

Deliverable Report D4.2 Exploitation Plan final version

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 Lead beneficiary: Fraunhofer Institute for Surface Engineering and Thin Films IST
 Main author: Jan Gäbler
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1 Introduction to the project SERPIC

The project *Sustainable Electrochemical Reduction of contaminants of emerging concern and Pathogens in WWTP effluent for Irrigation of Crops – SERPIC* will develop an integral technology, based on a multi-barrier approach, to treat the effluents of wastewater treatment plants (WWTPs) to maximise the reduction of contaminants of emerging concern (CECs). The eight partners of the SERPIC consortium are funded by the European Commission and by six national funding agencies from Norway, Germany, Italy, Spain, Portugal and South Africa. The official starting date of the SERPIC project was 1. September 2021. The project had a duration of 40 months and ended 31. December 2024.

The overall aim of the SERPIC project was to investigate and minimise the spread of CECs and antimicrobial resistant bacteria/antibiotic resistance genes (ARB/ARG) within the water cycle from households and industries to WWTPs effluents, and afterwards via irrigation into the food chain, into soil and groundwater and into river basins, estuaries, coastal areas, and oceans with a focus on additional water sources for food production.

A membrane nanofiltration (NF) technology was applied to reduce CECs in its permeate stream by at least 90 % while retaining the nutrients. A residual disinfection using chlorine dioxide produced electrochemically was added to the stream used for crops irrigation (Route A). The CECs in the polluted concentrate (retentate) stream were reduced by at least 80 % by light driven electro-chemical oxidation. When discharged into the aquatic system (route B), it will contribute to the quality improvement of the surface water body.

A prototype treatment plant was set-up and evaluated for irrigation in long-term tests with the help of agricultural test pots. A review investigation of CECs spread was performed at four regional showcases in Europe and Africa. It included a detailed assessment of the individual situation and surrounding condition. Transfer concepts was developed to transfer the results of the treatment technology to other regions, especially in low- and middle-income countries.

2 Report summary

This report describes the exploitation activities that are planned at the time of the creation of this document, as well as the connected dissemination activities. The horizon of activities goes beyond the project duration until TRL 9 when the SERPIC technology will be eventually applied in real application. It contains a timeline graph and a detailed description of the dissemination and exploitation activities.

3 Deliverable description as stated in the Project Description

The exploitation plan, developed in task **T4.4**, will be concluded in this deliverable in the final version. It will be published on the project website to enable contacts by additional stakeholders.

4 Introduction

The work package WP4 has two objectives: To achieve the adoption of the project results by other parties and stakeholders, the WP has the objective to ensure that the results will reach the relevant academic, economical and societal communities. The second objective is to ensure that the expected impacts to society and environment will be finally achieved. The main action to fulfil these objectives is the development of an **exploitation plan** to prepare the **use** of the project **results**. It shall cover not only the project duration but also the period afterwards with a timescale until the water treatment technology reaches market introduction (TRL9). The exploitation plan is strongly linked to the dissemination activities in task **T4.3**.

Due to the importance of the exploitation of the results for a successful future application, a step-wise strategy is followed to develop the exploitation plan: A preliminary version was forming deliverable **D4.1** and was presented to selected stakeholders for discussion and feedback. The agreement of the stakeholders about the general strategy of the exploitation plan formed milestone **M4.1**. Input from the stakeholders was considered for further development of the plan. The final version is presented in this public report as deliverable **D4.2** in the final project month 40.

The exploitation plan has a view to audiences beyond the consortium, addressing three groups: **academic, economical and societal communities**. Because each group has different interests and needs, separate sets of dedicated dissemination activities are planned to inform all three groups thoroughly about the results of the project. Thereby, other organisations like enterprises or R&D performers can uptake the results and further develop the technology to higher technology readiness level for their specific application. Furthermore, the consortium identifies interesting parties for joint follow-up activities. Scientific and educational communities are important for further research on the technology and to transfer the scientific results to other application areas. The stakeholder group from business comprises wastewater treatment plant provider, manufacturer of water treatment technology and corresponding components, and end-users like farmers, farmer associations and water providers. It is important to communicate also with the general public to inform them about new solutions for CEC-free plants and food, and to provide accountability about the use of public money. Both European, African and national channels are considered, also in national languages.

An important point in planning follow-up activities of the consortium is to **look for funds**, like research programs, for a potential subsequent R&D project.

5 Results

5.1 Exploitation and dissemination timeline

To reach organisations and people outside the consortium, they must know about the project and the interim results. Thus, a dissemination action is the prerequisite for each exploitation action. Therefore, exploitation and dissemination activities have been linked temporally. The timeline for these activities is shown in **Figure 1** and **Figure 2**. The figures show the most important activities that have already been implemented as well as the planned activities for the time after project end. **Figure 1** shows in an overview the timeline until the potential implementation of the SERPIC technology (TRL 9) in approximately five years after project end (2029). **Figure 2** shows the timeline only of the project duration in a detailed way. The increase of technology readiness level (TRL) is shown parallel to the timeline.

For each activity, the relevant stakeholder groups are assigned by symbols. Here, the group of economical communities is further separated into sub-groups, because these sub-groups need different dissemination approaches:

- a) wastewater treatment plants,
- b) manufacturer of water treatment equipment,
- c) farmers and farmer associations, and
- d) water providers.

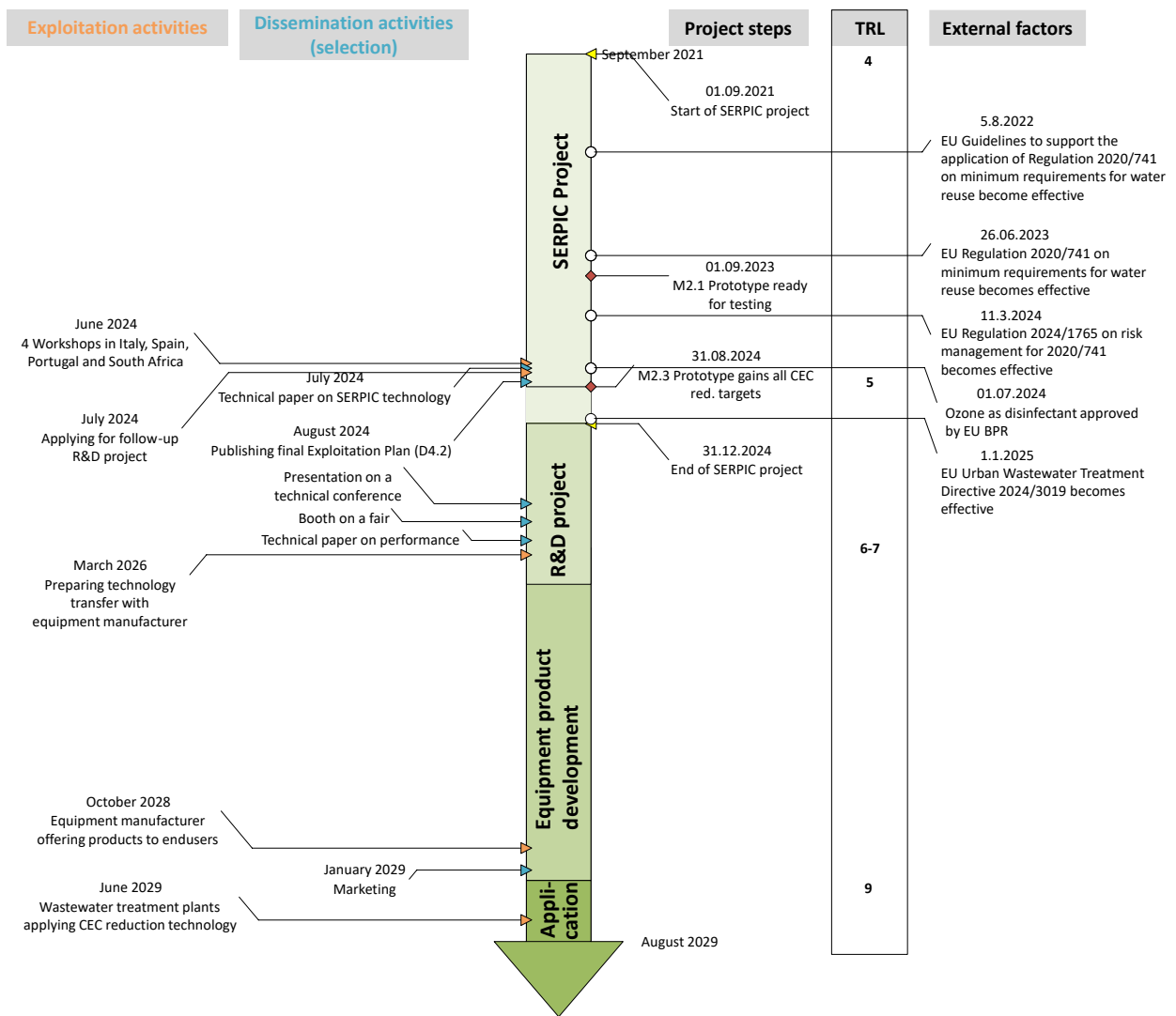


Figure 1: Timeline of dissemination and exploitation activities, overview until estimated implementation of the SERPIC technology at TRL 9, including important external regulation factors; implemented activities in black font, planned activities in grey font; BPR: Biocidal Products Regulation of the European Commission.

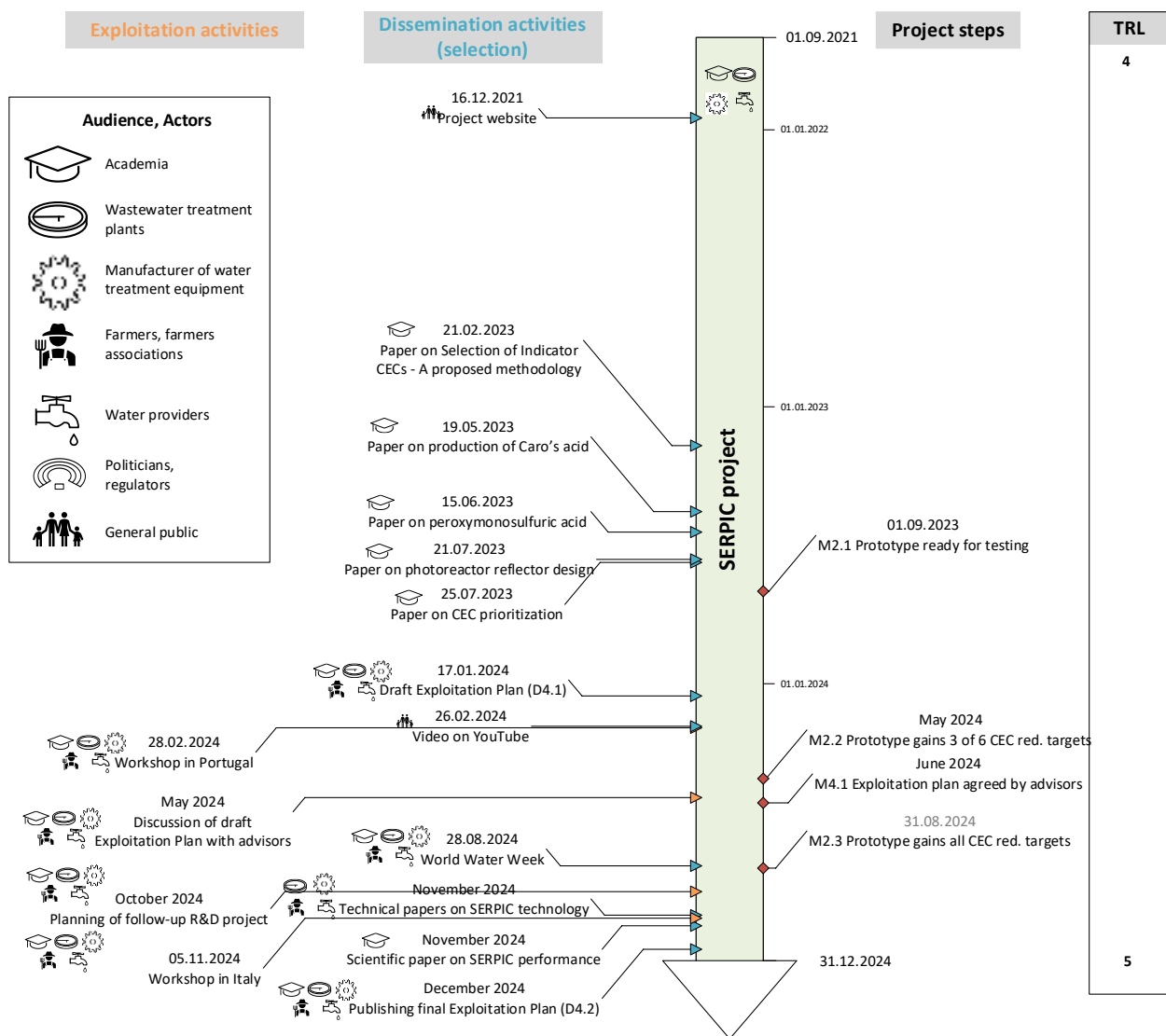


Figure 2: Timeline of dissemination and exploitation activities, details within the project duration; implemented activities in black font, planned activities in grey font.

Important dissemination and exploitation activities¹¹

Project video on YouTube

This video intends to inform the general public. It has an app. length of six minutes and consists of statements of consortium members complemented with graphical schemes of the process chain. It also shows the SERPIC prototype plant and the irrigation of crops with the treated wastewater effluent. It was produced by IST and was published 26.2.2024 on YouTube.

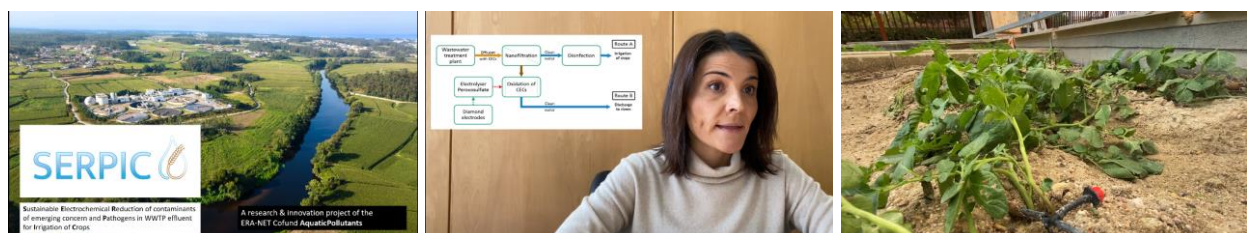


Figure 3: Screenshots of the SERPIC project video.

Elaborating Draft Exploitation Plan

This task consists of the elaborating the 2st version of the exploitation plan (D4.1) with the input of all consortium partners. It was finished in February 2024.

Presentation for stakeholders

To discuss the interim results with the Stakeholder Board, a short presentation was prepared in February 2024, and was used by all consortium members.

Workshop in Portugal

This was the first of the series of four national workshops to be implemented in the four target regions Italy, Spain, Portugal and South Africa. All workshops were integrated into other events to address a larger audience compared to a separate workshop only for the SERPIC results. The Portuguese workshop was organised by AdP and UP and was integrated into an event of project partner company Águas de Portugal, opened to the stakeholders of the SERPIC project. This event took place in Santarém at 28.2.2024.

Discussion of Draft Exploitation Plan with selected stakeholders

This document was presented to selected stakeholders, together with the presentation described above. The feedback of the stakeholders was considered for the further development of the exploitation plan for this final version.

Workshop in Spain

The Spanish workshop was integrated in a session during the 44th Annual Meeting of the RSEQ Specialised Group in Electrochemistry + 5th E3 Mediterranean Symposium. This event took place in Bilbao 3.-5.7.2024.

Applying for follow-up R&D project

As shown in the timeline, the consortium is convinced that another research & development project is necessary to increase the technology readiness level before industry can take-up the results and develop products from it. The consortium is actively looking for calls for proposals that fit to the topic and the involved countries like Horizon Europe, ERA-NETs or WATER4ALL. If necessary, additional partners will be searched to complement the necessary competences, e.g. for CEC analytics, horticulture or hardware equipment (e.g. membrane manufacturer).

Workshop in Italy

The Italian workshop was implemented during the ECOMONDO exhibition in Rimini 5.-8.11.2024. It was scheduled during the first day of the exhibition and it brought together many representatives of national institutions related to the wastewater management and reuse (decision makers, policy makers, practitioners, and researchers). More than 100 attendants were present.

Workshop in South Africa

The South African workshop will be implemented in January 2025.

Technical paper on SERPIC technology

The consortium agreed to publish technical papers of the SERPIC technology at the end of the project to inform water treatment equipment manufacturer about the project results. The idea is to create versions of the paper with identical content in the different national languages Norway, German, Italian, Spanish, Portuguese and English. Then, relevant journals will be selected in each country to reach relevant development engineers from equipment manufacturers, like

Filtration & Separation (English) or *Vann* (Norway). The papers will be written in a non-scientific manner and focus on the technological process chain, the main parameters of the prototype plant, the control concept and on the results of the life-cycle analysis.

Scientific paper on SERPIC performance

At the end of the project, a summarizing scientific paper is planned to inform the research community about the SERPIC results. The paper will focus on the CEC degradation performance and the fate of CECs in soil and plants. It will be a joint publication with co-authors from all consortium partners.

Final Exploitation Plan on project website

At the end of the project, the present document with the Exploitation Plan will be finalised considering the input from the stakeholders and the preparation of follow-up activities. It will be published on the SERPIC project website and advertised via the AquaticPollutants TransNet project and other channels.

6 Publications and other dissemination activities

The following **Table 2** lists all dissemination activities of the project.

Table 2: List of implemented dissemination activities.

Conferences, oral presentations		
Publishing name	Title of contribution	Publishing date
XVI Young Science Symposium, Ciudad Real, Spain	Persulfates electrogeneration using BDD anodes and 3D-printed reactors	23.06.2023
10th IWA Membrane Technology Conference & Exhibition for Water and Wastewater Treatment and Reuse, St. Louis, USA	Effectiveness of membrane filtration for removal of cell free antibiotic resistance genes from water and wastewater	26.07.2023
II Water Reuse Technical Workshop on Risk assessment for contaminants of emerging concern in water reuse systems, Ispra, Italy	Selection of indicator contaminants of emerging concern in water reuse projects	12.04.2024
World Water Week	Different Water Scenarios Afford Specific Technologies to Remove CECs	28.8.2024
World Water Week	Exploitation & Implementation - Stakeholder Engagement & Transfer	28.8.2024

World Water Week	Sustainable Electrochemical Reduction of contaminants of emerging concern and Pathogens in WWTP effluent for Irrigation of Crops - SERPIC	28.8.2024
Zukunftsplattform 24 - Die Dialogveranstaltung des Spurenstoffzentrums des Bundes	Projekt SERPIC: Ressourcenschonende Technologie ermöglicht Wasserwiedernutzung in der Bewässerung	8.10.2024
XII International Symposium on Environmental Engineering, Palermo, Italy	Risk assessment in the case of reuse of reclaimed water – A proposed methodology	01.10.2024

Conferences, poster presentations		
Publishing name	Title of contribution	Publishing date
One Health in the 21st Century 2021, Oslo, Norway	SERPIC	03.11.2021
3rd Water JPI Conference, Mülheim/Ruhr, Germany	SERPIC	17.11.2021
XLII Meeting of the specialized group of electrochemistry of the RSEQ, Santander, Spain	Generación electroquímica de persulfatos utilizando ánodos de BDD en un reactor electroquímico adaptado mediante impresión 3D	06.07.2022
6th conference on the Environmental Dimension of Antibiotic Resistance (EDAR6), Gothenburg, Sweden	Removal of cell free antibiotic resistance genes from water by membrane filtration and from membrane concentrate by 265 nm UV-LED	27.09.2022
X Jornadas Doctorales de la UCLM, Albacete, Spain	Reduction of CECs and ARB/ARG in wastewater from WWTP using electrochemically generated persulfate	25.11.2022
EA3G conference on ozone and advanced oxidation, Toulouse, France	Electrochemical production of persulfate with boron-doped diamond electrodes	28.11.2022
IOA World Congress 2023, Milan, Italy	Disinfection via electrogenerated ozone for wastewater reuse	04.07.2023
XII International Symposium on Environmental Engineering, Palermo, Italy 2024	Sustainable Electrochemical Reduction of contaminants of emerging concern and Pathogens in WWTP effluent for Irrigation of Crops (SERPIC).	03.10.2024

1 st Clausthal Conference on Circular Economy, Clausthal-Zellerfeld, Germany	Sustainable Electrochemical Reduction of contaminants of emerging concern and Pathogens in WWTP effluent for Irrigation of Crops	24.11.2023
Scientific journal papers		
Publishing name	Title of contribution	Publishing date
Science of the total environment	Selection of Indicator Contaminants of Emerging Concern when reusing reclaimed water for irrigation - A proposed methodology	21.02.2023
Separation and Purification Technology	Optimization of the electrolytic production of Caro's acid. Towards industrial production using diamond electrodes	19.05.2023
J. of Water Process Engineering	Outstanding productions of peroxymonosulfuric acid combining tailored electrode coating and 3-D printing	15.06.2023
Journal of Environmental Chemical Engineering	Reflector design for the optimization of photoactivated processes in tubular reactors for water treatment	21.07.2023
Science of the total environment	Quantitative and qualitative approaches for CEC prioritization when reusing reclaimed water for irrigation needs – A critical review	25.07.2023
Chemical Engineering Journal	Insights into the application of the anodic oxidation process for the removal of per- and polyfluoroalkyl substances (PFAS) in water matrices	23.01.2024
Chemosphere	Continuous UV-C/H ₂ O ₂ and UV-C/Chlorine applied to municipal secondary effluent and nanofiltration retentate: Removal of contaminants of emerging concern, ecotoxicity, and reuse potential	18.05.2024
Chemical Engineering Journal	Towards scaling up of the electrochemical production of Caro's acid: Electrode size and/or stacking?	09.07.2024
Chemical Engineering Journal	Integration of a 3D-printed electrochemical reactor with a tubular membrane photoreactor to promote sulfate-based advanced oxidation processes	24.10.2024
Journal of Environmental Management	Treatment of effluent from municipal wastewater treatment plants using electrochemically produced Caro's acid	13.12.2024

Contributions to monographs		
Publishing name	Title of contribution	Publishing date
Funded Projects Booklet Joint Transnational Call 2020	SERPIC	29.09.2021
Newsletters		
Publishing name	Title of contribution	Publishing date
AquaticPollutants e-newsletter, AquaticPollutants Newsletter #1	Selected target CECs steer the technological process chain development	28.04.2022
Nuova Ferrara, Local newspaper	Anche Unife studia possibili soluzioni: "La tecnologia aiuta a trovare rimedi"	20.06.2022
Resto del carlino, Local newspaper	Studio internazionale dell'Università: Progetto per usare acqua reflua ripulita grazie all'energia solare	20.06.2022
Estense.com, Local newspaper	Unife nel progetto internazionale per fronteggiare la scarsità d'acqua in agricoltura	20.06.2022
Websites and videos		
Publishing name	Title of contribution	Publishing date
AquaticPollutants	SERPIC	06.10.2021
JPI AMR - SERPIC	SERPIC	06.10.2021
AdP (Águas de Portugal)	SERPIC	01.12.2021
SERPIC project website	SERPIC	16.12.2021
NIVA	SERPIC	01.01.2025
UNIFE news	Crisi idrica Unife partecipa a SERPIC, progetto europeo per il riciclo dell'acqua in agricoltura	20.06.2022
UNIFE Dep of Engineering	H2020-SERPIC: progetto europeo che vuole fornire una soluzione contro la siccità e la crisi idrica	20.06.2022
AquaticPollutants	SERPIC project develops a methodology how to select indicator CECs	21.07.2023
YouTube , channel of JPI Oceans	ERA-Net Cofund AquaticPollutants - Communication Activities SERPIC	7.8.2023
YouTube , channel of Fraunhofer IST	SERPIC	26.2.2024

Website Fraunhofer IST	A look behind the scenes – The SERPIC project	21.5.2024
UNIFE Dep of Engineering	Ecomondo 2024 grande successo del workshop del nostro gruppo di ingegneria sanitaria ambientale	15.11.2024
Workshops		
Publishing name	Title of contribution	Publishing date
AquaticPollutants Kick-off, (online meeting)	SERPIC	30.09.2021
WS Final do projeto REUSE, Beja, Portugal	Projetos LIFE PHOENIX SERPIC	14.12.2021
XIV Jornadas de Engenharia do Grupo Águas de Portugal	SERPIC	28.02.2024
44 th Annual Meeting of the RSEQ Specialised Group in Electrochemistry + 5 th E3 Mediterranean Symposium	Network of Electrochemical Engineers	03.07.2024
ECOMONDO	SERPIC: La gestione del riuso delle acque reflue civili depurate. Trattamenti, affidabilità, rischi	05.11.2024