plant engineering. It emphasized their extensive experience in resource efficiency across various industries and their position at the forefront of water treatment technologies, offering innovative solutions to address the challenges posed by PROCURE4HEALTH.
- The deployment of capital was mentioned as a possible means to tackle all or part of the challenge.
- Utilizing membrane technology, one respondent suggested the potential reuse of "good" water in toilets while highlighting the need for further treatment of concentrated waste, albeit in smaller volumes.
- Companies specializing in healthcare and hazardous waste management claimed their capability to meet all challenge requirements, particularly in handling toxic hazardous, pharmaceutical, infectious, and pathogenic substances. They noted

that some minor inorganic substances might be better treated and disposed of outside the hospital, which could have economic significance.

- It was stated that overcoming obstacles necessitates meticulous planning, collaboration with regulatory bodies, investment in suitable technologies, and commitment to compliance and sustainability goals. Advanced consolidated technologies, such as those employing electrochemistry and new carbon-based materials, were cited as means to address such challenges and promote responsible water management.
- While acknowledging the complexity of installing and operating hospital wastewater treatment systems, it was suggested that some requirements could be addressed with expertise, although challenges might arise.
- Collaboration with partners and work within their institute were cited as avenues to address some of the challenge requirements.
- Another respondent proposed introducing patent solutions tailored for specific hospital departments, such as the lab fluid waste, dialysis centre, ICU, and infectious disease department.
- The application of electro-chemical treatment technology, combining electro-coagulation and electro-oxidation, was presented as a solution. This approach aims to separate particles, reduce organic load, remove pollutants like phosphorus and heavy metals, oxidize other pollutants, and disinfect water effectively.



		Answers	Ratio
Yes		10	76.92 %
No		2	15.38 %
I do not know yet		0	0.00 %
No Answer		1	7.69 %

Figure 5.- Answers for the questions regarding tackling all or part of the requirements of this challenge.

7) Can you identify relevant functionalities that have not been described in the market consultation document?

Five participants responded affirmatively, indicating that they can identify relevant functionalities beyond what is described in the document. Another five participants explicitly stated that they cannot identify any additional functionalities.

The responses highlighted several functionalities that are not explicitly addressed in the market consultation document. These include the importance of prioritizing water circularity and implementing next-generation technologies to address water scarcity. Additionally, the potential for recycling material flows and residues was emphasized to promote a more integrated and resource-conserving approach. The need for previous extraction functionality, real-time monitoring of wastewater parameters, and remote

operation capabilities were also identified as essential functionalities for optimizing treatment processes and ensuring regulatory compliance. Finally, there was a focus on the importance of separating fluid waste from wastewater and managing sludge to prevent odour and methane release.

A summary of the answers is provided below:

- One participant stated that water circularity emerged as a crucial aspect not extensively addressed in the market consultation documents, despite its significance in discussions regarding water's value and sustainability. Next-generation technologies, exemplified by that participant's solutions, offer the potential to alleviate water scarcity concerns by enabling water circularity, thus transforming scarcity into abundance. Given the current predictions of water demand exceeding supply by 40% globally and the prevalence of water scarcity affecting a significant portion of the global population, prioritizing sustainable water management becomes imperative. Additionally, recycling material flows and residues, including toxic chemical substances that double as valuable raw materials like heavy metals, underscored the importance of an integrated, resource-conserving approach that fosters environmental sustainability and promotes the circular economy.
- Previous extraction functionality, particularly concerning toxic and hazardous substances, was highlighted as a relevant consideration before discharge into the sewerage network. Optimizing the value-for-money index may prioritize previous extraction treatments over other substances, such as iodinated and non-iodinated contrast agents used in radiological techniques.
- Real-time monitoring of wastewater parameters, including pH, turbidity, and contaminant levels, was proposed as a relevant functionality absent from the market consultation documents. Such monitoring capabilities offer immediate feedback on system performance, facilitating process optimization and regulatory compliance. Moreover, integrating remote operation and control features into the system allows for centralized monitoring and adjustment of treatment processes, especially beneficial for managing multiple treatment sites or facilities across different geographic locations.
- Emphasizing the importance of segregating fluid waste from wastewater was mentioned as an aspect that merits consideration.
- The significance of obtaining sludge that is inactivated, devoid of odour, and methane-free was highlighted as a relevant functionality that had not been extensively addressed.

		Answers	Ratio
Yes		5	38.46 %
No		5	38.46 %
No Answer		3	23.08 %

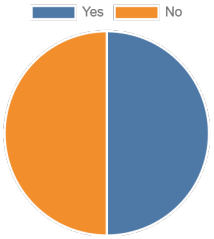


Figure 5.- Answers for the questions regarding identifying relevant functionalities that have not been described in the market consultation document.

8) Can you provide any other recommendations regarding on-site treatment of hospital wastewater?

A summary of the answers is provided below:

- One participant emphasized the adoption of water circularity principles to move away from linear models of water use, ensuring a closed-loop system even for toxic and non-biodegradable industrial water. It was stated that the technologies developed by that participant aim to mineralize or modify pollutants in sludge and concentrates, facilitating their biodegradation and preventing their transfer to other environmental compartments, thus maintaining the integrity of wastewater treatment plants.
- It was suggested to consider the current regulatory environment and legislative trends concerning hospital wastewater to inform the development of effective solutions.
- Addressing challenges such as land scarcity in modern hospitals, discontinuous wastewater discharge flows, and multiple distant hospital locations was highlighted as requiring imaginative and flexible solutions to optimize cost-effectiveness.
- Additional recommendations included segregating sewage into different streams based on medication levels, implementing source control measures to minimize contaminant introduction, integrating green infrastructure, and exploring resource recovery opportunities like nutrient extraction for fertilizer production and irrigation.
- Developing and implementing an emergency preparedness and response plan was considered crucial to mitigate risks associated with potential incidents such as equipment failures or contamination events, outlining containment, cleanup, and communication procedures.
- Solutions were suggested to generate minimal or no by-products requiring specific treatment, be easy to integrate as plug-and-play or retrofit options, have negligible CO2 impact, and remain cost-effective.
- Proper segregation of different wastewater streams and installation of dedicated technologies were emphasized as paramount. For instance, segregating lab fluid waste before biological wastewater treatment was deemed essential due to its high pollutant concentration and the presence of carcinogenic elements like Guanidine Thiocyanate derived from lab analyses.

- It was recommended to preferentially treat highly contaminated streams separately and avoid end-of-pipe solutions to enhance treatment effectiveness.

2.3.2 The State-Of-The-Art analysis

1) Do you think there is room for technological development beyond the state of the art? Please explain:

A summary of the answers is provided below:

- One respondent noted that while several new technologies are under primary development, there are also existing technologies capable of adequately addressing the current problem.
- Innovation and research activities were highlighted as drivers for the development of new solutions, particularly in areas like the discovery of new materials, more efficient processing methods, and smarter system design. Evolving demands in the healthcare sector were also acknowledged as potential drivers for technological advancements.
- Another perspective suggested that technological development often involves adapting or combining innovative solutions rather than creating entirely new ones, citing examples like the Tesla process. Compliance with regulations was noted as a driving factor in technological advancements.
- The importance of ongoing operation and maintenance (O&M) support for sustainable and economic solutions was emphasized, extending beyond technical/engineering aspects to include working methods that complement hospital operations and overall quality of care.
- Existing wastewater treatment technologies were acknowledged to have limitations, with an emphasis on the need to maximize resource efficiency and process optimization to overcome challenges efficiently.
- The potential for advancements in materials and technologies, such as 3D carbon-based electrodes and reticular metal printing, to increase efficiency and reduce costs in treating complex wastewater was highlighted.
- It was suggested that treating lab fluid waste on-site rather than sending it to incineration plants could be a viable solution, aligning with environmental protection requirements and the circular economy principles.
- The necessity for innovative solutions to anticipate and meet rising regulatory requirements, as well as the need for enhanced protection and reuse of natural resources and public health, was emphasized.

2) What kind of solutions or developments would you propose?

Concerning the proposed solutions and developments, a summary of the answers is provided below:

- One respondent suggested the adoption of a new microbial fuel cell (MFC) approach.
- In consideration of space limitations and discontinuous wastewater flow, another proposal emphasized the need for modular and stackable treatment plants, along with surge tanks to optimize advanced oxidation-reduction chemical reactors. The proposed solutions were required to meet specific criteria related to quality, feasibility, safety, and evaluability.
- A commitment to developing a prototype for generating plasma-activated water (PAW) using plasma technology was highlighted. The approach involved utilizing existing atmospheric plasma devices and potentially collaborating with a European company with patented PAW generation systems.
- Integrated and modular wastewater treatment systems, along with real-time monitoring capabilities, were recommended for effectively removing pollutants and optimizing system performance.
- The implementation of a participant's system, which automates waste transport and treatment within hospitals, was proposed as a solution to reduce environmental impact and improve patient and staff safety.
- A respondent's innovative approach to wastewater treatment, focusing on sludge-free chemical processing technologies and efficient reduction of emissions, was presented as a solution aligned with sustainable development goals.
- Integrating separation processes with advanced oxidation technologies and carbon-based electrodes was suggested to achieve highly effective functionalities for wastewater treatment.
- Another recommendation proposed the use of advanced oxidation processes (AOP) for removing biological and chemical hazards from laboratory fluid waste.
- Prioritizing treatment for the most polluted flows and installing vacuum toilets to treat these flows on-site was suggested as a solution.
- Lastly, an on-site, environmentally friendly, and cost-effective chemical oxidation technology for treating organic contaminants, drug residues, and radionuclides in hospital wastewater was proposed.

3) Do you know the TRL of those solutions/developments?

Respondents provided insights into the TRL of proposed solutions for hospital wastewater treatment, indicating a range of developmental stages. One respondent suggested that their proposed solutions might commence around TRL 4, potentially advancing to TRL 5 once initiated. Another respondent acknowledged the concept of TRL and implied that established technologies like conventional activated sludge systems or membrane bioreactors might have higher TRL levels (7-9) while implying ongoing R&D for more innovative approaches. Indications were given regarding the TRL of various technologies involved in hospital wastewater treatment, ranging from TRL 6 to TRL 9, with adaptations and developments ongoing to suit the specific hospital environment Others responded that their TRL levels are spanning from 3 to 9. A response suggested a TRL of 8 for their

technology, while another implied a TRL between 6 and 7, with expectations of reaching TRL 8 by the end of 2024.

4) Can the proposed solutions or developments treat highly soluble reagents and other hazardous chemicals? Please specify which substances can be treated.

The majority of the respondents (12) answered affirmatively to this question. A summary of the answers is provided below:

- A participant suggested that while the treatment of micropollutants remains unexamined, other substances might be effectively removed.
- Another participant detailed a multifaceted approach involving previous extraction and chemical reactors to address a spectrum of contaminants, including cytostatic mixtures and resistant bacteria.
- Additionally, hints were given regarding the potential to develop a test plan for Plasma Activated Water (PAW) to treat emerging contaminants.
- Responses suggested that the effectiveness of treatment depends on factors like the specific characteristics of chemicals and the compatibility of treatment technologies.
- Assertions were made regarding the comprehensive treatment of contaminants typically found in hospital wastewater by certain systems.
- Moreover, references were made to the successful oxidation of various materials by a participant's solutions, including organic materials, pathogens, pharmaceuticals, and surfactants, with a notable mention of AOX derivatives.
- The capability to handle highly soluble reagents and hazardous chemicals was implied.
- Other responses highlighted the treatment of bacteria, viruses, and micropollutants, as well as specific substances like Guanidine Thiocyanate commonly found in biomedical analyzers.
- Additionally, a specific electrode combination was noted to achieve micropollutant removal, with further research needed on pharmaceuticals and detergents.

5) Can you identify any patents or standards that are relevant to the on-site treatment of hospital wastewater challenge?

One participant referred to national, local, and European regulations, highlighting the regulatory framework governing the treatment of hospital wastewater. This participant cited directives such as the Water Framework Directive (2000/60/EC), the Groundwater Directive (2006/118/EC), and the Environmental Quality Directive in the field of water policy (2008/105/EC), among others. Additionally, the participant mentioned two patents held by them for the treatment of hospital solid waste, providing a basis for the development of new treatment processes, including Advanced Oxidation methods applicable to hospital effluents.

Another response cited a US patent (10,123,812) and an international standard (ISO 22196) related to measuring antibacterial activity on surfaces, potentially applicable in medical facilities requiring wastewater treatment. An affirmation was made regarding the capability of proposed solutions or developments to treat highly soluble reagents and other hazardous chemicals. Another participant stated they have exclusive rights to their intellectual property and patents. An international patent related to AOP reaction was referenced by a participant. Furthermore, the mention of patented sanitation solutions was made by another respondent. The participant referred to several patents held by itself, providing additional context on patented solutions for wastewater treatment.

The list of the patents and other assets that are provided in the answers is detailed below:

- Patent, WO2010046510A1(2008)
- Patent, WO2016132003A8 (2015)
- US Patent 10,123,812
- ISO 22196
- Espacenet Application number: HR2023P001041T 20181107
- WO 2013/093903
- WO2021/234686A1
- PCT/63/253,134

6) Are you aware of any patents that may constitute a barrier for you to deliver a solution in the envisaged PCP procurement?

One respondent stated they were not aware of any patents that might hinder their ability to provide a solution in the planned PCP procurement. Another highlighted the complexity of identifying and analyzing patents, suggesting the need for legal and technical expertise to assess potential obstacles. Additionally, one respondent asserted their exclusive rights over their intellectual property and patents. Overall, the majority of respondents indicated a lack of awareness regarding patents that could pose barriers to delivering a solution in the envisaged PCP procurement.

2.3.3 Miscellaneous

1) 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?

A summary of the answers is provided below:

- One respondent indicated the need for specific information regarding the substances present in hospital wastewater, including toxic-hazardous substances, pharmaceutical substances, infectious substances, and pathogens, as outlined in the tender details provided by Procure4Health. Additionally, they highlighted the

importance of understanding the characteristics of different hospitals, the duration of the validation period, and the types of hospitals involved across various countries to formulate an effective action plan.

- Another participant mentioned the necessity of knowing the target flow rate of wastewater to be treated.
- Furthermore, comprehensive data on various aspects is required, including a site assessment covering wastewater characteristics and infrastructure evaluation, technology assessment focusing on available treatment options, regulatory framework awareness, stakeholder engagement, budget allocation, and risk assessment.
- One respondent emphasized the importance of preliminary feasibility studies with interested hospitals, particularly those with a bed capacity of 300 or more, to gather volumetric data on wastewater and solid wastes.
- Additionally, detailed information on the annual mass and hydraulic volume flow of wastewater, wastewater characterization, financing details, and regulatory requirements were highlighted as essential for developing an effective action plan.
- Another participant emphasized the significance of understanding the site context, problem dimensions, wastewater characteristics, treatment objectives, site conditions, and regulatory requirements.
- Furthermore, the need for a comprehensive analysis of wastewater, projections to demonstrate expected performance, and clarity on financing sources and potential EU funding were mentioned as crucial aspects to consider.
- Lastly, knowledge about alternative technologies available in the market, their unique selling points, performance metrics, and implementation costs was identified as essential for planning purposes.

2) Do you have specific requirements to achieve the functionalities that PROCURE4HEALTH should take into account?

Six of the participants responded “yes” and five of them responded “no”. Two respondents did not provide answers. A summary of the answers is provided below:

- One participant indicated specific requirements that Procure4Health should consider, emphasizing the importance of aligning with current regulatory obligations in Spain and the EU regarding wastewater discharges. They highlighted the coordinated participation of local entities and hospitals to offer a comprehensive solution to the problem of highly contaminated hospital wastewater, especially by hazardous toxic substances.
- Additionally, several functionalities were outlined as essential considerations for Procure4Health, including efficiency in removing contaminants, cost-effectiveness, sustainability, user-friendliness, monitoring and control capabilities, integration with existing infrastructure, and safety measures.

- Another respondent stressed the importance of always adhering to regulations and fostering innovation by implementing new regulations.
- Furthermore, a specific requirement was mentioned regarding the direct connection of automatic analyzers to a dedicated pipeline for segregation at the source and separate treatment before discharge into sewage.
- Lastly, a request was made for email alerts regarding any relevant tender announcements or publications similar to TED.

3) How could you contribute to the on-site treatment of hospital wastewater challenge? Please explain:

The potential contributions from the market are summarised below:

- One participant suggested running the MFC system in a WWT plant of any larger hospital as a potential contribution to the on-site treatment of hospital wastewater.
- Another contributor outlined their contribution, focusing on compliance with current regulations, collaboration with local authorities and hospitals, and the utilization of previous extraction technology and chemical reactors for advanced oxidation processes. They also emphasized collaboration with research groups for analytical characterization and monitoring of effluents.
- A company specializing in plasma technology proposed developing a prototype for generating Plasma Activated Water (PAW) using atmospheric plasma devices. They also mentioned collaboration with a European company with a patented PAW generation system to propose solutions for addressing the wastewater challenge.
- A respondent who is responsible for public hospitals in Turkey highlighted its role in determining requirements for on-site wastewater treatment in hospitals and contributing to legislation and regulation studies.
- One respondent mentioned that various experiments conducted in the Netherlands could be applied abroad, potentially contributing to on-site treatment solutions.
- Another contributor, with expertise in chemical processing technologies, emphasized their capability in the efficient treatment of highly contaminated wastewater streams using next-generation oxidation technologies. They also mentioned a multidisciplinary approach and involvement in solution design, evaluation, and resource recovery.
- A research organization outlined its potential contribution through technical expertise in identifying innovative treatment methods suitable for hospital effluents, solution design and planning, technology evaluation, and promotion of sustainable practices.
- A suggestion was made for membrane filtration as a potential contribution to on-site treatment.
- Another respondent offered a dedicated treatment solution for the on-site management of lab fluid waste, particularly relevant post-COVID.

- Additionally, collaboration with hospital staff for understanding needs, test unit development and supervision, and the implementation of compact construction units tailored to toilets or lab facilities were proposed.
- Lastly, a company specializing in chemical oxidation technology highlighted its contribution potential in providing on-site, environment-friendly, fast, efficient, and cost-effective treatment for various contaminants in hospital wastewater.

4) What are the risks associated to the development and implementation of a solution that tackles the functional needs of PROCURE4HEALTH?

The potential risks are mentioned below:

- One participant highlighted the novelty and early research stage of the solution, indicating high risk associated with its development and implementation.
- Another respondent categorized project-level risks into financial, strategic, performance, and external risks, emphasizing the need for more details to assess financial risks accurately. They also mentioned potential synergies if the proposed treatments could handle hospital solid waste, potentially reducing treatment costs.
- A risk identified by one respondent was the possibility of the system being ineffective in removing all contaminants.
- Another contributor outlined risks related to conflicts of interest, conflicting objectives, and misunderstandings in multi-disciplinary teams. They emphasized the importance of problem analysis, milestone-based planning, and transparent project management to address these risks effectively.
- Addressing PROCURE4HEALTH's functional needs could involve risks such as complex wastewater composition and operational challenges during implementation, necessitating mitigation strategies and regular communication among stakeholders.
- Suggesting an initial on-site pilot trial, one respondent highlighted the importance of proving or disproving the effectiveness of the solution.
- Segregation at the source was identified as a critical risk, with poor segregation potentially leading to high capital expenditure requirements.
- Efficiency of the treatment technology could be impacted by components in the wastewater, posing a risk to its effectiveness.
- Lastly, risks related to new technology development were mentioned, including credibility, integrability, performance, costs versus benefits, supply chain, and after-sales service.

5) Do you have any suggestions and/or remarks?

Among the respondents, one suggested exploring the possibility of developing an Horizon Europe project to further investigate the use of an MFC for cleaning hospital wastewater. Another participant raised concerns about potential technical risks associated with the

development and implementation of the proposed solution. These risks encompass challenges related to technology complexity, compatibility issues with existing infrastructure, and unforeseen technical hurdles during implementation. Financial risks were also highlighted, including cost overruns, budget constraints, and the potential for unforeseen expenses. Additionally, operational risks such as system reliability and performance degradation over time were mentioned.

3 The follow up PCP

PROCURE4HEALTH is preparing the operational ground for a Pre-Commercial Procurement (PCP) proposal concerning on-site treatment of hospital wastewater. 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 below:

- 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.
- 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.

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4 Conclusions

Based on the analysis of the responses to the 19 questions posed during the OMC for PROCURE4HEALTH, several key insights have emerged. The OMC revealed that the market is characterized by a diverse range of technological solutions and expertise aimed at addressing the challenges associated with the on-site treatment of hospital wastewater. Responses indicated a wide array of approaches, including advanced oxidation processes, membrane filtration, plasma technology, and microbial fuel cells (MFCs).

The assumption of PROCURE4HEALTH that there is interest and capacity within the market to develop and implement innovative solutions for hospital wastewater treatment was largely validated by the responses received. Many companies expressed specific interest in collaborating with PROCURE4HEALTH and highlighted their readiness to contribute through the development and implementation of tailored solutions.

Several companies indicated specific interest in contributing to the development and implementation of solutions that align with the functional needs outlined by PROCURE4HEALTH. These included requirements related to efficiency, cost-effectiveness, sustainability, user-friendliness, monitoring and control, integration, and safety.

Some assured that they possess proprietary technologies, patents, or intellectual property rights that could be leveraged to deliver effective solutions for hospital wastewater treatment. These companies emphasized their expertise and experience in the field, along with their commitment to compliance with regulatory standards and alignment with project goals.

Some providers would like PROCURE4HEALTH to provide more specific information and guidance regarding regulatory requirements, target flow rates, site assessments, technology assessments, stakeholder engagement, budget allocation, risk assessment, and other critical aspects of the project. Clear and detailed specifications are essential for facilitating effective collaboration and ensuring successful project outcomes.

Overall, the responses received during the OMC underscore the potential for fruitful collaboration between PROCURE4HEALTH and market stakeholders in addressing the challenges of hospital wastewater treatment. By leveraging the expertise and innovation present in the market, PROCURE4HEALTH can advance its objectives of promoting sustainable and effective solutions for healthcare facilities.

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